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ABSTRACTS 摘要集

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AIE-Active Polymers and AIE-Based Technologies

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Polymers with aggregation-induced emission (AIE) characteristics are a class of materials that show weak light emission in dilute solutions but become intensively emissive in the aggregated state. They have attracted tremendous attention in the past decades due to their good processability, efficient solid-state emission, high sensitivity in fluorescence sensing, unique mechanical properties, diverse topological and morphological structures, etc. In this talk, the recent research progress on the synthesis, structures and functionalities of AIE-active polymers will be introduced. Moreover, new AIE-active systems (clusteroluminescent polymers) without conventional chromophores will also be discussed. A general method for the synthesis of AIE-active polymers is to incorporate AIE-active luminogens (AIEgens) into the side chain, main chain, or center/terminal of a polymer structure. By using different polymerization or post-modification strategies, a large variety of AIE-active polymers with linear, star-shaped, dendritic, hyperbranched, cross-linked, or three dimensionally ordered structures have been constructed. The combination of AIE effect and the polymer characteristics enable AIE-active polymers to find a wide-range practical applications, including fluorescence chemosensing, bioprobing, bioimaging, as well as light emitting device fabrication. We hope this talk could provide some insight into the design strategy and the structure-property relationship of AIE-active polymers to benefit the further advancement of this area, and to show a picture of the bright future of luminogenic polymers.

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MXene-Based Functional Fibers and Fabrics for Electronic Textiles

Yury Gogotsi
Drexel University

The rapid development of portable electronic devices has put forward new requirements for textiles, including the ability to conduct electricity, sense body movements, and communicate with nearby electronics. Just like conventional electronic devices, textile devices require power, demanding the development of flexible, comfortable, and wearable energy storage devices. To date, one particular gap inhibiting the development of such devices is the production of robust functional fibers with improved electronic conductivity, electrochemical energy storage capability and other functionalities [1]. MXenes, two-dimensional (2D) materials discovered at Drexel in 2011, are a promising candidate for this application due to their high electrical conductivity, plasmonic properties, low infrared emission and excellent energy storage performance [2,3]. Moreover, unlike most 2D materials, MXenes can be dispersed in water and used as a dye to coat fibers and yarns, similar to the process of coloring conventional fibers in the textile industry. In this work, we review the recent exciting developments in our diverse efforts to fabricate MXene functionalized fibers, along with a critical evaluation of the challenges in processing, which directly affect macroscale material properties and the performance of the subsequent prototype devices. We also provide our assessment of observed and foreseen challenges of the current manufacturing methods and the opportunities arising from recent advances in the development of MXene fibers and paving future avenues for textile design and practical use in advanced applications. We developed a simple and efficient method to produce meters of energy storing yarns by coating natural and synthetic yarns with MXene. These yarns are highly conductive, flexible, and knittable on industrial knitting machines. MXene-coated yarns and fabrics were manufactured into various designs of textile energy storage devices. Using the processes employed in this work, automated yarn coating and industrial knitting, textile energy storage devices can be rapidly designed, programmed, prototyped, and ultimately, mass-produced. These devices could one day be integrated into garments capable of monitoring body movements, sensing touch, and communicating with cellphones and computers.

Polyaniline Nanofibers: From Laboratory Curiosity to Commercial Product

Richard Kaner
UC Los Angles

Polyaniline is a conjugated polymer that is well known for its electrical conductivity and wealth of diverse properties. Polyaniline can be made into a nanofibrillar form using interfacial polymerization or through the rapid mixing of monomer, oxidant and acid. These methods are both template-free and readily scalable, leading to stable colloids and increased processability. Nanofiber formation is due to the suppression of secondary growth, which with conventional polyaniline synthesis methods leads to aggregation of polymer chains. The novel polyaniline nanofibers provide much higher surface area compared to conventional polyaniline, benefiting gas sensors with fast response times and high sensitivity. Metal nanoparticle-decorated polyaniline nanofibers can be used as catalysts, e.g. in Suzuki coupling, and in non-volatile memory devices. The high absorption of light and fast light-to-thermal conversion rate of polyaniline nanofibers causes the nanofibers to melt upon exposure to a camera flash. This photo-welding technique can be used to pattern electrodes for use in sensors. It can also be used to produce asymmetric membranes that can act as reversible mechanical actuators when exposed to acids and bases. Tetra-aniline, the basic building block of polyaniline, can be used to understand what limits conductivity in polyaniline. Nanostructured polyaniline, when blended with conventional polymers, can also be used for membrane filtration applications especially separating oil from water to clean up the mess created by oil fracking.

Bio-based Sustainable Structural Materials

Shu-Hong Yu
University of Science and Technology of China

Biominerals are well-known composites of inorganic and organic materials in the form of fascinating shapes and high ordered structures, which exist in Nature, for example, pearl, oyster shells, corals, ivory, sea urchin spines, cuttlefish bone, limpet teeth, magnetic crystals in bacteria, and human bones, created by living organisms. During the past few decades, it has been one of the hottest research subjects in materials chemistry and its cutting-edge fields to explore new bio-inspired strategies for the generation of materials with unique structural specialty and complexity. This lecture will present our recent advances on bio-inspired manufacturing of a family of bio-based structural materials with designed micro-/nano-scale structure and tunable surface chemistry and the macroscopic scale assemblies of the bio-based building blocks like cellulose nanofibers and other biomass particles with surface nanocrystallization. Especially, we will report our recent effort on how to realize the production of sustainable structural materials, such as synthetic nacre, cellulose nanofiber plates, nacre-inspired structural material, and regenerated isotropic wood. These sustainable bio-based structural materials prepared by bio-inspired manufacturing are emerging as a new material system, which holds the key to advance a global sustainability goal.

Carbonene based fiber: from controlled preparation to application

Jin Zhang
Peking University

Carbonene materials refer to the carbon nanomaterials constituted with sp2 hybridized carbon atoms arranged in a honeycomb lattice, mainly including carbon nanotubes (CNTs) and graphene. By the virtues of its astonishing intrinsic features, such as superior mechanical strength, great electronic conductivity, efficient thermal conductance and light-weight, carbonene materials demonstrate adorable potentials to serve as reinforcing component in hybrid fiber or directly assemble into intact mono-component fiber with adopting the primary characteristics of carbonene materials[1-3].

In this presentation, we will take CNTs/graphene reinforced aramid fiber and CNT fiber as instances to introduce our recent works on carbonene based fiber. Aramid fiber is a typical high-performance synthetic fiber, in which polyamide long-chain dominant linkages endows its superior mechanical strength and tensile modulus even than steel and glass fiber. Especially for heterocyclic aramid fiber (namely aramid III), the heterocyclic monomer containing in the aliphatic carbon backbone chain bring about the best mechanical strength among mass-productive aramid fibers, which even exceed the property of T700 carbon fiber[4-6]. The high proportion of meta-oriented phenylene rings contains in aramid fiber further gives its great heat- and flame- resistant properties. Such fascinating characteristics brings aramid fiber a series of peculiar applications in armor protection, bulletproof helmet and aerospace/military equipment. However, the prevailing commercialized aramid fibers, such as Nomex, Kevlar, Twaron and Technora etc. are mainly monopolized by a minority of leading companies, such as Dupont and Teijin. Although China has realized the industrialization of aramid III fiber production at the beginning of 21st century, there is still a series of challenges, such as the maximum tensile strength, large-scale production stability, waiting for addressing the issue of China's severe dependence on the imported aramid fiber[7-9]. Herein, we prepared CNTs and graphene reinforced aramid III hybrid fibers via in situ polymerization. With the combination of ball milling and ultrasonication, carbonene/aromatic polyamide precursor could form into a uniform and quite stable wet-spinning dispersion. With the π-π interaction between the hexatomic ring of carbonene and aromatic structure, carbonene material facilitate the crystallization and oriented arrangement of the polymeric chains. After the treatment of multi-state heat-drafting and fine-denier process, the resultant carbonene reinforced fiber exhibits remarkably mechanical strength and dynamic modulus promotion.

CNT fiber, a macroscopic assembly of aligned CNT bundles along the fiber axis, has attracted extensive attention according to its unique association of lightweight, extraordinary mechanical strength, excellent conductivity, and outstanding flexibility. Floating catalytic chemical vapor deposition (FCCVD) has been demonstrated as a fascinating strategy to produce high-performance CNT fiber. This is ultimately beneficial from high quality CNT bundle produced via in situ CVD growth and continuous postprocessing, including multi-stage drafting and chlorosulfonic acid rinsing. We systematically studied the synergistic relationship between the regular alignment and CNT bundle length during the CVD synthesis with optimization of carbon precursor, impurities control. Thus-fabricated CNT fiber achieved a specific tensile strength is 3.1 N/tex (~ 3.5 GPa) without any post-treatment. After rinsing with chlorosulfonic acid and other densification treatment, the mechanical strength promoted to 7.7 GPa, with a remarkable electrical conductivity of 2×106 S/m. Simultaneously, other reinforcing

components, such as aramid III polymeric additives and small size graphene have been separately introduced to prepare hybrid CNT fiber to further eliminate voids or tiny interspace with forming enhanced interfacial architecture between CNT bundles. With the preliminary studies in carbonene based hybrid and mono-component fibers, we have also explored their applications in some specific peculiar applications for serving as reinforcing components in mechanical structural materials.

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Solution Process Protocols: Impact on Conjugated Polymer Device Performance

Elsa Reichmanis
Lehigh University

Organic/polymer semiconductors offer opportunities for low-cost device fabrication for applications ranging from energy to health care to security. However, their successful commercialization relies not only on the design and development of sustainable, robust and reliable materials chemistries, but also the solution-based processes used for printing devices and circuits. Molecular design coupled with solution behavior play a significant role in determining a materials thin-film electronic performance. In the search for high performance charge transport materials, molecular structure is a prime consideration, where that structure must be amenable to assembly and organization into nano- through meso-scale architectures that support transport. Here, the relationships between molecular structure and solution processing protocols that provide for the requisite charge transport pathways will be explored.

Artificial Sense Technology

Xiaodong Chen
Nanyang Technological University

Artificial senses refer to the emulation of human's basic senses and assimilate them to functional devices and systems to help us understand and perceive the world around us. This research topic of artificial senses is transdisciplinary and lies at the confluence of materials science, bioengineering, medical sciences, electrical engineering, and computer science. Some use cases, including enhanced sensory capabilities to overcome physical human limitations, improved robotic capabilities and diagnostics with smart information processing, and prosthetics and health-monitoring devices to improve quality of life, are drawing much attention. In this talk, I will present some latest progress in artificial tactile and olfaction with the viewpoint from materials development, sensor fabrication, information processing, and system integration. Artificial senses would be a new enabling technology to construct next-generation intelligent devices and systems, paving the way for advanced soft robotic applications, rehabilitation, prosthetics, and so on.

Skin-Inspired Organic Electronics

Zhenan Bao
Stanford University

Skin is the body's largest organ, and is responsible for the transduction of a vast amount of information. This conformable, stretchable, self-healable and biodegradable material simultaneously collects signals from external stimuli that translate into information such as pressure, pain, and temperature. The development of electronic materials, inspired by the complexity of this organ is a tremendous, unrealized materials challenge. However, the advent of organic-based electronic materials may offer a potential solution to this longstanding problem. Over the past decade, we have developed materials design concepts to add skin-like functions to organic electronic materials without compromising their electronic properties. These new materials and new devices enabled arrange of new applications in medical devices, robotics and wearable electronics. In this talk, I will discuss basic material design concepts for realizing stretchable, self-healable and biodegradable conductive or semiconductive materials. I will show our methods for scalable fabrication of stretchable electronic circuit blocks. Finally, I will show a few examples of applications we are pursuing uniquely enabled by skin-like organic electronics when interfacing with biological systems, such as low-voltage electrical stimulation, high-resolution large area electrophysiology, "morphing electronics" that grows with biological system and genetically targeted chemical assembly - GTCA.

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High performance fiber composite materials

Muhuo Yu
Donghua University

Lightweight and high strength are the eternal pursuit of materials science and an important foundation for human development. High performance fiber composite materials are typical representatives of lightweight and high-strength materials, which have been widely used in aerospace, weapon equipment, transportation and other fields, their large-scale application in manufacturing is conducive to improve the technological level of manufacturing.

This report will present our team's more than 20 years of research work on high-performance fiber composites, including matrix resin toughening, surface and interface construction methods and reliable connections. Finally, taking the hollow fiber tube capsule for minimally invasive interventional medical treatment as an example, the large-scale manufacturing and application technology of fiber-reinforced thermoplastic composite products are introduced.

Luminescence Materials: The Path to Applied Imaging and Assistive Technologies

Xiaogang Liu
National University of Singapore

Lanthanide-doped nanoparticles exhibit unique luminescent properties, including a massive Stokes shift, a sharp bandwidth of emission, high resistance to optical blinking, and photobleaching. Uniquely, they can also convert long-wavelength stimulation into short-wavelength emission. These attributes offer the opportunity to develop alternative luminescent labels to organic fluorophores and quantum dots. In recent years, researchers have demonstrated the use of spectral-conversion nanocrystals for many biological applications, such as highly sensitive molecular detection and autofluorescence-free cell imaging. With significant progress made over the past decade, we can now design and fabricate nanoparticles that display tailorable optical properties. In particular, we can generate a wealth of color output under single-wavelength excitation by rational control of different combinations of dopants and dopant concentration. By incorporating a set of lanthanide ions at defined concentrations into different layers of a core-shell structure, we have expanded the emission spectra of the particles to cover almost the entire visible region, which is unavailable to conventional bulk phosphors. In this talk, I will highlight recent advances in the broad utility of lanthanide-based nanocrystals for multimodal imaging, bio-detection, therapy, display, X-ray scintillation and nanophotonics.

Advances in Nanostructured Functional Fibers: Antiviral Filtration, Chemical Sensor, and Energy Applications

Il-Doo Kim
KAIST,Korea

Electrospinning has been recognized as one of the most efficient techniques for producing non-woven fiber webs in the order of several hundreds of nanometers by electrically charging a suspended droplet of polymer solution with/without inorganic precursors or melt. Various types of materials with a high degree of porosity, a large surface area, superior mechanical properties, and modified surface functionalities, can be electrospun into nanofibrous structures. In particular, Microstructural tailoring and compositional tuning enable the intriguing materials innovations and structural evolutions, which can induce high performances in broad applications. In this talk, I will explain the fundamental operation mechanism of electrospinning as well as recent progress and a collection of advances, particularly focused on the synthesis, characterization, and utilization of electrospun functional nanofibers. These materials include functional polymer membranes for antiviral filter applications, porous metal oxides for chemiresistive sensors, and high conducting carbon nanofibers as current collectors for Li-air batteries etc. As a new processing platform, I would like to emphasize a nanofiber yarn synthetic technique, which produces high density nanofiber yarn. Metal-oxide coated yarn and dye-loaded yarn exhibit outstanding gas sensing properties with high response and superior selectivity. The detailed presentation contents include: 1. Understanding on processing parameters in electrospinning and antiviral filter applicaitons 2. Rational designing of microstructures and morphologies of metal oxide nanofibers 3. Effective anchoring of catalytic nanoparticles onto nanofibers for selective sensing 4. Nanofiber platform for highly efficient colorimetric gas sensing 5. Recent advances in energy storage devices using electrospun nanofibers

I will end my presentation by suggesting future research direction and potential suitability of 3D nanofibers for energy application and 1D high density yarn for applications in outstanding colorimetric sensors, exhaled breath gas analyzing sensors for early stage disease diagnosis.

3D Printing of Continuous Fibre Composites – Issues and Challenges

Lin Ye
The University of Sydney

This lecture will discuss some issues, challenges and opportunities in 3D printing of composites using a FFF (fused filament fabrication) process, addressing fusion bonding between filaments, void formation, topological optimisation and design of fibre placement path etc. It will also articulate some methods and algorithms adopted in processes of characterisations and design.

From Data to Knowledge – Materials/Mechanics Informatics

Tongyi Zhang
Shanghai University

This presentation briefly introduces the concept of data driven discovery of formulas and materials/mechanics informatics, which is growing extremely fast by integrating artificial intelligence and machine learning with materials/mechanics science and engineering, where techniques, tools, and theories drawn from the emerging fields such as data science, internet, computer science and engineering, and digital technologies, are applied to the materials/mechanics science and engineering to accelerate materials/mechanics, products and manufacturing innovations. Discovering knowledge from data is a quantum jump from quantity to quality, which is the characteristic and the spirit of the development of science. The development of Natural Science is the continuous and endless progress that human being observes nature behaviors, develop learning models, and then gain knowledges. Integrating domain knowledge with machine learning is the key and a crucial approach, which allows gaining knowledge from data quickly, accurately, and scientifically.

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INVITED LECTURE

A biomimetic basalt fiber/epoxy helical composite spring with hierarchical triple-helix structures and superior mechanical properties inspired by the collagen fibers in compact bone

Qigang Han、Mingdi Shi、Yanbiao Sun、Bo Li、Zhiwu Han
Jilin University

The lightweight property of helical composite spring (HCS) applied in automotive field has attracted more and more attention recently. However, it is hardly to simultaneously maintain the stiffness, fatigue and compression properties. Here, a biomimetic basalt fiber/epoxy helical composite spring with hierarchical triple-helix structures was intelligently designed and manufactured based on basalt fiber, epoxy and nano-silica (NS), which was inspired by the collagen fibers in compact bone. In particular, the effect of nano-silica (NS) content on the stiffness and fatigue performance of HCS was investigated. It was found that the stiffness and fatigue performance of HCS with 0.4 wt% NS was 52.1% and 43.5% higher than those of the HCS without NS. Moreover, the epoxy resin matrix of the modified HCS possessed excellent interface adhesion with basalt fiber. On this basis, bionics was introduced into HCS modified by 0.4 wt% NS o develop a novel bone-inspired HCS with multifunction. The biomimetic structures include two braided fiber bundles (TS-BFB) and four braided fiber bundles (FS-BFB). The experimental and simulation results showed that the biomimetic hierarchical triple-helix structures greatly improved the stiffness and compression performance of HCS compared with the traditional unidirectional fiber bundle (U-FB). This work provides an effective method to improve the mechanical properties and extended the applications of HCS.

INVITED LECTURE

Construction of MoX2 (X=S, Se) @hollow multi-nanochannel carbon nanofibers composites as flexible high-performance anodes for lithium-ion batteries

Anqi Ju
Donghua Univeristy

The ultrathin layer of MoSe2 nanosheets were grown on three various structures of flexible carbon nanofibers by simple solvothermal method, and three kinds of flexible electrode materials (NCFs/MoSe2, NMCFs/MoSe2 and NHMCFs/MoSe2) were obtained. The NHMCFs/MoSe2 with hollow multi-nanochannel structure could effectively alleviate the volume expansion of MoSe2 during charging/discharging process, and the hollow multi-nanochannel structure in NHMCFs was beneficial to the penetration of electrolyte and rapid diffusion of Li+, which enhances the rate performance of NHMCFs/MoSe2 flexible electrode. Both the inner and outer surfaces of NHMCFs are uniformly coated by MoSe2 nanosheets, thus the mass loading of MoSe2 in NHMCFs/MoSe2 increased 21.25% and 13.85% compared with NCFs/MoSe2 and NMCFs/MoSe2 electrode, respectively. And the NHMCFs/MoSe2 delivers the highest capacity of 586.7 mA h/g among three electrodes after 400 cycles at 1 A/g, which is 3.54 times of NCFs/MoSe2 and 2.49 times of NMCFs/MoSe2. Based on the structural stability of the NHMCFs matrix, we fabricated MoS2 nanoflowers with ultra-large interlayer spacing on NHMCFs (MoS2/NHMCFs), the surfactant (PVP) was used to expand the interlayer spacing of MoS2, which is between 0.78 and 1.11 nm. The expanded interlayer spacing of MoS2 nanoflowers can reduce the energy barrier of lithiation/delithiation of MoS2, and accelerate the diffusion rate of Li+ during the charging/discharging process. The MoS2/NHMCFs electrodes delivered a high-rate capability 832 mA h/g at 10 A/g and ultralong cycling stability with 99.29 and 91.60 % capacity retention at 10 A/g after 1000 and 2000 cycles, respectively, further confirming that NHMCFs is a promising electrode substrate for LIBs.

INVITED LECTURE

Nearly stoichiometric polycrystalline SiC fibers with thermal stability up to 1900℃

Yanzi Gou
Science and Technology on Advanced Ceramic Fibers and Composites Laboratory, National University of Defense Technology

With high tensile strength, remarkable thermal stability and excellent oxidation resistance, continuous silicon carbide (SiC) fibers are of strategic significance as one of the most promising reinforcements in the fields of aviation, aerospace and nuclear industry. In this work, nearly stoichiometric polycrystalline SiC fiber was fabricated from polyaluminocarbosilane (PACS), which was synthesized by the reaction between low-softening-point polycarbosilane (LPCS) and aluminum(III) acetylacetonate. The PACS precursor was firstly melt-spinned or electro-spinned, followed by curing under air, pyrolysis at 1300℃ under nitrogen and sintering above 1800℃ under argon. The SiC fiber was composed of SiC grains of twins and stacking-faults with grain sizes of around 200 nm, exhibiting transcrystalline fracture behavior. Besides elemental composition and microstructure, the thermal stability, oxidation resistance and creep resistance of the fiber were also investigated.

INVITED LECTURE

Understanding the Mechanical Behaviors of Macroscopic Carbon Nanotube and Graphene Assemblies Using a Multi-Scale Model

Enlai Gao
Wuhan University

We comparatively assess the state of the art advances in high-strength carbon nanotube fibers and graphene films over the past decades. First, experimental achievements of fabrication-structure-performance are reviewed, and a few critical issues that have been ignored in previous studies are proposed. Then, the theoretical models based on the shear-lag theory and beyond the shear-lag theory regarding the strength and microstructures of nanocarbon-based engineering materials are elaborated. It is found out that obstacles - assembling nanocarbon building blocks into macroscopic architectures and tailoring their interface interaction, alignment, density for transferring the atomistic mechanical features into macroscopic dimensions of engineering materials - still remain a long-term challenge. Finally, perspectives were proposed to offer insights on how to construct high-strength carbon nanotube fibers and graphene films in the future through the optimization from the fabrication of nanocarbon building blocks to the assembly of them into macroscopic materials.

INVITED LECTURE

Ion-injection-driven carbon nanotube yarn muscle

Jiangtao Di
Suzhou Institute of Nano-Tech and Nano-Bionics, CAS

In recent years, biomimetic muscle yarn has emerged as a new type of intelligent material and attracted considerable attention. It can output tens of times the energy/power density of biological muscles and has important application prospects in many aspects, such as life and health, bionic robots, variable-sweep wing aircraft, and so on. Carbon nanotube (CNT) yarns integrate such properties as high mechanical strength, extraordinary structural flexibility, high thermal and electrical conductivities, novel corrosion and oxidation resistivities, and high surface area, which makes them a very promising candidate for artificial muscles. In this report, I will introduce our recent research progress in artificial muscle yarns, focusing on CNT yarns driven at low voltages (< 5V). Through the construction of a high-twist-pervaded structure, the effective driving volume of the yarn was greatly improved, and the yarn produced a large reversible contraction of 62.4% under high load (10000 times the mass of the yarn muscle) and low driving voltages (<5 V). Importantly, the yarn muscle also demonstrates long-term stability and an important feature of linear dependence of the contractile stroke on the driving voltage. Furthermore, a solid CNT artificial muscle yarn based on an ionic liquid system was constructed, which could output a large driving force and retain stable contractions in a wide range of humidity and temperature. On this basis, we found that the piezoelectric effect can be observed on an electrolyte-coated high-surface-area CNT yarn muscle, generating large lengthwise voltage gradients without the assistance of an external electrical bias when the yarn was stretched. Between the two ends of the yarn muscle, sensitive and high-recognition voltage signals with ultralow noise are generated, when the yarn is subjected to mechanical stretching at a wide range of strains and frequencies. Because of features such as a simple structure, easy fabrication, high flexibility and stretchability, and a wide range of responses, this type of yarn is promising for smart textiles, wearable sensing devices, and implantable artificial muscle feedbacks.

INVITED LECTURE

Graphene fibers and multi-functional graphene composite fiber

Chao Gao
Zhejiang University

Graphene has been assigned to a new constructing block for high-performance multifunctional materials, because of its superior mechanical, electrical and thermal properties. However, due to the poor dispersibility of graphene in water or other polar solvents, and impossible melting process, it is hard to process graphene in industrial applications. We have synthesized pure graphene fibers through the reduction of graphene oxides (GO) liquid crystals (LCs). The obtained lightweight graphene fibers show high strength and high modulus, as well as high thermal conductivity and high electrical conductivity. This achievement has open a new approach to structural integrated functional carbon-based fibers from natural graphite. We have also developed an in-situ stretching polymerization method on pleated micro powder, achieving uniform dispersion of graphene in polymer substrates. Our team has developed core technologies such as high-efficiency dispersion, in-situ polymerization and fine-denier spinning of graphene with polyester and nylon fibers, and achieved pilot production of multifunctional composite fibers, which are assigned as internationally leading technologies of graphene. Luckily, we have also obtained the first certification of single-layer graphene oxide and multi-functional graphene composite fiber from the International Graphene Product Certification Center (IGCC).

INVITED LECTURE

Interfacial interactions between silk fibre and polycaprolactone and exploration of 3D silk structure construction

Juan Guan[1,2]、Ruya Shi[1]、Ke Ma[1]
1. Beihang University
2. Advanced Innovation Center for Biomedical Engineering

Natural silks spun by silkworms are unique protein fibres, stretching a length of over 1000 meters. Although silkworms master the cocoon construction with ease, it remains a challenge to construct a 3D silk structure with tailor design without using these caterpillars. We propose to use polycaprolactone (PCL) as the binder for the construction of 3D silk structure. PCL is recognized as a fully absorbable and biocompatible medical polymer, suitable for a variety of tissue engineering applications. Nevertheless, the interfacial interactions between silk fibres and PCL are unclear.

The surface characteristics of B. mori and A. pernyi silk fibres, the chemical and physical properties of PCL melt, as well as the interfacial contact and adherence between silk and PCL are studied using techniques including atomic force microscopy, inverse gas chromatography, rheometer and etc. The results indicate the interfacial bonding between silk and PCL can be modified and optimized, i.e. through the use of a sizing agent and the control of melt temperature. Based on the understanding at the molecular level, we successfully build a bowl structure from silk and PCL using the fused melt deposition (FDM) technique. The technique for 3D silk structure construction will be further explored to engineer mini-sized implants with high resolution and shape fidelity. The research would enrich the material solutions for modern tissue engineering.

Laser-induced superhigh-temperature graphitization of carbon fibers

Zhenghe Zhang[1]、Weimin Yang[1,2]、Lisheng Cheng[1,2]、Jing Tan[1,2]
1. Beijing University of Chemical Technology
2. State Key Laboratory of Organic-Inorganic Composites

Graphite fibers are materials with a high specific modulus that have attracted much interest in the aerospace industry, but their high manufacturing cost and low yield are still problems that prevent their wide applications in practice. This work presents a laser-induced process for the graphitization of carbon fibers and explores the effect of laser irradiation on the microstructure of carbon fibers. Superhigh-temperatures over 3000 °C can be achieved instantaneously with the laser irradiation applied on the carbon fiber. The laser irradiation profoundly increased the graphitization degree of the carbon fiber and dramatically decreased the interlayer spacing of the graphite microcrystal in the fiber. Both chemical and crystal characterizations reveal an enhanced order of the graphite-like structure in the fiber. The modulus of the graphitized PAN-based fiber was as high as 421 GPa. Meanwhile, after laser irradiation the pitch-based carbon fiber, an electrical conductivity as low as 7.04×105 $S \cdot m^{-1}$ was recorded with the fiber, which is closely approaching the lowest conductivity ever publicly reported (Thornel K1100 MPCF). This investigation shows that laser induced graphitization is a promising approach to reduce carbon fiber cost, produce carbon fibers with multifunctional properties and expand the market of carbon fibers for electronic devices and energy applications.

Industrial application development of 1 million to 10 million ultra-high molecular weight polyethylene

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Ultra-high molecular weight polyethylene (UHMWPE) is an engineering plastic with excellent physical and mechanical properties. A combined theoretical and experimental study is performed on mechanisms of ethylene polymerization initiated by novel supported Ziegler-Natta catalyst. Ligands and electron donors were containing N adjust the electron and steric effects around Ti atoms, thereby adjusting the ethylene, comonomers, and hydrogen reaction ratio. The addition of the F strong electron-withdrawing group to the complex makes the active center of the catalyst more stable, and the β-H elimination reaction is more difficult to occur. Effectively promote the polymerization of ethylene, and combine advanced polymerization technology to efficiently synthesize ultra-high molecular weight polyethylene with a molecular weight of 1 million to 10 million. To fully understand this mechanism, structures of β-agnostic complex and direct insertion of alkyl olefin complex are calculated energetically by DFT. Remarkably, the electron-withdrawing complex is more inclined to linear chain growth, and the electron-rich group is inclined to branch formation promoted by the β-H elimination.

Preparation, performance and application of high-content carbon nanotube/polymer composites

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Carbon nanotubes are considered ideal fillers for the preparation of high-performance polymer composites due to their high long diameter ratio, lightweight, etc. one-dimensional nanostructures and excellent performance. However, it is difficult to achieve good dispersion of high-content carbon nanotubes due to the traditional composite molding process, so it is difficult to maximize the effect of carbon nanotube enhancement. Among them, by prefabricating a self-supporting macro carbon nanotube network structure, Buckypaper, and then seeping into the polymer, can prepare well-dispersed high-content carbon nanotube/polymer composite materials. However, there is still room for improvement in composite processes, interface compatibility and application.

Based on this, we mainly study that by means of microwave irradiation, the interface force between Buckypaper and PE is improved, and the buckypaper/PE composite material after microwave irradiation is increased by 60% and 100% respectively compared to the untreated tensile strength and modulus, which shows the effectiveness of microwave radiation treatment. A composite molding process was improved by spraying buckypaper surfaces with PE powder, improving PE impregnation in Buckypaper, and the tensile strength of the prepared composite material (30% Buckypaper) was increased by 134% compared to the membrane thermal pressure method.

In terms of application, Buckypaper was deposited in situ onto the surface of carbon fiber cloth to prepare carbon fiber/epoxy composite material, and the conductivity in the direction of interlayer shear strength and thickness was 68.6% and 6080% higher than that of pure carbon fiber/epoxy resin, which shows that Buckypaper has a good enhanced effect on the preparation of polymer composite materials.

The preparation of a new 3D printing materials with cotton

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3D printing technology has been developed rapidly because of its advantages such as short process, low cost, flexibility and so on. Cotton fiber is an important raw material in the textile industry, and the products of it are loved by people because the good moisture absorption and air permeability with them. In order to apply cotton fiber to 3D printing and further expand the application field of 3D printing materials, a composite solution system was prepared by using cotton fiber powder and carboxymethyl chitosan. The optimum preparation process of cotton composite solution system as follows which was determined by single factor analysis: the main length of cotton staple fiber was 3mm, the concentration of cotton staple fiber was 6g/L, the concentration of carboxymethyl chitosan solution was 15g/L, and the temperature was 30℃. The preparation of the composite solution system provides a certain prerequisite for the application of cotton in 3D printing. In 3D printing, the composite solution system containing cotton can be compounded with high temperature melted materials to prepare 3D printing composite materials.

Synthesis of Syndiotacticity-rich, High Polymerization Degree PVA Polymers with VAc and VBz, Properties of PVA Fibers with High-Strength, High-Modulus by Wet Spinning

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To overcome this difficulty of limited strength and modulus of PVA fibers fabricated with low polymerization degree (DP) and low syndiotacticity diad content (S-diad) polymers, vinyl benzoate (VBz) has been chosen to synthesis of PVA polymers via non-emulsifier emulsion polymerization. Distinguished from the previous studies, the monomers of vinyl acetate/vinyl benzoate (VAc/VBz, n/n=100/0, 90/10, 80/20,70/30 and 60/40) were used to successfully synthesis of PVA polymers with high DP and high S-diad. In order to further evaluate the effects of VBz content on PVA polymers, there are characterization methods employed as follows: fourier-transform infrared spectroscopy (FTIR), Proton nuclear magnetic resonance (1H-NMR), Gel Permeation Chromatography (GPC) and Ubbelohde viscometer. The results showed that VBz could significantly influence in the DP and S-diad of PVA polymers. In addition, a series of PVA fibers have been fabricated using the synthesized polymers by wet spinning method, the mechanical and thermal properties have been investigated by tensile tester, X-ray diffraction (XRD), differential scanning calorimetry (DSC), thermogravimetric analyzer (TGA) and scanning electron microscope (SEM), and found that there is a substantial increase in strength and modulus with the increase of DP and S-diad. Meanwhile, high DP and S-diad of PVA polymers had an opposite effect on the spinnability.

Exploration and Characterization of Modified PAM Electrospinning Process

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A porous and hydrophilic nanofiber membrane was prepared with polyacrylamide(PAM) and sodium alginate(SA) according to the method of electrospinning. Fourier transform infrared spectra, thermogravimetric analysis and differential scanning calorimetry were employed to characterize the PAM/SA composite nanofiber membrane, indicating that the PAM/SA membrane was successfully prepared and it displayed superior thermodynamic properties. Optimal spinning conditions were explored through single factor experimental design. The effect of experimental concentration, voltage and pushing speed on the diameter and surface morphology of nanofibers was explored through single factor experiments, and the optimal process conditions were screened out. The PAM/SA nanofibers with average diameter of 95 nm can be observed on scanning electron microscopy when the spinning voltage was 14 kV, the refraction pump pushing speed was 0.5 mL/h and the polyacrylamide concentration was 4%. Furthermore, it could be found that the fiber diameter decreases with the decrease of the spinning voltage and the speed of the propelling solution. Most importantly, the water contact angle test found that the hydrophilicity of the nanofiber membrane was extremely good, and the water contact angle was as low as 42°. The nanofiber membrane displays great potential application value in humidity sensor, moisture conduction, dehumidification, etc.

Synthesis of graphene/carbon nanotube fiber via direct spinning

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Carbon nanotube fiber (CNTF) is expected to be developed as the next generation of high-strength and multifunctional carbon-based fiber materials to replace commercial carbon fiber, due to its light weight, good mechanical properties (strength, toughness, flexibility, and so on) and high electrical conductivity. However, several significant questions still prevent the realization of CNTF strength close to the theoretical value (~60 GPa), such as low orientation, loose accumulation and weak interface adhesion of the internal CNT bundles. Herein, high strength graphene/CNT composite fiber was prepared by introducing oxide graphene (GO) into traditional C/Fe/S-based precursor during floating catalytic chemical vapor deposition (FCCVD). The graphene oxide was reduced at high temperature and meanwhile bonded closely with the in-situ grown CNT bundles. Then, graphene and CNT aerogel was formed and densed to produce the original composite fiber. The study found that the graphene wrapped around the CNT bundles and filled the micron-sized gaps between, resulting in a denser fibrous structure. The tensile strength of the original graphene/carbon nanotube composite fiber was over 3 GPa, which was nearly twice that of pure CNTF. After post-treatment (continuous drawing in chlorosulfonic acid), the strength of the composite fiber was up to ~6 GPa and the conductivity was as high as ~4 × 10^6 S m^{-1}, indicating the possibility of expanding its prospect as a structure-function integrated material.

Pseudo-ductility analysis of unidirectional carbon/glass hybrid UACS laminates based on thin carbon fiber prepreg

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Due to series of advantages such as high strength, low density and large specific modulus, fiber reinforced composite has been widely used in fields of aerospace, rail transportation and wind power generation etc. However, like most engineering materials, fiber reinforced composites have the problem of mutually exclusive strength and toughness. Because of the inherent brittleness and the difficult in predicting the damage of carbon fiber reinforced polymer (CFRP), CFRP components usually need a large safety margin during design, which fails to take full advantages of the mechanical properties of CFRP. In contrast, the failure strain of glass fiber reinforced polymer (GFRP) is larger than CFRP, and obvious failure characteristics can be observed. In this paper, the damage progression in laminates made by unidirectionally arrayed chopped strands (UACS) with vertical slit distribution patterns under tension is simulated. Vertical slits were introduced into the carbon fiber prepreg, then, the unidirectional carbon fiber prepregs and glass fiber prepregs were stacked together by a certain sequence to make interlaminar hybrid laminates, to produce the hybrid effects and the final failure warning. The numerical analysis results indicate that the hybrid laminates show the pseudo-ductility and the warning before the final failure. The thickness ratio of carbon/glass plies and the absolute thickness of carbon plies both have significant influence on the nonlinear behavior of the hybrid material.

Electrothermally driven twisted artificial muscles with large tensile strain and actuation stress

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Carbon nanotubes have attracted much attention in design of twisted artificial muscles due to their excellent physical and chemical properties. Heterocyclic aramid III fiber, that is, para-heterocyclic aromatic polyamide fiber with outstanding integrated performances including good chemical stability and heat resistance, high modulus and strength as well as low specific density, is an irreplaceable key material in the fields of aerospace, bulletproof protection and other fields, and has an important impact on national defense, military industry and national economy development. Here, an electrothermal driven artificial muscles with large tensile strain (15%) and actuation stress (more than 180 MPa) was prepared by twisting and coiling a group of carbon nanotube (CNT) yarns and heterocyclic aramid III fiber. Carbon nanotubes conduct electricity and produce Joule heat, which changes the temperature of the yarn muscle fibers, resulting in untwisting and tensile contractions. Interestingly, the actuation performance of yarn muscles can be adjusted by changing the crystallinity of heterocyclic aramid III fibers, which provides a way to explore its actuation mechanism.

ORAL PRESENTATION

Effect of the crystalline structure of cotton cellulose on the photocatalytic activities of cotton fibers immobilized with TiO2 nanoparticles

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The amount of photocatalysts loaded on the supporting materials and their bonding configuration by physical or chemical mode have great effects on the photocatalytic properties and stabilities of the photocatalytic composites in practical application. However, the influence of the crystal structure of supports on the photocatalytic activities of the resultant photocatalysts has rarely been studied till now. Herein, four polymorph cotton fibers (cellulose I, II, III and IV) were utilized as the support to load anatase TiO2 nanoparticles by a hydrothermal method. The structural changes of cotton fibers before and after TiO2 modification were characterized by scanning electron microscopy (SEM), transmission electron microscopy (TEM), X-ray diffraction spectroscopy (XRD), thermal gravimetric (TG), X-ray photoelectron spectroscopy (XPS), UV–Vis diffuse reflectance spectroscopy (DRS) and photoluminescence spectroscopy (PL). Their photocatalytic properties were examined by the photodegradation of Congo red (CR) dye under visible light illumination. Experiment results indicated that the crystalline structure of cotton cellulose affected the loading dosage of anatase TiO2 nanoparticles on cotton fibers, leading to the differences in CR photodegradation rate over the TiO2 modified cotton fibers. Compared with the other three cotton cellulose fibers, the cellulose II fibers could load more TiO2 nanoparticles via the C-Ti3+/Ti4+, N-Ti3+/Ti4+ and O-Ti3+/O-Ti4+ bonds, which resulted in high photocatalytic activity for the photodegradation of CR. The first-principles approach of density functional theory (DFT) is used to study the density of state (DOS) of TiO2 modified cellulose I, II, and IVI cotton fibers. The results showed a substantial degree of large energy level change between conduction and valence band regions of C-T-II, illustrating promote the transport of electrons, which is consistent with the experimental work.

Numerical simulation of short fiber reinforced composite laminates based on discontinuous slits subjected to low velocity impact

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With the increasing use of composite materials in various fields, especially in the application of discontinuous fiber reinforced composite materials to satisfy structural complexity and fluidity, it is very important to understand its failure mechanism. Numerical simulation is an important method to evaluate non-visual damage of composite materials under low velocity impact. In this paper, a 3D finite element model of discontinuous carbon fiber laminates under low speed impact is established. The simulation model is based on the continuous shell element in ABAQUS, and the damage modes of fiber/matrix and notched filling resin in carbon fiber prepreg layer are simulated by using Hashin failure criterion and flexible damage criterion, respectively. In addition, the formation and propagation of interlayer damage are predicted by using cohesive interfacial element combined with the traction separation law. The simulation model of carbon fiber laminates was established in the same method, and the reliability of the simulation method was verified by comparing with the experimental data. The damage of discontinuous carbon fiber laminates under different impact energies at low speed was evaluated. The results show that the discontinuous carbon fiber laminates have high impact resistance property.

Graphene reinforced aramid fibers

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Meta-aramid fiber, namely poly-m-phenylene isophthalamide (PMIA) fiber, which owns excellent flame retardancy, high-temperature resistance, insulation, and chemical stability, is widely used in heat insulation fields such as fireproof materials and high-temperature protective fabrics. However, due to the lack of conjugation effect between the amide and benzene ring bonds in the molecular chain, and the low internal rotation energy, the PMIA fiber segment has good flexibility and low crystallinity, which limits their widespread applications in the high-strength protection field. Here, we demonstrate that the graphene additions can reduce the porosity in the PMIA fiber and enhance the mechanical property. Our study shows that 1 wt% graphene/PMIA composite fiber exhibits a 58% increase in strength and 91% enhancement in elongation at break compared to the original PMIA fiber. The WAXD and other tests have also clarified that the addition of graphene effectively promotes the microscopic arrangement and orientation of polymer chains to modify the microstructure.

Study on the preparation and properties of photocatalytic basalt fiber

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Basalt fiber (BF), a filament made from natural basalt rock, is a kind of aluminosilicate material mainly containing the oxides of Si, Al, Fe, Ca, Mg, and so on. BF possesses many superior properties, such as excellent mechanical properties, high resistance to the chemical, temperature and radiation attacks, outstanding electrical and sound insulation. In addition, it is widely known as the "green and environment-friendly high-performance fiber material in the 21st century". Normally for the production of BF, the chemical composition of raw materials should not exceed a certain range. In this study, BF was successfully prepared from basalt rock with high content of titanium and iron by adjusting the spinning process. In addition, the fiber was identified as an excellent photocatalyst to remove organic pollutants in water. The photocatalytic degradation ability of BF was verified by using methylene blue (MB), the degradation rate was as high as 98.06% in three hours under the simulated sunlight irradiation. It also presented excellent recycling stability with the photocatalytic efficiency remained above 85% even after five cycles. Inspiringly, the material exhibited wide absorption in the visible light and superior visible-light-driven photocatalytic activities compared with basalt rock and BF in the existing literatures. The photocatalytic performance of BF was attributed to the synergistic effects arising from the change in the form of titanium during basalt rock melting and spinning processes as well as the doping effect of iron and other metal ions. It can produce photogenerated electrons and holes under sunlight irradiation, and the generated photogenerated electrons and holes have strong chemical activity, which can be used to decompose the organic compound in water. The technique and findings established in this study also showed some potential applications of BF for environmental remediation and Uv-visible radiation protection.

Holey rGO/Heterocyclic Aramid Composite Fibers with Enhanced Mechanical Performance

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Heterocyclic aramid fibers (F-III) are considered to be high performance fibers with excellent thermal and mechanical properties, leading to advanced applications in the fields of military and aviation. However, the strength and modulus are far away from the theoretical predictions of F-III which results from structural defects of fibers and weak hydrogen-bond interaction between molecular chains. In order to reinforce the interaction force and load transferring between molecular chains of F-III, a well designed holey reduced graphene oxide (HrGO) was used as an reinforcement phase to prepare HrGO/F-III composite fibers with enhanced mechanical properties. The composite model in which polymer chains of F-III align through holes on HrGO sheets was established and proved by theoretical simulation and microscopic observation. The interaction between polymer chains is significant improved in HrGO/F-III composite fibers due to the unique composite structure, contributing to the enhancement of mechanical properties of composite fibers. Typically, the stress of HrGO/F-III composite fiber (with 0.075 wt% HrGO) is up to 5.81 GPa, which is 11.3% higher than that of pure F-III fiber (5.22 GPa). HrGO/F-III composite fibers exhibit outstanding dynamic mechanical performance, especially dynamic modulus of which is higher than 30% comparing with F-III fiber, making composite fiber show great potential application in high-frequency vibration scenario. The relationship between the microstructure and the mechanical properties of HrGO/F-III composite fibers were built here to look into the performance transfer from micro dimension of nanomaterials to macro dimension of composites.

Basalt fiber-supported MOF composites for gas adsorption and separation

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Basalt fiber (BF) is one of the high-performance fibers in China, apart from its high strength and modulus, it has been also known for its excellent thermal insulation, antioxidant and EMF protection, and its excellent adaptive ability to suit varied environments. The production of BFs is low-cost and environmentally friendly, which makes them promising candidate of new-generation high-performance fibers to meet the requirements of industrial development in China [1][2]. The metal-organic framework (MOFs) could provide well-defined porosity and versatile chemical environment, which makes them prominent in the field of gas adsorption separation, catalysis, and sensing. There are yet problems in the practical application of MOFs. For example, MOF crystals are inherently less mechanically stable, which may lead to pipeline congestion when they cracked, degenerated separation performance, and lower recovery rates, thus hindering the further application of MOFs.

This study fabricated morphology-controlled functional fiber composite BF@MOF under mild conditions. The synergetic effect of MOF crystal size and the ligand functional group on the gas adsorption and selectivity performance of BF@MOF were explored. The study found that the gas adsorption behavior of BF@MOF was relative to the structure and loading of MOF. Meanwhile, the mechanical properties of MOF modified basalt fibers were also enhanced, which would be beneficial in the application. This study provided a mild and simple method for the fabrication of BF@MOF composite, which combines the advantages of basalt fiber and imidazole MOF. The resultant composite was granted with porous structure, excellent mechanical properties, and processability. This facile engineering of MOF modified basalt fiber would open a new avenue for developing high-performance fiber composite in wide range of applications.

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Toward high filtration efficiency and ultra-low resistance: Electrostatically assisted air filtration by polydopamine coated PET coarse filter

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Airborne particulate matters (PM) pose serious health threats to the population, and efficient filtration devices are needed for indoor and vehicular environments. However, there is an intrinsic conflict between filtration efficiency, air resistance and service life. In this study, we designed a thin coating of polydopamine (PDA) on the polyethylene terephthalate (PET) coarse filter (pore size ~ 10^2 μm) through in situ dopamine polymerization. By applying the coated filters in a two-stage electrostatically assisted air (EAA) filtration device, we significantly pushed the efficiency – air resistance – filter life envelope. The 8 mm thick EAA PDA-140@PET filter had a high filtration efficiency of 99.48% for 0.3 μm particles, a low air resistance of 9.5 Pa at a filtration velocity of 0.4 m/s, and steady performance up to 30 days. Compared with the untreated bare PET filter, the penetration rate for 0.3 μm particles was lowered 20×. The coated PDA was of submicron thickness, 10^{-3}× the gap distance between filter fibers, so low air resistance of the coarse filter could be maintained. The filter showed steady high filtration efficiency (averaging 98.63%, 99.04%, and 99.83% for 0.3, 0.5 and 1 μm particles) and an acceptable increase of air resistance (9.5 to 17.4 Pa) in a 30-day long-term test. At the end of the 30-day test, the EAA PDA-200@PET filter held nearly as much particles as its own weight (93%), without significant degradation of the excellent filtration efficiency. The working mechanism of the EAA coarse filter was investigated, and the materials selection criteria were delineated.

THE ENVIRONMENTAL THERMAL AND HYGROTHERMAL AGING EFFECT ON THE MECHANICAL PROPERTIES OF THE RECYCLED PAPERBOARD UNSATURATED POLYESTER COMPOSITES.

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Reprocessing and reusing the resources is a recommendable method for environment preservation. Recycling paperboard is one of the most prospectus instances as it can highly conduce to eco-friendly energy saving, low consumption, and environmental protection. Moisture absorption -release behavior and related mechanical properties of cellulose fiber polymer composites are the potential concerns in their outdoor applications. The present work investigates the influence of the environmental hydrothermal fatigue effect with open-air moisture on the mechanical properties of three different types of recycled paperboard unsaturated polyester (UP) resin composites. The environmental hygro-thermal aging at 80°C (in water) was carried out up to 40 days of the specimens already experienced 100 days environmental thermal cycles of +58°C to -25 °C with open-air moisture. The severe environmental influence on notched and un-notched tensile strength, notch sensitivity, the modulus is delineated in this work. The low cycle fatigue (LCF) characteristics of the composites were presented by the stress-strain graphs. Fick's law discussed the potential changes in the microstructure due to the degradation caused by thermal aging and water uptaking. Post-hygrothermal water barrier properties were evaluated by contact angle measurement and work of adhesion analysis. The dynamic mechanical analysis, thermogravimetric analysis, FTIR, and microscopic observation were also accomplished to characterize the results.

Preparation and characterization of thermoplastic poly(vinyl alcohol) using imidazolium-based ionic liquids as plasticizers

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This work investigates the plasticizing effect of different ionic liquids (ILs), 1-butyl-3-methylimidazolium bromide (BMIMBr), 1-butyl-3-methylimidazolium tetrafluorob-orate ($BMIMBF_4$), and 1-butyl-3-methy-limidazolium trifluoromethanesulfonate (BMIMOTF) on poly (vinyl alcohol) (PVA). PVA/IL composites were manufactured successfully and investigated by differential scanning calorimetry (DSC), thermo gravimetric analysis (TGA), X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FT-IR), and melt flow indexer (MI). The results showed that ILs could promote hydrogen bonds with the hydroxyl groups of PVA and destroy effectively the hydrogen bonding between the hydroxyl moieties. Melt temperatures, crystallization temperature, and degree of crystallinity of BMIMBr-plasticized PVA composites were lower than that of $BMIMBF_4$ and BMIMOTF-plasticized PVA. Among these three ILs, BMIMBr had the best compatibility with PVA, and was the most suitable as an additive to promote thermal processing of PVA.

High-Strength Superstretchable Helical Bacterial Cellulose Fibers with a "Self-Fiber-Reinforced Structure"

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As a hydrogel membrane grown on the gas–liquid interface by bacterial culture that can be industrialized, bacterial cellulose (BC) cannot give full play to the advantages of its natural nanofibers. Conversion to the properties of nanofibers from high-performance to macrofibers represents a difficult material engineering challenge. Herein, we construct high-strength BC macrofibers with a "self-fiber-reinforced structure" using a dry-wet spinning method by adjusting the BC dissolution and concentration. The macrofiber with a tensile strength of 649 MPa and a strain of 17.2% can be obtained, which is one of the strongest and toughest cellulose fibers. In addition, the macrofiber can be fabricated to a superstretchable helical fiber without adding other elastomers or auxiliary materials. When the helical diameter is 1.6 mm, the ultimate stretch reaches 1240%. Meanwhile, cyclic tests show that the mechanical properties and morphology of the fiber remained stable after 100 times of 100% cyclic stretching. It is exciting that the helical fiber also owns outstanding knittability, washability, scalability, and dyeability. Furthermore, superstretchable functional helical BC fibers can be fabricated by embedding functional materials (carbon materials, conductive polymers, etc.) on BC or in the spinning dope, which can be made to wearable devices such as fiber solid-state supercapacitors. This work provides a scalable way for high-strength superstretchable and multifunctional fibers applied in wearable devices.

Tentative Confinement of Ionic Liquids in Nylon 6 Fibres: A Temporal Weakening of the Hydrogen Bonds for the Sake of Obtaining High Performance Properties

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A reversible confinement of ionic liquid (IL) among the amide segments has been carried out for the preparation of high-modulus and high-strength aliphatic semicrystalline nylon 6 fibres. In this research work, the suppression or the weakening of the hydrogen bonds during the conventional low-speed melt spinning process is followed by a hot-drawing stage and a subsequent IL extraction of the IL out of the 2% wt IL-confined fibres (by using pentahydrate sodium thiosulphate, $Na_2S_2O_3.5H_2O$, solution) and an immediate thermal stabilization process (under tension) for the improvement of the properties of the pristine nylon 6 fibres. The resulted crystal structural developments (improvements) of the IL-confined fibres are attributed to ultimate molecular orientations, which have contributed to the developments of the overall fibre properties. Here, the influences of the IL on the γ and the α crystal phases, the γ-α transitions, the morphological properties, and the tensile properties are investigated. The FTIR reported, experimentally, additional peaks at 1237 cm^{-1} for the γ crystal phase and at 1417 and 1476 cm^{-1} for the α crystal phase, in conformity with the theoretical (DFT) computations. The XRD demonstrated that the conventional low-speed melt spinning can successfully be used to prepare as-spun IL-confined fibres having highly improved properties. The so prepared as-spun IL-confined fibres are found to have a γ phase structure that has a small crystal size and high crystal perfections. Fortunately, the γ-to-α crystal phase transition for the IL-confined nylon 6 fibres can be acquired during the hot-drawing stage (stress-induced phase transformation). Furthermore, the IL extraction process followed by a thermal stabilization process, interestingly, has led to significant increases in both of the tensile strengths and the tensile moduli of the reverted nylon 6 fibres. The values that are found are 8.46 cN/dtex for the tensile strength and 39.09 cN/dtex for the tensile modulus. The structure-property relationships between the IL-confined and the reverted nylon 6 fibres have also been studied.

Continuous preparation of high-conductivity lignin-based carbon nanotube fibers

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Renewable resources derived from biomass are high-quality candidate materials to replace non-renewable petrochemical energy. Lignin is the most abundant natural aromatic renewable polymer, with a carbon content of more than 60%, and is a suitable carbon precursor for preparing carbon-based fiber materials. This article reports a strategy to synthesize carbon nanotube (CNT) fibers using lignin, which is achieved by floating catalytic chemical vapor deposition. Finally, a lignin-based carbon nanotube fiber with a tensile strength of 1.35 Gpa and an electrical conductivity of 6.28×10^5 S/m can be obtained, and continuous production of lignin-based carbon nanotube fibers can be achieved with a production rate of 2 m/min. This study shows that the method of preparing carbon nanotube fibers from renewable resource lignin has potential industrial production value.

In situ preparation of nitrogen doped carbon nanotube films for photocatalytic degradation of wastewater

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Carbon nanotube film is a three-dimensional continuous film material, which contains a large number of carbon nanotubes with excellent properties. It has the characteristics of low density, high strength, high toughness, high conductivity and high thermal conductivity. Its appearance has realized the engineering application of carbon nanotubes. In this experiment, nitrogen doped continuous carbon nanotube films were prepared in situ by floating chemical catalysis with biomass as carbon source and urea as nitrogen source. The conductivity reached 2×10^5 S·M^2, the graphitization degree is 6.1, and the atomic ratio of nitrogen content accounts for 5.7%. It can be applied to photocatalytic degradation of dye wastewater. Due to its conductivity, it can also be used as electrocatalytic anode material. This work hopes to enrich the biomass carbon source library of carbon nanotube membrane and expand its application in industrial wastewater treatment.

Research progress in the Preparation of low-cost polyacrylonitrile based carbon fibers by melt spinning

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Carbon fibers, considered high specific strength and high modulus material, have been widely used in aerospace, defense and security, automotive, and sporting goods fields. The polyacrylonitrile-based carbon fibers (PCFs) account for about 90% of the global CFs production, but PCFs precursors only can be obtained by solution spinning technology due to their particular paracrystal structure. Lower spinning rate, more severe water- electricity consumption, high cost and more wastewater discharge are caused by polar solvents. Suppose the solution technology can be substituted by melt-spinning technology in whole or in part. In that case, many profiled novel cross-sections of carbon fiber can be obtained, the productivity can be significantly improved, more environmentally friendly, and its application field can be further broadened. The important research progress in melt spinning PCFs and thermal stability technology in recent years was reviewed, and the challenges and future development of PCFs were summarized in this paper. Some new ideas for the process design and controllable equipment of melt-spun PCFs were provided.

Improvement of flame retardancy of polyamide 6 via copolymerizing with phosphine oxide derivative

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DongHua University

Polyamide 6 (PA6) is the most productive and widely used polyamide product, with high mechanical strength, excellent self-lubrication, and good solvent resistance. However, similar to most polymers, flammability nature limits the application of PA6, especially in some special fields requiring flame retardance such as electrical appliances, curtains, and carpets. Therefore, the preparation of polyamide with excellent flame retardancy and comprehensive properties has a very broad prospect. Reactive phosphorous-based flame retardants are widely used in the flame retardant research of polymers. In this work, a novel inherently flame-retardant PA6(PFR-PA6) was synthesized by copolymerization with phosphine oxide derivative (PFR). The chemical structure, thermal property, and flame retardancy of PFR-PA6 were investigated. The chemical structure analysis indicates that the PFR had been introduced into PA6 molecular chains. With the addition of PFR, the thermal stability of PFR-PA6 was reduced, but flame retardancy improved significantly. The PFR-PA6 exhibited an increased limiting oxygen index value greater than 30%.

One-step hydrothermal deposition of Ag-doped g-C3N4-TiO2 nanocomposites on cotton fabric surface with enhanced photocatalytic activity

Wenjun Li、hui zhang、wendou chen、pei chen、yaning zhang
Xi'an Polytechnic University

In this study, Ag-doped g-C3N4-TiO2 nanocomposite photocatalysts were deposited on the surface of cotton fabrics by a simple one-step hydrothermal method. The structure features of as-modified cotton fabrics were examined by a series of characterization techniques, including scanning electron microscopy (SEM), transmission electron microscopy (TEM), X-ray diffraction (XRD) spectroscopy, X-ray photoelectron spectroscopy (XPS), UV-Vis diffuse reflectance spectroscopy (DRS) and photoluminescence spectroscopy (PL). The experimental results showed that highly dispersed Ag nanoparticles were doped into g-C3N4-TiO2 nanocomposites which were evenly coated on cotton fabric surfaces. The introduction of Ag nanoparticles into g-C3N4-TiO2 composites could significantly improve the photodegradation rate of methyl orange (MO) dyes under visible light irradiation. Importantly, the doping site of Ag nanoparticles had distinct influence on the photocatalytic activity of Ag-doped g-C3N4-TiO2 nanocomposites. Compared with the g-C3N4-TiO2 coated cotton fabric, the Ag-doped g-C3N4-TiO2 coated cotton fabric displayed the excellent photocatalytic properties for the photodegradation of MO dye because of the narrowed band gap and the faster separation and transfer of photoinduced charge carriers. The substrate of cotton fabric had a little influence on the active radicals produced by the Ag-doped g-C3N4-TiO2 nanocomposites. In addition, the as-modified cotton fabrics exhibited good reusability and stability after five recycles for the photodegradation of MO dyes.

Study of thermosetting PPO resin for high speed copper clad laminate of the 5th generation (5G) communications

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Poly(phenylene oxide) (PPO), is a well-known thermoplastic synthetic material widely used in electrical or electronic equipments, due to its balanced mechanical properties, low moisture absorption, low dielectric constant, low dielectric dissipation factor and dimension stability. New thermosetting low-molecular-weight PPO containing allyl groups was prepared by redistribution and end group reactions have been developed for high speed copper clad laminate of the 5th generation (5G) communications. The structures and properties of the thermosetting PPO were studied by ^{1}H-NMR, GPC, TG, TMA and DSC. The results showed that higher glass transition temperature, higher thermal stability and lower coefficient of thermal expansion of the modified PPO resin. The copper clad laminate (CCL) composited by the thermosetting PPO and glass fiber fabric (NE-glass) were measured thermal properties and dielectric properties, respectively. The results indicated that the thermosetting PPO-based CCL could meet the high-speed needs of printed circuit board (PCB) for the 5th generation communications.

The Fabrication of Sea-island Polyphenylene Sulfide Ultrafine Fiber

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material science and Engineering School

The high-viscosity polyphenylene sulfide (PPS) is blended with low-viscosity PPS to prepare spinning grade PPS. The high-viscosity PPS is the basic structure support, and the low-viscosity PPS improves the fluidity of the melt. The two jointly regulate the molecular weight distribution of the PPS and improve the spinnability. The PPS/Polyethylene terephthalate (PET) composite fiber were prepared by melt spinning. PPS ultrafine fibers were fabricated by removing PET matrix phase from the PPS/PET composite fiber in the sodium hydroxide solution. We systematically studied the effect of spinning speed on strength and diameter of PPS ultrafine fibers. The results exhibited that the diameter of PPS ultrafine fibers from 4 μm decreased to 0.9 μm with the spinning speed from 800 m/min increased to 3600 m/min. In addition, breaking strength of PPS ultrafine fiber is up to 4.4 cN/dtex when the spinning speed at 3600 m/min. Hence, this methods for the large-scale fabrication of high strength ultrafine fibers providing ideal strategy.

Flexible and thermal-stable SiO2/ZrO2 hybrid nanofiber membranes for high-temperature thermal insulation

Xiaoshan Zhang、Nana Xu、Bing Wang、Yingde Wang
National University of Defense Technology

Ceramic nanofibers with combined properties of high flexibility, excellent thermal stability and thermal insulation performance are attractive for use in extreme conditions, especially at high-temperatures. In this work, SiO_2/ZrO_2 hybrid nanofibers (HNFs) were prepared by combining the electrospinning method and high-temperature pyrolysis process. The obtained SiO_2/ZrO_2 HNF membranes exhibited high strength (4.97±0.6 MPa), good flexibility and excellent thermal stability up to 1200 ºC. More importantly, the SiO_2/ZrO_2 HNF membranes presented outstanding high-temperature thermal insulation performance (0.167 W $m^{-1}\cdot K^{-1}$ at 1000 ºC). The results obtained in this work emphasize the great potential of SiO_2/ZrO_2 HNF membranes for high-temperature thermal insulation applications.

Preparation of PAN/PVP Hygroscopic Composite Electrospun Nanofiber Membrane Desiccant

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Beijing Institute of Fashion Technology

The fabrication of desiccants with light weight, convenient carrying and excellent moisture absorption is of great significance for dehumidification. Herein, Electrospun polyacrylonitrile/polyvinylpyrrolidone(PAN/PVP)-lithium chloride/calcium chloride(LiCl/CaCl2) composite membranes were prepared as desiccant materials in this work. The effects of PVP molecular weight, inorganic salt content and the ratio of LiCl and CaCl2 on the microstructure and properties of the composite membranes were investigated experimentally using scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FTIR) and water contact angle. In addition, the hygroscopic properties of PAN/PVP composite nanofiber membranes at different temperatures and humidity were tested by constant temperature and humidity chamber. The experimental results manifest that the composite nanofiber membranes possess the best morphology and excellent moisture absorption performance when the weight average molecular weight of PVP is 1.3*106, the inorganic salt content is 4 wt% and the mass ratio of LiCl and CaCl2 is 16:1. Furthermore, the composite nanofibrous membranes exhibit an excellent moisture absorption capacity of 1.9 g/g at 45 °C and 95% relative humidity (RH), which indicates that PAN/PVP-LiCl/CaCl2 composite nanofiber membranes have excellent application prospects as solid desiccants.

Advanced functional polyimide fibers

Jie Dong、Han Dong、Mengmeng Li、Xin Zhao、Qinghua Zhang
Donghua University

Polyimide fibers have outstanding mechanical property, high thermal stability, good solvent resistance and excellent light stability and have been considered as desirable potential candidate materials for lone-term servicing in severe environments, especially in aerospace and environmental conservation. Herein, we report the recent progress in advanced functional polyimide fibers in our group, including the highly thermally-resistant polyimide fiber and its applications in special protection, low dielectric constant polyimide fiber and electrically conductive polyimide fiber, etc. The preparation, structures and properties of these polyimide fibers are discussed. It is hoped that it can provide some useful information for the industrial application of polyimide fibers.

Adsorption assisted TFNC membrane for removal of Pb(II) and other contaminants with high efficiency

Tonghui Zhang、Peiyun Li、Siping Ding、Xuefen Wang
Donghua University

Nowadays, heavy metal ions are widely present in various wastewaters, which will cause great harm to the environment and human survival[1-2]. How to quickly and thoroughly remove heavy metal ions from wastewater is very important to obtain clean water. Herein, a high-performance thin film nanofibrous composite (TFNC) membrane made up of a polyacrylonitrile (PAN)-UiO-66-$(COOH)_2$ composite nanofibrous substrate (CPAN) and a calcium alginate (CaAlg) skin layer was well prepared. Due to the strong adsorption function of UiO-66-$(COOH)_2$ MOF, the optimal CPAN nanofibrous substrate possessed high adsorption capacity for Pb^{2+} ions (254.5 mg/g). Meantime, because the CaAlg skin layer had a relatively loose structure, it possessed a high organic rejection but with high permeation flux. The water permeability of this TFNC membrane was about 50 L m^{-2} h^{-1} at 0.1 MPa with high rejection for dyes (> 95%). As a result, the CaAlg/CPAN TFNC membranes could be applied for dynamic adsorption and filtration for the removal of Pb^{2+} ions and organic wastes. Compared with unmodified CaAlg/PAN membrane, the optimal CaAlg/CPAN TFNC membrane showed much better ability to treat Pb-containing wastewater and had good recyclability. In addition, the CaAlg/CPAN TFNC membrane could treat 7659 L m^{-2} Pb^{2+} ions wastewater under the WHO drinking water standard, and could effectively deal with more simulated lead-containing wastewater. This work provides an alternative solution for effective and large-scale removal of heavy metal ions and other various contaminants in wastewater.

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Session B
KEYNOTE SPEECH

Bioinspired Polymer Using Multifunctional Block Modules with Synergistic Dynamic Bonds

Pingchuan Sun
Nankai University

Nature embraces an intriguing strategy to create high-performance biomaterials, such as spider silk which presents an unparalleled combination of stiffness, tensile strength, and toughness via hierarchical structures. However, to fabricate synthetic polymers with such excellent properties remains a challenging task. Inspired by the integration of multiblock backbone and densely H-bonding assemblies in spider silk as well as the delicate iron–catecholate complexes in mussel byssus, we proposed a novel molecular design with multifunctional block modules to obtain polymer materials that exhibit excellent mechanical property, self-healing ability, and reprocessability. It was achieved by introducing reversible metal coordination bonds and quadruple H-bonds bearing 2-ureido-4-[1H]-pyrimidinone (UPy) dimers as multifunctional blocks into a segmented polyurethane backbone with urethane blocks and semicrystalline polymer blocks. These two types of dynamic cross-linking knots served as the sacrificial bonds to dissipate energy efficiently under external stress burden, endowing the dual physical cross-linked networks with increased toughness and breaking elongation. Solid-state NMR revealed the formation of quadruple H-bonds in UPy dimers and the presence of metal coordination interactions. This work provides a feasible way to develop bioinspired materials with self-healable and reprocessable features, in addition to balanced enhancement of both stiffness and toughness.

Session B
KEYNOTE SPEECH

Exploring Macromolecular Isomerism using Janus POSS

Wenbin Zhang
Peking University

Macromolecular isomerism has been an important yet largely understudied subject. Giant molecules based on molecular nanoparticles exhibit properties highly dependent on the primary structures, providing an ideal platform for such studies. In recent years, our group have developed a complete set of multifunctional Janus POSS building blocks, used them to make regio-isomeric giant molecules and systematically studied their self-assembly behavior. Specifically, we have designed regio-isomeric giant surfactants (such as DPOSS-2PS) and shape amphiphiles (such as DPOSS-2BPOSS and DPOSS-4BPOSS). The self-assembly of these isomers are influenced by the distinct symmetry and collective interaction of these regio-isomers in a subtle and delicate way. Moreover, we also identified a few unconventional phases, such as Frank-Kasper A15 phase, sigma phase in these regio-isomers. The results suggest that macromolecular isomerism may be exploited as a new way for fine-tuning the structures and properties of macromolecules, which shall be of great interest in both fundamental research and technical innovation.

Session B
KEYNOTE SPEECH

The Precision Synthesis of Discrete and Recyclable Polyesters

Zhengbiao Zhang、Suhua Duan、Zhihao Huang
Soochow University

Discrete oligoesters are highly attractive in a wide range of investigations because of their great fidelity on structure-property relationships. Even though numerous synthetic approaches have been developed, a more compatible synthetic platform with broad group tolerance is still desired. Herein, we report an efficient and versatile iterative exponential growth strategy for discrete oligoester synthesis, employing an optimized protective group pairs consisting of a TBDPS ether and a t-butyl ester. The versatility is demonstrated by facile preparation of eight structurally diverse discrete oligoesters under mild, safe, and scalable reaction conditions, with the number of repeat units up to 256mer. Moreover, the contributions of the terminal protective groups on the melting and crystallization of discrete ε-caprolactone oligomers were investigated. With this robust synthetic platform, various functional moieties can be readily incorporated into polyester chains, and a myriad application of polyesters could thus be reasonably anticipated.

Session B
KEYNOTE SPEECH

Catalytic Synthesis and Properties of Polar Functionalized Polyolefins

Changle Chen
University of Science & Technology of China

Polyolefin is the largest class of thermoplastic polymers, with wide applications and huge annual production. The introduction of even a small amount of polar functional groups into the polyolefins could excise great control over important material properties. As the most direct and economic strategy, the efficient copolymerization of olefin with polar functionalized monomers represents one of the biggest challenges in this field. This was also recognized as one of the last “holy grails” in this field.

In this presentation, I want to discuss that some novel palladium catalysts that could copolymerize ethylene with a variety of polar monomers because of their slow chain walking feature, which have never been realized previously by Brookhart type α-diimine palladium catalysts. The concept of direct synthesis of polar functionalized ultra-high-molecular-weight polyethylene was introduced, which has not been deemed possible previously. These polar functionalized copolymer materials (even at low polar monomer incorporation ratio) showed greatly improved surface properties comparing with the pure polyethylene. I will also present some new strategies to modulate the olefin polymerization and copolymerization processes. Finally, some new catalysts have been designed and studied in copolymerizations of ethylene with a variety of polar comonomers.

Session B
INVITED LECTURE

Ionic liquid-based functional materials

Qi Zhang
The Chinese University of Hong Kong, Shenzhen

Facing the urgent needs in the emerging areas of flexible electronics, we introduce ionic liquids into polymers as functional components, by taking advantages from the flexibility of polymer materials, the conductivity of ionic liquids, as well as their excellent designability. A series of electrical functional soft materials with excellent performance have been designed and prepared, including ionic liquid-included composite dielectric elastomers with high dielectric constant and high transparency, phase-changeable ionic gels with conductor-insulator transition characteristics, and poly(ionic liquid)-based ionoelastomers, etc. The research on ionic liquid-based soft materials with electrical functions is expected to promote the rapid development of flexible electronics, and will provide the possibility for the industrial technology innovation.

Session B
INVITED LECTURE

Colloidal quantum well light emitting diodes

Baiquan Liu
Sun Yat-sen University

Colloidal quantum well light emitting diodes (CQW-LEDs) are highly promising for the new-generation displays and lighting technology, because they can exhibit high efficiency, good color purity, low power consumption, fast response, ultrathin thickness, ultralight weight, flexibility, and other excellent properties. Although the exploration of CQWs in LEDs is impressive, the performance of CQW-LEDs lags far behind compared with other types of LEDs (e.g., organic LEDs, colloidal quantum-dot LEDs, and perovskite LEDs). Herein, in order to further improve the performance of CQW-LEDs, different methods are used to control the distribution of charge and exciton in CQW-LEDs. The influence of charge injection and transport, morphology, material composition, device engineering, and other factors on the performance is deeply clarified. A series of high-performance CQW-LEDs are developed, and the external quantum efficiency of CQW-LEDs is close to the theoretical limit of 20%.

Session B
INVITED LECTURE

Reactive Fibrous Materials for Chemical and Biological Protection

Gang Sun
University of California, Davis

The massive usage of toxic chemicals and the emergence of pathogenic microorganisms pose threats to human safety. Conventional protective materials mainly function by passively blocking or physically adsorbing the hazards, and the contaminated materials could cause environmental and human safety concerns during post-treatments. Thus, development of novel protective materials with active chemical detoxification and pathogen inactivation functions, has attracted much attention. In this presentation, we introduce approaches of using chemical modification methods, including chemical grafting, co-electrospinning, in situ polymer growth, and electrostatic adsorption, to functionalize fibrous materials, allowing them to perform desired active protection against chemical and biological threats. Firstly, the attack of glutathione or guanine by electrophilic fumigants in the human body is adopted to design colorimetric sensors. By using nanofibrous membrane and high-affinity solvent as sensor matrix and attractor, respectively, trace amounts of fumigants can be detected by naked eyes within minutes. Additionally, nucleophilic pyridyl groups are involved in constructing a hierarchical nanofibrous membrane by co-electrospinning, achieving a bifunction of “detoxification-and-sensing” against alkylating fumigants. Thirdly, photosensitizer and biological thiol structures are grafted on a nanofibrous membrane in turn to perform a daylight-induced detoxification function to ene-based toxicants based on thiol-ene click chemistry. Lastly, the in situ synthesis of a porous organic polymer (POP), which possesses nucleophilicity, ultrahigh specific surface area and porosity, on fibrous materials, has shown a tri-function of “adsorption-detoxification-sensing” under fumigant exposures. Moreover, the cationic feature of the POP structure makes additional functionalization of the material by anionic photosensitizers possible, via electrostatic adsorption. The capture of photosensitizers in POP not only introduces the photo-induced ROS production but also modulates the photochemistry of the photosensitizers, which results in enhanced antibacterial and micropollutant photodegradation efficiencies of the materials. In conclusion, the development of reactive fibrous materials using various chemical modifications is promising for the design of innovative PPE to provide improved chemical and biological protection.

Session B
INVITED LECTURE

Progress in Organic/Polymer Wide-bandgap Blue-emitting Semiconductors

Linghai Xie、Haifeng Ling、Mengna Yu、Dongqing Lin、Ying Wei、Wei Huang
Nanjing University of Posts & Telecommunications

Fluorene-based wide-bandgap semiconductors were a kind of important luminescent conjugated molecules, which have been widely applied in organic light-emitting diodes (OLEDs), organic lasers and sensors, because of the molecular diversity, low-cost manufacturing and mechanical flexibility. Herein, we present our progress in the field of molecular design and photophysical properties of fluorene-based wide-bandgap blue-emitting semiconductors. Firstly, in allusion to the undesired low-energy emission band (known as “g-band” emission), we designed and synthesized hoop-shaped strained semiconductor [4]cyclo-9,9-dipropyl-2,7-fluorene ([4]CF). Contrary to the deep blue emission of controlled linear quaterfluorene, [4]CF gives rise to strong green emission around 512 nm in the solution, film and crystal state, offering a new explanation for the g-band. Previously, the quasi-planar conformation of polyfluorenes became an alternative to stable blue emission. The planar conformation adopted by some conjugated polymers could always achieve molecular alignment and regular molecular crystalline structure in solid-state systems, which were confirmed by AFM, XRD and PL spectra. Time-resolved FLIM shows excitons of the β-conformation decay faster than those in the amorphous state. And FAIM measurements report on the level of order within the film, which can be varied by controlling chain conformations, providing a direct visualization to screen the self-dopant in β-conformation films for the first time. Molecular bulk is another prerequisite favorable for the thermal and morphological stability in organic wide-bandgap semiconductor. Introducing rigid moieties into the alkyl-substituted fluorenes helps to improve both thermal and photo stability, so we developed conjugation-interrupted asymmetrically H-shaped fluorene-based deep blue emissive oligomers H-Ph. H-Ph shows better performance with lower EthASE (12.4 nJ) and Ethlaser (0.22 nJ/pulse) as well as higher slope efficiency (3.82%) compared to polyfluorene, which is probably correlated with its fast fluorescence decay (corresponding to shortest τ), which indicates in the three/or four-level transition of lasing process the fast transition from the high energy excited state to the low-energy one and also the subsequent immediate radiative decay to the ground state. We also synthesized supramolecular chiral oligofluorenol (2O8-DPFOH-SFX) and surprisingly find the stereoisomerism effect. Conformational transition and molecular crystallization only occurred in raceme, improving emission spectral stability, confirming the crystal-induced luminescence or stability enhancement (CLoSE) effect. For the mesomer, it shows intrinsic amorphous (non-planar) conformation. The annealed mesomer film has a stronger green emission band at 510 nm with an Igreen/Iblue of 0.5, but no obvious change in the green band was observed for the annealed rac-2O8-DPFOH-SFX film (Igreen/Iblue= 0.143), indicating its excellent spectral stability without undesirable green emission. In order to subtly avoid various pathways for defect generation, we proposed a novel supramolecular self-encapsulation strategy to construct PHDPF-Cz, with the incorporation of diphenyl groups as steric repulsors and π-stacked Cz as the attractor at the 4-position. The synergistic effect of the steric bulk groups and π-stacked carbazoles affords PHDPF-Cz as an ultrastable property, including spectral, morphological stability, and storage stability. Further evidence for the supramolecular self-encapsulation was obtained via the demonstration of the uniformity of emission from a large-scale and high quality film with the size of 30 cm × 10 cm via solution-processing technology. larger-scale flexible PLEDs (8 cm × 8 cm) show a power luminous efficiency of 1.73 cd A-1 with reasonable operating conditions of ＜5 V. On this basis, we proposed a gridization strategy and constructed a series of extendable nano-architectures, which preliminarily display special optoelectronic properties. The molecular grid platform is expected to be a promising candidate to achieve high stability, high mobility luminescence and quantum chiral emission in organic optoelectronics.

Session B
INVITED LECTURE

Proton Ionic Liquid for Perovskite Solar Cells

Yonghua Chen
Nanjing Tech University

Solvent is vital to control crystallization and crystal growth of the state-of-the-art solution-processed hybrid organic-inorganic perovskites. However, researchers just focus on the highly toxic and coordinating solvents (e.g., dimethylformamide, dimethylsulfoxide, and g-butyrolactone) and the based modification (e.g., antisolvent), which may hinder the success of perovskite solar cells (PSCs) in practical applications, and a largely serious unexplored challenge remains until now. Here, we report an alternative environment-friendly ionic liquid as a novel solvent for facile fabrication of PSCs in ambient air.[1-5] Ionic liquid has excellent chemical properties with high viscosity, negligibly vapor pressure, and nonhazardous. Completely soluble of both ammonium and lead salts by hydrogen bonds in ionic liquid were observed. Dense and pinhole-free perovskite films with high reproducibility can be readily prepared by simple one-step method without anti-solvent even under the relative humidity over 80%. The findings may open up a new approach for further improving PSCs performance with higher reproducibility and reliability in ambient atmosphere.

Degeneration mechanism of polymer light emitting diodes

Quan Niu
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Polymer LED (PLED) has an important application prospect in large area display and lighting panel. However, its commercial application is limited by the stability problem under current stress. Although the industry has made great efforts in the past two decades, the understanding of the basic physical degradation mechanism of PLED is still unclear. In our study, we first proposed that the voltage drift of PLED under constant current condition is caused by the generation of hole trap , and leads to additional electron hole non radiative recombination mechanism .The conclusion that the formation of trapped states and the degradation of PLED devices are dominated by exciton hole interaction is self consistent, which enables us to describe the degradation behavior of a variety of PPV substitutes in a unified way . According to the above conclusion, we can suppress the formation of hole traps by mixing luminescent material with a wide band gap semiconductor. Because the density of traps is diluted, the PLED of the blend material shows excellent stability.

Session B
INVITED LECTURE

High flux and High Thermal-responsive Nano-filtration Membranes from Structurally Controlled Zwitterionic Nanocapsules

Zhijuan Sun [1]、Qian Wu[1]、Changhuai Ye[2]、Lixin Xue[1]、Congjie Gao[1]
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2. Donghua University

Incorporation of nano fillers into membrane materials is a promising method to improve the performance of thin film nanocomposite (TFN) membranes, especially in breaking the trade-off between permeability and rejection of TFN membranes. Embedding structurally controllable zwitterionic nanocapsules (ZNCs) in the polyamide (PA) active layers could provide ultrafast water transporting channels to improve water permeability without sacrificing salt rejections. Unprecedentedly high thermal-responsiveness of the TFN membranes was also observed due to the thermal sensitivity of the included ZNCs. The loading level, diameter, crosslinking degree, and core/shell ratio of ZNCs affected not only the structure and nano-filtration (NF) performance, but also the thermal responsive sensitivity of TFN membranes. ZNCs -TFN membrane made of ZNCs with the diameter of 100-110 nm, crosslinking degree of 50 wt% and core/shell ratio of 3:1, at the loading level of 0.01% w/v in aqueous phase, could increase its water flux from 57 L·m-2·h-1 (LMH) to 96 LMH from 25 °C to 40 °C without losing salt rejection rates, possessing unprecedentedly high flux change slope of 2.59 L·m-2·h-1 /°C (LMHC) for NF membranes, 4.4 times higher than that of control thin film composite (TFC) NF membranes.

Session B
INVITED LECTURE

Preparation of fully oriented polylactic acid yarns by polymer melt differential electrospinning

Weimin Yang[1]、Yuhang Wang[1]
1. Beijing University of Chemical Technology

Preparing fully oriented micro/nanofiber yarns are an effective way to connect functional fibers and the textile processes. Recently, electrospinning technology is considered an ideal method to prepare nanofiber yarns. However, mostly applied solution electrospinning did not obtain fully oriented micro/nanofiber yarns (partially random in micro scale) due to the jet wiping effect, and resulting in unsatisfactory yarn strength and difficulty in subsequent textile processes. Here we took advantages of melt differential electrospinning process, to getthe uniform and stable circum-directional differential multi-jets,and furtherintroduced plasma electrostatic cyclone in to following process to eliminate charges on fibers, and we successfully prepared fully oriented yarns of biodegradable poly (lactic acid). The influence of spinning temperature, spinning distance, auxiliary suction flow, plasma gas and other process parameters on the yarn performance was analyzed in detail. This method provides a new way for the preparation of micro/nano functional fibers and enable the direct application in followed textile processes.

Session B
INVITED LECTURE

Robust and Functional shape memory polymers for Digital Light Processing based 3D/4D Printing

Biao Zhang
Northwestern Polytechnical University

4D printing is an emerging fabrication technology that enables 3D printed structures to change configuration over "time" in response to an environmental stimulus. Compared with other soft active materials used for 4D printing, shape-memory polymers (SMPs) have higher stiffness, and are compatible with various 3D printing technologies. Among them, ultraviolet (UV)-curable SMPs are compatible with Digital Light Processing (DLP)-based 3D printing to fabricate SMP-based structures with complex geometry and high-resolution. However, UV-curable SMPs have limitations in terms of mechanical performance, which significantly constrains their application ranges.

We reported a mechanically robust and UV-curable SMP system which is highly deformable, fatigue resistant, and compatible with DLP-based 3D printing, to fabricate high-resolution (up to 2 μm), highly complex 3D structures that exhibit large shape change (up to 1240%) upon heating. More importantly, the developed SMP system exhibits excellent fatigue resistance and can be repeatedly loaded more than 10 000 times. To address the unrepairable nature of SMP-based 4D printing materials, we further reported a double-network self-healing SMP (SH-SMP) system for high-resolution self-healing 4D printing. The polycaprolactone (PCL) linear polymer imparts the self-healing ability to the 4D printing structures, and the mechanical properties of a damaged structure can be recovered to more than 90% after adding more than 20 wt % of PCL into the SH-SMP system. In addition, by using a two-step polymerization strategy, a family of new reprocessable thermosets for UV curing based 3D printing was developed. The photopolymerization takes place during the 3D printing process, and it is triggered by UV radiation to covalently connect monomers and crosslinkers, which transforms the liquid polymer resin into desired 3D shapes. In the new thermoset where both ester functional groups and hydroxyl functional groups exist, the transesterification occurs at high temperatures where the dynamic covalent bonds start the bond exchange reactions (BERs) to make the materials reprocessable, namely, re-shapable, repairable and recyclable. By choosing proper functional acrylate or methacrylate based monomers and cross-linkers, we developed a mixed solution that can be first photopolymerized to create desired 3D shapes, and then be reshaped, repaired, recycled at high temperatures. To demonstrate our new material, we printed lattice structure with resolutions which can be later programmed into other shapes. The material's modulus increases by more than 500 times after the post-curing. The BER enables us to repair a damaged 3D printed structure.

These functional SMPs improve the mechanical performance and sustainable property of the SMP-based 4D printing structures, which allows them to be applied to engineering applications such as aerospace, smart furniture, and soft robots.

Session B
INVITED LECTURE

Flexible and Multifunctional Silk Textiles with Biomimetic Leaf-Like MXene/Silver Nanowire Nanostructures

Hao-Bin Zhang、Liuxin Liu、Wei Chen、Zhong-Zhen Yu
Beijing University of Chemical Technology

Although flexible and multifunctional textiles are promising for wearable electronics and portable device applications, the main issue is to endow the textiles with various multifunctionalities while maintaining their innate flexible and porous features. Herein, a vacuum-assisted layer-by-layer assembly technique is demonstrated to construct a leaf-like conductive network with two-dimensional MXene nanosheets as lamina and one-dimensional silver nanowires (AgNWs) as highly conductive skeletons (veins) on the surface of textile substrates to prepare flexible electronic textile with excellent electromagnetic interference (EMI) shielding, superhydrophobicity, highly sensitive humidity response, and high breathability. Interestingly, the coated MXene nanolayer protects AgNWs from oxidation and enhances its bonding with the textile substrate, and the evolution of MXene surface functional groups affords the textile self-derived hydrophobicity property. Consequently, the MXene/AgNW-silk textile exhibits a low sheet resistance of 0.8 Ω sq-1, excellent EMI shielding performance in the X-band, and highly sensitive humidity response while retaining porosity and breathability.

Session B
INVITED LECTURE

Recent Progresses in the Living Polymerization of Polar Vinyl Monomers by "Frustrated Lewis Pair"

Yuetao Zhang、Jianghua He
State Key Laboratory of Supramolecular Structure and Materials, College of Chemistry, Jilin University

Since Stephan and Erker proposed the concept of “frustrated Lewis pairs” (FLPs), the Lewis pairs have not only achieved noteworthy successes in small molecular chemistry, but also exhibited very promising prospects in polymer synthesis. Recently, we have made breakthrough in the living/controlled polymerization of polar vinyl monomers by FLPs. By using a true (noninteracting) FLP consisting of a strongly neucleophic but bulky N-heterocyclic olefins with exocyclic double bonds bearing two methyl groups and a sterically encumbered but modestly strong Lewis acid (4-Me-2,6-tBu2-C6H2O)AliBu2 ((BHT)AliBu2), we successfully realized the living/controlled polymerization of conjugated polar alkenes, including methyl methacrylate (MMA) and benzyl methacrylate (BnMA) and synthesized well-defined diblock and triblock copolymers. Later, many living/controlled catalyst systems have been developed to achieve living/controlled polymerization of various monomers.
It is known that the properties of polymers are closely related to their molecular weight (MW) and would exhibit big leap when MW is over 106 g/mol. However, it remains as big challenge to synthesize ultrahigh molecular weight (UHMW) polymers, especially PMMA with with Mn > 106 g/mol. A organophosphorus superbase, imidazolin-2-ylidenamino substituted phosphines (IAPs) is combined with a less acidic and bulky Lewis acid (4-Me-2,6-tBu2-C6H2O)AliBu2 ((BHT)AliBu2) to produce UHMW PMMA with up to 1927 kg/mol at room temperature. We have performed a series experiments to elucidate what real essential reasons are accounted for the production of UHMW polymers. Moreover, the identification of such highly efficient and “immortal” organophosphorus superbase catalyst system enabled us to produce a sequence-controlled tripentacontablock copolymer possessing by far the world’s largest block number of 53 at room temperature. Furthermore, by developing dual-initiating FLPs based on the newly designed bis(imino)phosphine superbase, we successfully realized the synthesis of biobased thermoplastic elastomers exhibiting considerable superior mechanical properties compared with the petroleum-derived ones, especially at high working temperatures.

Session B
INVITED LECTURE

Vertical organic light-emitting transistors

Zhongbin Wu
Northwestern Polytechnical University

Organic light-emitting transistors, three-terminal devices combining a thin-film transistor with a light-emitting diode, have generated increasing interest in organic electronics.[1] However, increasing their efficiency while keeping the operating voltage low still remains a key challenge. Here, we demonstrate organic permeable base light-emitting transistors; these three-terminal vertical optoelectronic devices operate at driving voltages below 5.0 V; emit in the red, green and blue ranges; and reach, respectively, peak external quantum efficiencies of 19.6%, 24.6% and 11.8%, current efficiencies of 20.6 cd A–1, 90.1 cd A–1 and 27.1 cd A–1 and maximum luminance values of 9,833 cd m–2, 12,513 cd m–2 and 4,753 cd m–2.[2] The nano-pore permeable base electrode located at the centre of the device, which forms a distinctive optical microcavity and regulates charge carrier injection and transport, is the key to the good performance obtained. Our work paves the way towards efficient and low-voltage organic light-emitting transistors, useful for power-efficient active matrix displays and solid-state lighting.

Session B
INVITED LECTURE

Neutron Total Scattering Investigation on the Dissolution Mechanism of Trehalose in Alkali/Urea Aqueous Solution

He Cheng
China Spallation Neutron Source

The atomic picture of the cellulose dissolution in alkali/urea aqueous solution is still not clear . To clarify the problem, we use trehalose as the model molecule and total scattering as the main tool. Three kinds of alkali solutions, i.e. LiOH, NaOH and KOH are compared . The most-probable all-atom structure of the complex fluid system is thus revealed. The hydration shell of trehalose has layered structure. Smaller alkali ions can penetrate into the glucose rings around oxygen atoms to form the first hydration layer. Then the larger urea complexes with hydroxide groups to form the second hydration layer via electrostatic interaction. Therefore, the solubility of alkali aqueous solution for cellulose, decreases with the alkali cation radius, e.g., LiOH>NaOH>KOH. Our findings is helpful to design better green solvent for cellulose.

Session B
INVITED LECTURE

The Photoactive Activity of Silk Fibroin/Cellulose Acetate Blend Nanofibrous Membranes for Efficient Degradation of Dyes

Shixiong Yi
Southwest University

Creating photoactive nanofibrous membranes for effective treatment of dyeing effluents is critical to meet the great demands of environmental protection in textile industry, However, it has proven extremely challenging. Herein, we present a scalable methodology to prepare 3,3',4,4'-benzophenone tetracarboxylic dianhydride grafted silk fibroin/cellulose acetate blend nanofibrous membranes (G-SF/CA BNM) by combining green biomass materials and electrospinning, which could produce the reactive oxygen species (ROS) under light irradiation. The principle of this design is that G-SF/CA BNM could store photoactivity under light irradiation and release ROS under dark conditions. The resultant G-SF/CA BNMs exhibited integrated properties of ultrathin fiber diameter (154 nm), larger surface area (11.25 m2 g-1), good mechanical properties, robust photoactive activity, excellent rechargeable capability and excellent degradation performance for reactive dyes such as reactive red 195, reactive yellow 4 and acid blue 7 (> 99.99%) within 60 min. The successful fabrication of such materials may open up new avenues for designing and constructing highly efficient photoactive membrane materials for environmental applications.

Session B
ORAL PRESENTATION

Fineness characteristic of Untreated Dendrocalamus Asper, Schizostachyum Grande, Bambusa Vittata, Schizostachyum brachycladum, and Bambusa Blumeana Bamboo Fibers subject to mechanical extraction

Fatin Nadiah Mat Jais[1]、Mohd Nazrul Roslan[1]、Norhazaedawati Baharuddin[2]
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In the past few decades, natural fibres are becoming more popular as a result of their environment-friendly. There are different originated sources of natural fiber such as from seed, leaf, grass and bast. Bamboo is a type of natural bast fiber along with hemp, kenaf and flax. Bamboo textile is nothing new and had been applied in various applications such as in sportwears, towel, socks, t-shirts and many more. The good properties of bamboo fiber enable the fiber to be applied even in geotextile field area as reinforce material in composite to increase the strength of construction of bulding. One of the most natural and ancient way to extract bamboo fiber is by using water retting technique. In modern technology, the mechanical extractor used in the fiber extraction is to ensure the finer fiber to be obtained. This type of extraction helps getting rid the chemical acts in the fiber processing, thus promoting better environmental-friendly concept. The study revealed that the fineness of the fiber is different between each species and there was no significant in the fineness trend among the bamboo location (basal, middle, top). Bamboo of species Dendracalamus asper at middle location shows the highest fineness indicating coarsest fiber out of five (5) bamboo species in the study while the finest fiber was S. brachycladum (LMG) at middle location at fineness of 10.20 tex. This represents that each bamboo location contains different biological constituent for every different species and is non-significant towards each parameter. Thus, it is suggested that deeper study need to be done to each different bamboo species at different bamboo location if to be applied in crucial bamboo textile fiber application.

Session B
ORAL PRESENTATION

Construction of nano-multilayer coatings on copolyester fabrics via layer-by-layer self-assembly for improved anti-droplet and flame retardent performance

Wenqing Wang
Beijing Institute of Fashion Technology

Aiming to realize anti-dripping and improve fire retardancy of polyester fabrics, novel hybrid multilayer nano-coatings composed of γ -amino propyltriethoxysilane (KH-550), bio-based betadex sulfobutyl ether sodium (SBE-β-CD), and [(6-Oxido-6H-dibenz-[c,e][1,2]oxaphosphorin-6-yl)methyl] butanedioic acid (DDP), were successfully constructed through layer-by-layer self-assembly (LBL) method. Polyacrylic acid (PAA) layer were firstly deposited onto polyester fabrics via UV-grafting, facilitating the following electrostatic adhesion for bi-layer electrolytes. Moreover, polyethyleneimine (PEI) and phytic Acid (PA) multi-layered nano coatings were also constructed through polydopamine chemistry mediated LBL technology. The LBL assembly electrolytes as well as coating thickness were investigated in order to have a better optimization of the nano-coatings with the desired flame resistance properties. The morphological analysis, thermal stability, flame retardant properties of multilayer modified polyester were carried out by scanning electron microscopy (SEM) equipped with an energy dispersive spectrometer (EDS), thermogravimetry analysis (TGA), limiting oxygen index (LOI), UL-94 test, and cone calorimeter test (CCT), respectively. After the functional multilayer coated, the ignition time was delayed. Moreover, total heat release and peak heat release rate were reduced but char residues increased. Of particular significant is the melt dripping phenomena disappearance in optimum condition of (K/S)6+(K/D)3 hybrid LBL coatings with LOI value of 36% and V-0 rating in UL-94 test. With bi-layered (PA+PEI)2 coating, the heat release of polyester reduced 75.4% with non-dripping phenomena. The analysis of SEM, fourier transform infrared spectrometer (FITR) and X-ray photoelectron spectroscopy (XPS) results of the residual char indicated a compact exterior layer but multicellular structures for interior layer with thermodynamically stability SiO_2 in (K/S)6+(K/D)3 modified polyester, which was served as a barricade shield to protect the underlaying polymer matrix during the combustion process. This suggested that both condensed-phase and gas-phase flame-retardancy made contributions to the flame retardant mechanism. In the case of (PA+PEI)2functionalized polyester fabrics, an intumescent anti-droplet layer composed of acid source PA and gas source PEI was attributed to the flame retardant behavior. The synergistic effect of hybrid LBL multilayer surface could impart polyester fabrics with high fire retardancy and non-dripping performance.

POSTER PRESENTATION

Thermodynamic behavior of interpolymer complexes assessed by isothermal titration calorimetry in organic solution system

Caihong Zhang、Shuguang Yang
Donghua University

Due to its unique hydrogen bond interaction, hydrogen-bonded polymer composites have been widely studied and applied in elastomer materials, adhesive and layer by layer assembly materials (LbL). The formation and physico-chemical properties of hydrogen bonded complex are affected by chain structure, solvent, temperature and other factors. Isothermal titration calorimetric (ITC) can accurately measure and calculate the thermodynamic parameters such as ΔH, ΔS and heat capacity of the reaction system, and accurately analyze the polymer complexing capacity and driving mechanism. In this work, ITC is used to investigate the interaction between hydrogen bond donor polyacrylic acid and diffenrent hydrogen bond acceptor in aprotic organic solvents. The thermodynamic characteristics of hydrogen bond interaction under different molecular weight of hydrogen bond acceptor, solvent type, titration order and temperature are analyzed. The results show that the hydrogen bond interaction is exothermic in the DMF, DMAc and NMP, and the stronger the polarity of the solvent, the weaker the interaction. Increasing the polymer chain length is beneficial to the formation of more stable hydrogen bond complexation. The different released total heat from the forward and reverse titration results indicates that the mixing order of solution affects the composition of the complex, and increasing the temperature will destroy the hydrogen bond interaction. This study can guide the formation of hydrogen bond complexes and realize the controllable construction of hydrogen bonds in organic systems, so as to expend the types and methods of polymer processing and forming.

Numerical simulation of electrospun polyacrylonitrile Taylor cone based on multiphysics coupling

Peng Chen、Qihong Zhou、Ge Chen
Donghua University

In the electrospinning process, the Taylor cone as the jet source directly affects the jet movement and the quality of the fiber membrane. Therefore, to understand the formation mechanism of the Taylor cone intuitively, a multiphysics coupling model that comprehensively considers the gravitational field, electrostatic field, and fluid field is established, and numerical simulations are conducted in this study. First, we construct a level set function and analyze the force of the droplet. The gravity, surface tension, and electric field force are coupled to the incompressible Navier–Stokes equation as volume forces, and the non-conservation of the droplet area is solved by approximating the Dirac function with a smooth function. Subsequently, the deformation of the electrospun polyacrylonitrile (PAN) Taylor cone under different process parameters is simulated. Finally, data obtained from the numerical simulation and the average diameter of the electrospun PAN fiber membrane are analyzed via grey relational analysis. The results show that the volume force is the key factor affecting the average diameter of the fiber membrane (the correlation is 0.934). This paper provides an effective reference and basis for the analysis and control of the electrospinning process.

Single-Molecule Study on the Force-Induced Melting of Polymer Single Crystals

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The force-induced melting is critical for thedrawability and toughness ofsemicrystalline polymer materials[1-3]. Thestudy on the behavior of a single polymer chain during the force-induced melting of a polymersingle crystal will shedlight on the structure-function relationshipand facilitate the design/preparation of high performance polymer materials. Theappearance of AFM-based single-molecule force spectroscopy (SMFS) makes itpossible to manipulate individual molecule and measure the inter- orintra-molecular interactions quantitatively [4,5]. However, due tothe complexity of the system, it is very challenging to study molecularinteractions in condensed polymer system at single molecule level. By combiningproper sample preparation, AFM imaging and single-molecule force spectroscopy,we established a method to pull a single polymer chain out of its singlecrystal and quantify the melting force [6]. In addition, the effects ofamorphous loop, chain conformation as well as the environment on theforce-induced melting have been investigated systematically [7-12]. Furthermore, steered molecular dynamics(SMD) simulations have been used to disclose the molecular details of thoseforce-induced melting processes [13]. Morerecently, we developed an AFM-based method to investigate the nanomechanicalproperties of Poly(3-alkylthiophene) nanofibers [14,15].

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Session B
POSTER PRESENTATION

Multiblock Copolymer-based Super Strong and Tough Elastic Fibers

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Soochow Univeristy

There is always a vital demand for engineering materials to be strong and tough, though these are two mutually exclusive intrinsic properties of a material. Yet in Nature, there are some exceptions, such as spider silk, cocoon fiber, and mussel byssus, due to the sacrificial bonds (hydrogen bonds and metal-ligand coordination bonds) in these materials. Inspired by these, numerous efforts have been carried out to improve the strength and toughness of elastomers by introducing sacrificial bonds into covalent crosslinked networks. Despite the significant improvement of strength and toughness, their mechanical properties were still much lower than these natural materials.
We believe the one-dimensional oriented fibrous structures is also important for natural materials to achieve these supreme properties. However, most of elastomers reported previously for biomimic purpose cannot be used to spin fibers due to their covalently crosslinked network structures. Herein, we reported the synthesis of a four-component multiblock copolymer with PTMO as elastic segments, PEO as hydrophilic segments, PBT as physically crosslinked segments, and pendant terpyridine ligands as supramolecular crosslinking part. Elastic fibers can be prepared from the multiblock copolymer, and after soaking into aqueous Fe(II) solution, the strength and toughness of the elastic fibers were improved significantly due to the formation of terpyridine-Fe(II) metal-ligand coordination bonds. With the formed double network structure, the obtained elastic fibers show excellent resilience, with ultrahigh true tensile strength (ca. 300 MPa) and toughness (ca. 100 MJ m-3), even higher than mussel byssus (ca. 75 MPa and 45 MJ m-3). The strategy reported here provides a new platform to create strong elastic fibers with high toughness and excellent resilience.

Hollow Polyacrylonitrile Bubble Fiber: Crystalline and Pore Design

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Bioinspired structure-function integrated fibers have been recently received great attention like multi-channel fiber with a biomimetic morphology like polar bear hair. Effective processing strategies are desired to design multi-channel in fibers. It will endow fibers with low density, high porosity and low thermal conductivity. We proposed a novel and facile strategy to fabricate hollow polyacrylonitrile (PAN) bubble fiber via a wet-spinning integrated chemical foaming process. Diphenylmethane diisocyanate (MDI) rapidly reacted with H2O, generating CO2 as a blowing agent which diffused and nucleated in gelled PAN and led to a hollow cellular structure. Additionally, pore distribution and crystalline were adjusted by controlling MDI content and draft speed. When MDI content increased to 10%, a lumen appeared in fibers. Increasing draft speed, lumen diameter decreased from 0.78mm to 0.28mm and cellular bubbles turned to oriented lamellas. The crystalline and orientation of hollow fibers increased. However, the obtained fiber had a relatively lower crystallinity with a maximum value of 14.88%. The formation mechanism of hollow bubble fibers was further theoretically analyzed via evolution of cellular pores distribution and crystalline during bubble diffusion under shear force. The fabricated hollow PAN bubble fiber has broad application prospects in functional-membrane or carbon fiber membrane in future. This novel design principle and facile processing method can also be applied to other polymer materials.

Session B
POSTER PRESENTATION

Formation and properties of surface structured melt-spun polymer blend fibers

Fang Zhou、Long Chen、Dan Pan
Donghua University

PET/PP, PET/PA6 blend fibers with different scale of surface grooves were prepared respectively. According to the observation of SEM, it was found that the amount of dispersed phase, viscosity ratio, and draw ratio during spinning can cause the change of surface morphologies of blend fibers. The relation between surface structure and properties was evaluated based on the analysis of the properties of fibers with grooved surface structure and their fabrics were discussed with various surface structures. The results indicate that the fabric's properties of moisture conductivity, the hydrophilicity and hydrophobicity can also be regulated by adjusting the type, content of dispersed phase and draw ratio during spinning.

KEYNOTE SPEECH

Vinylene-Linked COF-Based Thin-Films for Electrochemical Energy Storage

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The unique characters of porous nanomaterials, including extremely high surface area, nano-confined effect, etc, render them with exceptional behaviors in mass transport and electronic conductivity, highly desired for the development of high-performance devices or equipments in energy and environmental fields. Of them, two-dimensional (2D) covalent organic frameworks (COFs) feature elegant structures and highly tunable properties on the basis of versatile organic synthesis methods, showing huge potentials in the applications of a broad scope. For COFs, the formation of dynamic covalent linkages, including borate, imine, and olefin linkages, is not only crucial for achieving highly crystalline structure but also substantially affects the electronic structures, topological geometries, and morphologies of COF materials, which consequently determines their properties and processibilities. Vinylene-linked COFs exhibit high stability and superior electron communication. Meanwhile, their fully polymeric skeletons render them well compatible with nanocarbons or polymeric materials for the formation of multi-component composites with the demand for various purposes. However, the low reversibility of vinylene formation severely limits the range of viable monomers. Therefore, identifying a reliable and sustainable monomer is one of the most urgent tasks to expand the scope of vinylene-linked COFs and explore their practical application. Hereby, we are presenting the preparation of several new types of functional monomers and the corresponding vinylene-linked COFs, and further exploring their composition with carbon nanotubes or poly(ethylene oxide) to form thin films. Finally, their electrochemical performance and energy storage devices were investigated systematically.

KEYNOTE SPEECH

Functional Conjugated Porous Organic Polymers: Preparation and Applications

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Porous organic polymers (POPs), as a new type of porous material, have been rapidly developed in the past ten years from synthesis methods to various applications. POPs have excellent characteristics such as adjustable porosity and pore structure, customizable chemical functions, high thermal/chemical stability, etc., making them potential materials in broad application fields, such as gas adsorption and separation, metal adsorption and enrichment/removal, heterogeneous catalysis, electrochemical energy storage, sensing and nanofiltration.
The rapid increase in demand for (clean) energy and the serious environmental problems involved in carbon emissions caused by fossil fuel consumption make a carbon neutral strategy very necessary for the global society. Combining the high carbon dioxide adsorption capacity and catalytic activity of POPs, the use of suitable POPs can contribute to carbon neutralization goals. Carbazole-based POPs have a BET surface area of up to 2000 m2 g-1, and can easily introduce catalytically active groups into the POPs framework, so they can show very high catalytic ability and product selectivity. Since carbon dioxide is a suitable raw material for high-value chemicals and fuels, carbon dioxide conversion can not only reduce carbon emissions, but also produce high-value fuel products, thereby balancing energy demand and environmental remediation in a sustainable way.
Similarly, by introducing a variety of chelating groups into the POPs framework, such a highly porous structured material will exhibit a strong ability to capture a variety of metal ions, and can remove harmful heavy metal ions in environmental water systems and other scenarios. The ideal purpose is to achieve efficient remediation of the environment in terms of metal ion pollution.

KEYNOTE SPEECH

Tuning Structure and Function in N-containing Conjugated Microporous Polymers

Charl F. J. Faul
University of Bristol

In the quest for new materials to help to solve global challenges, we have focused our efforts in recent years on the production of functional supramolecular[1] and polymeric materials.[2, 3] Here the focus will be on highly cross-linked covalent 3D polymer architectures.

After a brief introduction to the field of microporous conjugated polymers (CMPs), the focus of the rest of the lecture will be on nitrogen-rich 3D CMP analogues of the well-known conducting polymer, poly(aniline).[4] Various simple design rules will be explored,[5a] and the recent success of using simple inorganic salts to carefully tune porosity and pore size distributions, but also tune CO2 uptake with high selectivity.[5b] The versatility of these materials will briefly be shown in their application for VOC capture,[6] gas capture,[7a] and energy storage.[7b] Future focus areas of research will also be highlighted.

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KEYNOTE SPEECH

Stimuli-Responsive Polymer Composites and 4D Printing: From Materials to Applications

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As typical stimuli-responsive materials, shape memory polymers (SMPs) and their composites (SMPC) have the ability to change shape, stiffness, size, and structure when exposed to external stimuli, leading to potential uses for SMPs throughout our daily lives in a diverse range of areas including the aerospace and automotive industries, robotics, biomedical engineering, smart textiles, and tactile devices. SMPs and SMPC can be manufactured into different structures, such as fibers, foams, 3D or 4D structures. Our group is focusing on the advanced 4D printing of SMPs and SMPCs. We have developed a series of 4D printed SMPs and SMPCs structures including tracheal stent, vascular stent, bone stent, and space deployable structures, showing the shape morphing in response to environmental changes. 4D printed structures are capable of remote actuation with magnetic and electricity filed by incorporating of functional fillers in defined regions. Moreover, 4D printing technology is developing and will lead to revolutionary in several important fields. Many opportunities and challenges in the smart materials and structures are addressed.

INVITED LECTURE

Structural Design of Conjugated Microporous Polymer Electrodes for High-Performance Rechargeable Batteries

Jiaxing Jiang、Chong Zhang、Wenyan Ma、Lian-Wei Luo
Shanxi Normal University

Electrochemically active organic compounds and polymers have been emerging as promising electrode materials for rechargeable batteries by virtue of their elemental sustainability, environmental friendliness and flexible structural designability. However, the insulating nature of organic materials and the dissolution behavior in organic electrolytes hinder the performance improvement. Conjugated microporous polymers (CMPs), possessing extended p-conjugation along the polymer skeletons, high physicochemical stability, plentiful porous structure and high surface area, show great potential for rechargeable batteries. The nature of p-conjugation along the polymer skeletons endows CMPs with a reversible doping-dedoping behavior as conventional conjugated polymers. The electrochemical performance of conjugated polymers was determined by not only the content of redox active units but also the nature of polymer structure. The inherent porous structure and high surface area can provide large void space to accommodate ions and shorten the ion diffusion distance, ensuring a high electrochemical activity and fast kinetics. The highly crosslinked polymer structures prevent the dissolution of active materials in electrolytes, and thus a stable cycleability. Herein, we designed and synthesized a series of CMPs electrodes for rechargeable batteries, and demonstrated that the electrochemical performance of CMPs electrodes could be efficiently improved by the rational structure design.[1-5]

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INVITED LECTURE

Functional custom porous frame material

Yuebiao Zhang
ShanghaiTech University

Porous framework materials are molecular-based crystalline porous structures with designable structures, adjustable functions, and clear structure-activity relationships. They have broad application prospects in clean energy technologies such as carbon capture, gas storage, adsorption and separation, and photoelectric conversion.Further expansion of its basic and applied research will provide new materials and new technologies for our country to strive to achieve the national strategic goal of "carbon peak in 2030 and carbon neutral by 2060".This report will start from actual application requirements, introduce the function-oriented pore topology and chemical environment, expand its intelligent design and efficient synthesis, and further clarify the host-guest interaction, electron transfer and material transfer mechanisms in the pore.In response to specific challenges such as gas storage capacity, gas capture, dynamic structure, and in-situ characterization methods, a high-grade porous MOF material with high gas storage capacity is created through a diversified construction strategy of pores; reveal the novel mechanism of carbon capture by ultra-microporous MOF materials through competitive adsorption research methods; the dynamic in-situ structure of flexible porous COF materials is analyzed by advancing the COF macro-preparation and multi-element structure characterization.

INVITED LECTURE

Design, synthesis, and catalytic performance regulation of novel hybrid materials

Shuang Li
Sichuan University

Hybrid materials, which consist of two or more inorganic and/or organic components interfused at small length scales are suitable candidates for the construction of electrocatalysts. Our research focuses on the design of nanostructured metal-organic hybrid materials for electrocatalytic applications (including HER, OER, and ORR). In course of these studies the construction of hybrid materials with various nanoscale morphologies was achieved, including layered and hierarchical porous structure or microspherical morphologies. Beside the control of the micro- and nanoscale, also the nature and environment of the metal active centers can be adjusted on atomic length scales in these catalysts.
In this talk, we will present the preparation of different metal-organic precursors and their controlled transformation in carbon-based hybrid catalysts, as well as their application in electrocatalytic reactions. Also the influence of the coordination environment of active metal centers, the nanostructures and porosities of the materials on the kinetics of catalytic reactions will be dsicussed. Finally it will be shown, how multiple metal active centers can be applied and regulated at the atomic scale via support effects.

INVITED LECTURE

Fiber-supported catalysis and polymer effect

Xianlei Shi、Shuangshuang Liu、Lijuan Jiang、Mengmeng Du
Henan Polytechnic University

The development of environmentally and cost-efficient benign catalytic systems have potential to impact fine chemicals and pharmaceutical manufacturing, which, in turn, could exert positive effects on environmental and economic respect. In recent studies of our group, on the basis of "polymer effect", a series of fibrous catalysts including fiber-supported ionic liquids, N-heterocyclic carbines (NHCs) and metal complexes based on polymer fibers were set in the continuous-flow processing or spinning basket reactor for clean catalysis and were verified in several reactions ranging from organic synthesis to biomass and CO2 conversions, and were deemed to be one of the most promising catalyst forms from the reaction engineering point of view. Moreover, this newly developed fiber-based catalytic method provides a new strategy to design and develop greener, safer and more economical processes in the chemical industry.

INVITED LECTURE

Shape memory fibers: from materials to applications

Fenghua Zhang、Yanju Liu、Jinsong Leng
Harbin Institute of Technology

Shape memory polymers (SMPs) as a class of smart polymers exhibit shape change and shape recovery properties in response to various external stimuli, such as heat, light, pH, microwaves, electrical and magnetic fields, and water. SMPs and their composites can be fabricated into a variety of fibrous morphologies, including oriented fibers, non-woven fibers, fibers with a core/shell structure, as well as fibers with a functional particle filling. The fiber structure enables SMPs to achieve greater properties, specific surface area and multifunction. Moreover, the resulting fibers exhibited excellent shape memory performance and have wide range of potential applications, especially in biomedical engineering and smart textiles.

INVITED LECTURE

Multi-structured hollow nanofibers for catalysis and energy storage

Yong Zhao
Beihang University

With the progresses in material sciences, the generation of microscopic materials experiences an architectural evolution process from simple to complex. The complex interior structures will enable such materials a number of potential applications. Here we fabricated a series of multi-structured hollow nanofibers by a facile electrospinning method and investigated their applications in catalysis and energy storage.

INVITED LECTURE

Study on the structure and performance of polymer solar photochemical conversion materials

Hangxun Xu
University of Science and Technology of China

Semiconducting materials can split water into hydrogen and oxygen via harnessing solar energy as the energy input, providing a viable route to address the energy and environmental crisis. Conjugated polymers recently emerge as a novel class of photocatalyst for solar-to-chemical energy conversion as their chemical and electronic structures are highly tunable compared to their inorganic counterparts. Especially, the surface reactive sites of polymer photocatalysts can be rationally designed, offering enormous opportunities to optimize and boost the photocatalytic activity. In this context, investigations into the reaction mechanisms and unravelling the reaction pathways have become critically important. In this talk, I will briefly present our efforts in developing efficient polymer photocatalysts for overall water splitting through combined in situ characterizations and advanced computational studies. It is shown that the reaction pathways can be precisely tuned from the molecular level. Furthermore, we also design a new structure of covalent triazine frameworks which can be electropolymerized and form well-aligned band structures with inorganic semiconductors for photoelectrochemical water splitting. Our studies could provide in-depth understandings of the structure-property relationships of man-made polymer materials for solar-to-chemical energy conversion.

INVITED LECTURE

Improved Photocatalytic Activity of Covalent Organic Frameworks for Hydrogen Evolution

Jia Guo
Fudan University

Two-dimensional covalent organic frameworks (2D COFs) have attracted increasing attention of researchers for booming the photo/electro-catalysis fields. Since 2D COFs are featured with periodic atomic arrangement and ordering layered stacking, the structure-to-activity relationship could be investigated by a molecular mechanism, thereby allowing the depth-in understanding of the distinctive roles of organic materials in the photocatalytic reaction. For visible photocatalytic H_2 evolution in water splitting, suppressing electron/hole recombination and promoting photogenerated electron transport are both essential for the increase in photocatalytic efficiency. Taking the two aspects into account, we address the following three strategies for regulating the photocatalytic performances of 2D COFs. (1) A multivariate 2D COF is designed to incorporate electron transfer mediators into the frameworks. Combined with photosensitizer units, the photogenerated charge transfer is largely improved and accordingly, the H_2 evolution rates increase and can remain for a long-term photocatalytic cycling. (2) The PEG-filling 2D COF is prepared to stabilize the layered stacking structure by virtue of H-bonding interaction between PEG chains and COF skeletons. The photogenerated electron transfer is facilitated within densely stacking multilayers during the photocatalysis, leading to a significant increase in the performances. (3) A series of keto-enamine-linked 2D COFs are synthesized to investigate the effect of excited state intramolecular proton transfer (ESIPT) on the photophysical properties of 2D COFs. Our findings demonstrate that ESIPT remarkably strengthens the photogenerated electron transfer between electron-donating and -withdrawing moieties in some specific frameworks. Therefore, our strategies not only improve the photocatalytic performances, but also open up versatile avenues for designing high-quality COF-based photocatalysts.

INVITED LECTURE

Microenvironment construction in textile fiber surface and applications in catalysis and adsorption

Ning Ma、Minli Tao、Wenqin Zhang
Tianjin University

Sustainable chemistry and engineering have attracted much attention in recent years. Accordingly, a large number of novel materials have been developed and displayed excellent performance of adsorption and catalysis. As cheap, flexible, durable, versatile, easily available, diversely woven and relatively stable materials, industrial textile fibers have attracted increasing interests on their utility as highly efficient adsorbents to hazardous pollutants and good carriers for small-molecule organocatalysts and transition metal catalysts. Because acrylic fiber, also known as polyacrylonitrile fiber (PANF), has a large number of cyano and methoxycarbonyl groups, high-density and deep-level modification can be achieved in the surface of PANF to construct unique microenvironment composed of organic functional moieties, polymer segments, and solvent molecules. Recently, diverse microenvironments have been designed and constructed in PANF and polypropene fiber surface by our research group to achieve efficient adsorption and catalysis. In these modified fibers, most of the functional groups have been covalently grafted onto the polymer chains, making the fibers fairly stable, easily separated and highly recyclable.

INVITED LECTURE

Enabling blow-spinning and electrospinning of 2D Sheets

Zhen Xu
Zhejiang University

With the rise of the family of two-dimensional macromolecules, their assembly fibers also show a wealth of functional characteristics. Among them, graphene fiber as the representative, will develop into a new type of structural function integrated carbon fiber material. At present, two-dimensional macromolecular fiber is mainly concentrated in low-speed solution spinning, greatly limiting its quantitative production preparation. How to break through the spinning speed of two-dimensional molecules and expand their spinning method has become a challenge in the development of its materials.
Aiming at the problem of two-dimensional molecular unchained tangle and shielding effect on polymer tangle, it is proposed to use ultra-high molecular weight polymer to overcome the shielding effect, and to effectively regulate the viscous rheumatic properties of two-dimensional molecular solution with the lowest amount of polymer, and realize the high-speed blowing and electrospinning of two-dimensional macromolecules. The realization of blowing spinning to achieve the efficient preparation of two-dimensional macromolecular fibers, reached the speed level of industrial spinning, the production of high conductivity and high thermal conductivity and high pores of graphene fiber paper material, in the fuel cell gas diffusion layer material has a performance advantage. At the same time, the realization of electro-spinning prepared two-dimensional macromolecules of nanofibers, covering graphene, molybdenum disulfide and other material types, the development of a common two-dimensional molecular electro-woven nanofiber preparation method.

INVITED LECTURE

Design and synthesis of covalent organic frameworks on macroscopical scales

Xiaojia Zhao
Hebei Normal University

Covalent organic frameworks (COFs) have been widely studied in electrocatalysis and energy storage field due to their advanced structural features and performances. However, research on COFs currently is mostly focusing on the design and synthesis of new topological structures as well as functionalized COF materials. The micropore or small mesopore regime in COFs could impede mass transport through the material thus the accessibility to the actually available abundant active sites on this high surface areas. In these regards, the design of COFs should not only focus on microscopic length scales, but also include the engineering of COF materials on a macroscopic level i.e. from several nanometres to centimetres, which can not only maintain their well-defined crystalline structures, but also achieve better performances on mass transport, conductivity and stability. This project aims to design COF-based composites under different dimensions and control COF structures and morphologies on different length scales, which could pave the way for the construction of advanced COF materials and widen their applications in renewable energy field.

INVITED LECTURE

Liquid Crystal Elastomer Based Unprecedented Two-Way Shape-Memory Aerogel

Hong Yang
Southeast University

With the advantage of reversible shape-morphing between two different permanent shapes under external stimuli, the two-way shape memory aerogel is expected to become a preferred aerogel for developing practical applications in actuators, sensors, robotics, etc. Herein, the first two-way shape-memory liquid crystal elastomer (LCE)-based aerogel is prepared by an orthogonal heat and light curing strategy coupled with an intermediate mechanical stretching step. The differential scanning calorimetry, temperature-varied wide-angle X-ray scattering and polarizing optical microscope results indicate that the aerogel possesses a liquid crystal phase and the insider mesogens are well oriented along the stretching direction. In addition to having superior compressibility and excellent shape stability, this LCE-based aerogel can perform a reversible shape deformation during the heating/cooling cycles with a shrinkage ratio of 37%. This work, that we disclose here, realizes a truly two-way shape-memory behavior rather than the one-way shape deformation of traditional polymer aerogel materials, and may promote potential applications of this novel LCE-based aerogel material in control devices, soft actuators and beyond.

INVITED LECTURE

Preparation of large-size two-dimensional polymer single crystals

Yingjie Zhao
Qingdao University of Science and Technology

The preparation of large-size 2D polymer monocrystalline is the core scientific problem facing the field at present, which is called the challenge of "hell level" difficulty by researchers. Unlike linear polymer crystallization, this two-dimensional topology material generally does not have solubility and can only be prepared by means of "edge aggregation, edge crystallization" to achieve single crystal preparation, which is very demanding for polymerization rate control and polymerization reaction type. We prepare large-size 2D polymer monocrystallines through the preparation of monomer monocrystalline to polymer monocrystalline transformation. It plays an important role in understanding its structure and effect relationship, and it is of far-reaching significance to give full play to the advantages of the highly ordered aperture of two-dimensional polymer materials and expand its application in the fields of electronic devices and membrane separation.

INVITED LECTURE

Rational design of donor-acceptor conjugated polymers for photocatalytic hydrogen evolution from water

Xiong Chen
Fuzhou University

Organic conjugated polymers (CPs), featured by their sustainability, cost-effectiveness, processability and finely-tuned properties by versatile organic protocols, have been regarded as a new generation of photocatalysts to complement inorganic semiconductors for water splitting. So far, several types of CPs, such as polymeric carbon nitride (PCN), conjugated poly(azomethine) networks, covalent organic frameworks (COFs), and conjugated microporous polymers (CMPs), have been designed and synthesized as the molecular platform for photocatalytic hydrogen evolution with considerable performances. Nevertheless, owing to the small dielectric constants, the charge transfer process is still inefficient in most of the polymer photocatalysts, especially when comparing with that in inorganic materials. To improve the light absorption and boost the charge mobility and/or exciton-separation efficiency of conjugated polymer photocatalysts, donor (D)-acceptor (A) strategy has been widely applied for directing the structural design of polymers. In this presentation, our recent efforts to realize enhanced photocatalytic activity based on D-A conjugated polymers will be discussed.

INVITED LECTURE

Controlled fabrication of MOF-polymer composites with hierarchical pore structure

He Zhu
The Chinese University of Hong Kong, Shenzhen

Materials with hierarchical pore structure are widely found in nature. These materials have macropores for rapid transport, micropores for sufficient exchange/reaction, and mesopores that act as channels between the macropores and micropores. Metal-organic frameworks (MOFs) are an emerging class of porous organic-inorganic hybrid materials with high porosity, large specific surface area, and high thermal stability, which are showing great potential in various fields such as gas storage, separation, chemical sensors, and catalysis. The construction of polymer composites with hierarchical pore structure using MOFs as basic building blocks can improve the mass transfer performance of the materials, while solving the problem that MOF particles are not easy to handle and recover, thus enhancing their applications in various fields. This work demonstrates a facile one-pot strategy for processing MOF-polymer composites into membranes, beads, fibers, and monoliths with hierarchical pore structure. The obtained materials show good performances in the energy and environmental applications.

INVITED LECTURE

Synthesis of N-doped carbon/metal catalyst with different morphology derived from in-situ carbonization of N-containing hyper-crosslinked polymer and its catalysis research

Qi Ge、Li Zhang、Haitao Yu、Kun Huang
East China Normal University

N-doped carbon/metal nanomaterials have been widely applied in the field of chemical industry and material science because of their unique molecular structure and excellent catalysis activity. In this paper, the N-doped carbon/metal catalyst (M@NC) nanomaterials with high-dispersion and excellent activity are synthesized by an in-situ carbonization technology using N-containing hyper-crosslinking polymer (N-HCPs) porous nanomaterials as precursors. On this basis, hierarchically porous N-HCPs nanomaterials with different morphologies are designed and synthesized by the hyper-crosslinking mediated self-assembly strategy using cheap and easy-getting N-containing small molecules and diblock copolymers as constructing units. Through effective adjustment to their molecular structure, functionality, surface activity and metal dispersion, the fundamental and applied research of hierarchically porous M@NC are carried out in the heterogeneous reaction (hydrogenation, oxidation, coupled reaction) based on the N-doped, high surface area, particular nano-cavity microenvironment and multi-porosity structure.

INVITED LECTURE

Controlling the cocrystalline structures in conjugated triblock copolymers for field-effect transistors

Juan Peng
Fudan University

Despite recent impressive advances in synthesis of all-conjugated diblock copolymers via facile quasi-living Grignard metathesis (GRIM) polymerization, it remains challenging to achieve well-defined all-conjugated triblock copolymers of interest. Herein, we report the judicious design and synthesis of a series of all-conjugated triblock copoly(3-alkylthiophene)s and correlate their different crystalline structures and charge transport properties in organic field-effect transistors (OFETs). These triblock copoly(3-alkylthiophene)s self-assemble into cocrystals with an edge-on orientation in as-cast and 150 °C-annealed samples. Intriguingly, upon two-step thermal annealing, the system with the middle block possessing a shorter alkyl side chain can maintain the cocrystalline structures. In contrast, microphase separation occurred in the triblock copolymers when the middle block has a longer alkyl side chain. A detailed investigation discloses the effect of side chain engineering on the final cocrystalline structures. Overall, this work elucidates the relations between the crystallization and charge transport behavior of conjugated triblock copolymers, entailing them for a wide range of potential optoelectronic applications.

INVITED LECTURE

Aerogel fibers: design, fabrication and performance

Xuetong Zhang
Suzhou Institute of Nano-tech and Nano-bionics, Chinese Academy of Sciences

Aerogels, a fascinating three-dimensional (3D) network structure composed of nano-scale building blocks as well as plenty of air in between these building blocks, have been applied in many emerging fields such as optics, energy, environment, aerospace, etc. Fibers, generally filamentous materials with length to diameter ratios of larger than 1000, have been derived from nature or have been fabricated by mankind for the purpose of meeting the requirement of national wellbeing and people's livelihood. Aerogel fibers, the simultaneous embodiment of aerogel 3D network structure and fibrous geometry, are a unique type of materials that combine the lightweight and multi-mesoporous properties of aerogel with the flexible and slender characteristics of the fiber. Aerogel fibers have been the focal points in a broad spectrum of applications, ranging from thermal insulation, wearable textiles, to stimuli-responsive electronics, due to their high specific area, high porosity, low density, and low thermal conductivity. This presentation will illustrate how to obtain functional inorganic aerogel fibers, polymeric aerogel fibers and graphene aerogel fibers from various nanoscale building blocks, and demonstrate the application of these aerogel fibers in energy, textile and other fields.

INVITED LECTURE

Fabrication of supramolecular helical nanofibers based on helical polyisocyanides

Zongquan Wu
Hefei University of Technology

Helical poly(phenyl isocyanide) (PPI) was incorporated onto semiconducting poly(3-hexylthiophene) (P3HT) via Ni(II)-catalyzed one-pot block copolymerization of the corresponding two monomers, and formed well-defined P3HT-b-PP block copolymers with controlled molecular weights and low dispersity. The helical chirality of PPI block and crystallization of P3HT segment driven the block copolymer self-assembly into well-defined helical nanofibers with defined helicity, but in irregular lengths. To obtain helical nanofibers with controlled dimensions, we developed crystallization-driven asymmetric self-assembly method, which induced the P3HT-b-PPI block copolymers assembled into uniform cylindrical micelles with controlled dimensions and helicity. Interestingly, the helical nanofibers exhibited white light emission, and circularly polarized luminescence (CPL) with defined handedness and tunable dissymmetric factor.

INVITED LECTURE

Designing conjugated porous polymers for visible light- promoted chemical transformations

Kai Zhang
Fudan University

Conjugated porous polymers (CPPs) have recently emerged as a new class of organic and heterogeneous photocatalysts for visible light-promoted photoredox reactions. The CPPs have been established as a potential alternative to resolve critical drawbacks of traditional molecular and homogeneous photocatalysts due to their structural durability, non-toxicity, low cost by the absence of noble metals, and high designability. Tremendous attempts have been made for the design and synthesis of CPPs for a variety of visible light-promoted photocatalytic chemical transformations.
In this talk, an overview is given on the recent developments in controlling structural, and photophysical and electronic properties of CPPs, and to extract the underlying design principles with respect to the molecular structure and macroscopic feature, in particular, from building block design to morphology, porosity, chemical functionality, and processibility of CPPs for the enhancement of photocatalytic activity. Typical examples of the structural effects on their catalytic efficiency are demonstrated via a series of visible light-driven catalysis ranging from energy-related hydrogen evolution via water splitting,[1] to organic photoredox reactions as C-H activation reaction,[2] C-C or C-N bond formations,[3-4] cycloadditions[5] etc.

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INVITED LECTURE

超高分子量聚乙烯多孔超薄膜

润莱 李、凯霖 杨、威龙 孙、强 傅
Sichuan University

For long, the trade-off effect between ultrathin thickness and being micro- or sub-micro-porous rules the preparation of polymeric thin membranes. Especially, it is extremely challenging for the polyolefin to lower down their thickness below 1 micron and to maintain its porous structures. Since (1) dynamically the chain slippage and orientation compete with each other to cause an inefficient stretching; (2) thermodynamically high surface area increases the surface instability of ultrathin membrane.

Based on the above analysis, UHMWPE membrane preparation was divided into two parts to mainly address the two issues respectively. The prepared UHMWPE ultrathin membranes are less than 200 nm thick, with porosity over 40%. And they are highly transparent, flexible and stiff, with thickness and porous structures tunable.

2D Conjugated Polymers

Long Chen
Tianjin University

In this presentation, our recent works on synthesis of 2D covalent organic frameworks (COFs) and 2D Conductive metal-organic frameworks (2D c-MOFs) will be introduced. Firstly, we developed a two-in-one molecular design strategy for facile synthesis of 2D imine based COFs. The integration of two different functional groups (e.g. formyl and amino groups) in one simple molecule affords various bifunctional building blocks. Furthermore, the versatility of this two-in-one strategy was verified by many examples. This two-in-one molecular design strategy dramatically reduces the difficulty of COF synthesis, and is anticipated to be applicable for the synthesis of various COFs by using different building blocks, various linkages and topologies. Furthermore, an efficient and universal approach via in-situ vapor-assisted transformation of the monomer films to the corresponding COF films was developed based on these “two-in-one” designed A2B2 monomers.
On the other hand, 2D c-MOFs have exhibited potential applications in chemiresistive sensors, electrodes for energy storage, electrocatalysts, and electronic devices. Our recent works on design and synthesis of new 2D c-MOFs as well as the exploration of new potential applications of 2D c-MOFs in spintronics will be introduced.

INVITED LECTURE

MOF thin film gas sensing material

Gang Xu
Fujian Institute of Research on The Structure

Real-time detection of trace gases is of great significance for ensuring the safety of people's lives and property, reducing production costs, improving production efficiency, and protecting the environment. The chemical resistance gas sensor has the advantages of low cost, convenient use, and real-time monitoring. It is a research hotspot in trace gas detection.However, traditional metal oxide gas sensing materials have performance defects such as low room temperature sensitivity and poor selectivity, which have become a bottleneck restricting their applications. Metal-organic framework materials (MOF) have a huge specific surface area, selective gas adsorption, a large number of exposed active sites and adjustable electrical properties, which are expected to solve the performance defects of traditional gas-sensitive sensing materials.We have successfully solved the difficult problem of preparing conductive MOF high quality thin films by "module assembly method", "interface limited growth", "van der Waals epitaxial growth" and other methods, and systematically carried out basic research on the application of MOF thin film materials in chemical resistance gas sensor.

INVITED LECTURE

Controlled Preparation of Mesoporous Nanomaterials for Energy Storage and Conversion by Tunable Self-assembly of Block Copolymers in Solution

Yiyong Mai
Shanghai Jiao Tong University

This talk will introduce the studies on controlled construction of mesoporous nanomaterials for energy storage and conversion by tunable self-assembly of block copolymers in solution. The contents contain 2 aspects. 1. A general dual-template interfacial self-assembly strategy was developed for the controllable fabrication of 2D free-standing mesoporous materials. This approach also allows for the precise control of their thickness, pore structure/size and electrochemical performance, which are highly desirable for energy-related applications. 2. By the precise self-assembly of block copolymers in solution, highly ordered polymer cubesomes with bicontinuous structures were obtained, which supplemented a vacant self-assembled structure in the morphological phase diagram of block copolymer self-assembly in solution. Utilizing the cubesomes as the templates, the precise construction of ordered bicontinuous polymer function materials was achieved. The bicontinuous structures exhibit advantages in smooth mass transport, which are desired in energy-related applications. These studies broaden the application scope of macromolecular self-assembly, and open avenues for tunable synthesis of ordered mesoporous materials for energy-related applications.

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POSTER PRESENTATION

PVA/PVDF film with a wettability gradient surface

Yiyang E、You Lv、Jingxi Yang、Wenting Hu、Yuan Zhu
Southern University of Science and Technology

Wettability gradient material refers to a functional material whose surface energy or microscopic morphology changes continuously along a certain direction of the material, which is very useful in a wide range of areas, such as liquid self-transportation, microfluid flow, biosorption and efficient heat transfer. In this study, a polyvinyl alcohol (PVA) and poly (vinylidene fluoride) (PVDF) film with a wettability gradient surface was prepared. A dual-channel syringe pump which can set the injection speed and acceleration was used as injection device. By constantly changing the injection speed of the syringe pump and the constant uniform translation of the electrospinning device, the film with a wettability gradient surface was forming. The contact angle of water droplets on the film surface varies from 40.68° to 52.14°, which proved its wettability gradient.

Rapid Metal-Free Synthesis of Pyridyl-functionalized Conjugated Microporous Polymers for Visible-Light-Driven Water Splitting

Zhonghua Cheng、Yaozu Liao
Donghua University

Converting solar energy into clean, sustainable chemical fuels via photocatalytic water splitting represents a potentially viable approach to address energy crisis and environmental issues. Conjugated polymers consisting of naturally abundant elements such as C, H, and N are very promising candidates as low-cost semiconducting materials for photocatalytic water splitting. More importantly, they offer an unprecedented scope for molecular engineering and precisely tuning their optoelectronic properties.A number of conjugated polymers with various structures and morphologies have been developed for visible-light-driven water splitting.
Recently, conjugated microporous polymers (CMPs) with extended π-conjugation have particularly received attention for this goal. Moreover, given their distinct topological properties and functionalities, other emerging applications such as gas uptake and separation, energy storage, heterogeneous catalysis, and sensing can also be envisaged. Nonetheless, CMPs are generally synthesized via metal-catalyzed coupling reaction or high-temperature condensation polymerization where precious metal catalysts, massive energy consumption, and long-term reaction are usually required. Facile and green syntheses of low-cost CMPs with suitable functionalities and optoelectronic structures for efficient visible-light-driven water splitting are still challenging. Here we report a facile synthesis of pyridyl-functionalized conjugated microporous polymers (PCMPs) via a simple aminative cyclization between aryl aldehydes and ketones

Research on temperature-responsive electrospun nanofibers that can be crimped by heating

Jinzhong Zhang[1]、liusheng zha[1]、jinpeng huang[1]、xiaoyun liu[2]、jianmao yang[2]
1. Donghua University
2. Analysis and Testing Center, Donghua University

In this study, the electrospun nanofibers with double-face structure were prepared by side-by-side electrospinning technique combined with photo-crosslinking process, using glycidyl methacrylate modified polyvinyl alcohol and the temperature-responsive polymer with photo-crosslinkable groups on its molecular side chain synthesized by N-isopropylacrylamide and acryloyloxybenzophenone as the fiber-forming polymers, respectively. Their double-face structure was confirmed by SEM and TEM, and their chemical composition was characterized by FTIR. The effects of spinneret structure, spinning solution flow rate and side-by-side electrospinning process conditions on the diameters and double-face structure of the electrospun nanofibers were investigated. The obtained results show that the prepared electrospun nanofibers have a higher proportion of double-face structure when a certain angle is present between the flowing directions of two spinning solutions within the spinneret and their flow rates are both 0.3ml/h, with the spinning voltage being 22 kV and the collecting distance being 15 cm. The obtained double-face nanofibers have good stability in water and increase with the content of the photo-crosslinkable groups within the temperature-responsive polymer. When the temperature of the aqueous medium was elevated from 25 °C to 35 °C, the shortened double-face nanofibers changed from stretching state to curling state, and the temperature response process was reversible. The fastest curling temperature is ca. 29 °C. This kind of smart nanofibers capable of curling upon temperature rising have potential application value in micro-actuator and fabrication of injectable hydrogel.

Ni or Co single atomic anchored conjugated microporous polymer for high-performance photocatalytic hydrogen evolution

Chen Yang、Yaozu Liao
Donghua University

The fabrication of single atomic photocatalysts via a simple pathway is a crucial challenge to enable efficient production of hydrogen. Herein, we demonstrate a gaseous diffusion strategy to construct single atomic photocatalysts by using the intrinsic nanopore of pyridyl-functionalized conjugated microporous polymer (PCMP) to host nickel (Ni) or cobalt (Co) atoms. Comprehensive microscopy and spectroscopy characterizations were carried out to understand the morphology and structure variations of Ni or Co single atomic anchored PCMP as photocatalysts. The experimental results show that Ni or Co present as single atoms anchoring with pyridyl nitrogen, which prominently alter the electronic structures of PCMP and delocalize the charge density of the metal atom to promote proton adsorption. The outcome of the single atomic anchoring substantially reduces the energy barrier of photocatalytic water splitting. As a result, Ni or Co single atomic photocatalysts exhibit efficient hydrogen evolution performance with a rate of 1.72 mmol g-1 h-1 (AQE=2.05% at 420 nm) under visible-light irradiation beyond pure PCMP. Moreover, the photocatalysts show excellent stability with negligible decreases in the rate of hydrogen evolution upon long-term cycling (25 h). Our findings offer a rational way for the engineering of single atomic photocatalysts for energy and environment-related applications.

Gold Recovery from E-waste by Triazole-based Porous Poly(ionic liquid)s

Xinghao Li、Weiyi Zhang、Yaozu Liao
Donghua University

The rapid development of the electronics industry produces a large amount of e-waste, but the e-waste contains a lot of valuable metals. The gold contained in waste is widely used in catalysis, jewelry, electronic devices and other fields[1,2]. Methods to extract gold from electronic waste include pyrometallurgy and hydrometallurgy. While pyrometallurgical process usually generate secondary pollutants, hydrometallurgical process employ a more environment-friendly treatment when using digestive solution to transfer the valuable metals in the electronic waste into solution to form electronic waste water. However, most of the existing adsorbents have poor selective adsorption of gold, low adsorption capacity and low stability, which is not beneficial to the effective recovery of gold[3]. Triazole-based porous poly(ionic liquid)s, due to its special structure, the carbene sites of polytriazolium have a strong interaction with certain noble metals, which can ply a very good stabilizing effect on metals[4].
Herein, we chose a Triazole-based poly (ionic liquid)s with specific “cation-methylene-nitrile sequence”, and cross-linked with ammonia to obtain a porous adsorbent with high surface area. The adsorbent has good selective adsorption to gold ions, and its maximum adsorption capacity can reach 1.89g/g, and the adsorption behavior appeared to show a slight dependence on the solution pH values. Density functional calculations indicate the energetically favorable multinuclear-Au binding enhances adsorption as clusters, leading to ultrahigh gold capacity. The adsorbent is easy to preparation and recyclable, a significant advantage over other emerging materials.

Studies on the Preparation and Performance of Conductive Polymer-based Elastic Hydrogel Fibers

He Liu、wei Lv、Bin Sun、Yaozu Liao
Donghua University

In recent years, with the improvement of people's demand for quality of life and the development of technology, the demand for flexible wearable electronic devices has increased significantly. The design and development of high-quality flexible materials is the key to the development of flexible wearable electronic devices, and has received extensive attention from scientific researchers. Hydrogels are considered to be a potential flexible material with the advantages of good biocompatibility, flexible elasticity and stimulating responsiveness. Compared with block and sheet hydrogels, fibrous hydrogels have the advantages of hydrogel materials, such as fiber anisotropy, high aspect ratio, anisotropy, and easy weaving. The conductive polymer-based elastic hydrogel fibers possess some properties of conductive polymers, such as electrical properties, high mechanical properties, easy preparation and processability, but also have the biocompatibility, air permeability, and workability of hydrogel fibers, which have caught much attention in the field of flexible wearable devices.
In this paper, the template method is used to prepare hydrogel fibers, in the hydrogel fiber polyaniline (PANI) is used as conductive active material, polyvinyl alcohol (PVA) as the hydrogel elastic matrix, and 3-aminophenylboronic acid (ABA) as the chemical cross-linking agent. By changing the content of aniline and ABA, a series of hydrogel fibers (PPFH) with different concentrations were prepared. ABA provides a dynamic borate bond as a chemical cross-linking point to connect the chains between PANI and PVA. Scanning electron microscopy test results show that PPFH hydrogel fiber has a unique garland structure, which makes the fiber material have high mechanical properties (strength 0.55 MPa, elongation 530%) and electrical properties. The freeze-dried PPFH was sputtered with gold (current collector) using an ion sputtering apparatus. The electrochemical test showed that the PPHF achieves a high specific capacitance of 400 F/g at the current density of 0.5 A/g. In addition, due to its good mechanical properties, when PPFH is used as a strain sensor, the GF is 2.57 at 0-50% tension and 4.27 at 50-100%. It can be seen that PPFH hydrogel fibers have potential application prospects in the field of supercapacitors and sensors.

INVITED LECTURE

Autonomous power supplying and self-powered sensing smart fiber materials

Kai Dong
Beijing Institute of Nanoenergy and Nanosystems
University of Chinese Academy of Sciences

As a new kind of smart textile technology, textile triboelectric nanogenerator (TENG) can seamlessly integrate traditional wearable textile materials with advanced TENG science, which not only embraces the abilities of energy autonomy supply and self-powered sensing, but also maintains the desired aesthetic perception and comfortability for wearing. With the advantages of lightweight, low cost, flexible structure, extensive material selections, and high performance at low operating frequencies, textile TENGs have received broad interests both from research and industry fields, which show great application prospects in wearable micro-/nano power sources, self-powered sensing, healthcare monitoring, biomimetic systems, human-machine interfaces, and artificial intelligence. However, two key bottlenecks, i.e., low output power and inferior sensing ability have largely limited the development of textile TENGs. Large numbers of efforts have been made in order to improve the performance of the two aspects. This article aims to summarize these methods, which can provide theoretical guidance for the design and application development of textile TENGs in the future.

INVITED LECTURE

Growth engineering of 2D crystals for smart electronics

Dechao Geng
Tianjin University, China

Controlled growth of large-area and high-quality 2D materials has attracted intensive efforts in the past few decades owing to extraordinary properties and wide applications. Numerous methods have been developed for such aim, of which chemical vapor deposition (CVD) method offers compelling benefits in shaping 2D material single crystals due to its high controllability, high scalability and ultra-low cost. In my talk, liquid Cu assisted CVD method will be highly emphasized in formation of 2D crystals. Comparing to conventional solid Cu catalyst, the as-developed liquid Cu displayed several advantages over nucleation and growth of 2D materials. With introduction of liquid Cu, we first fabricated large-scale and uniform graphene single crystals and monolayer films, which showing relatively high carrier mobility[1]. Inspired by this thought, novel 2D materials have also been successfully produced, such as Mo2C, hBN and SiC and so on.[2] The controllable realization of a wide range of 2D materials on liquid Cu further demonstrates the generality in making 2D crystals. With those 2D materials as building blocks, a series of 2D heterostructures have been constructed on liquid Cu surface, such as graphene/hBN lateral heterostructure and graphene/Mo2C vertical heterostructure. In one word, with the help of liquid Cu catalysts, controllable growth of 2D single crystals has been realized by CVD approach.

INVITED LECTURE

Engineered Porous Molecular Coatings as Reactive Oxygen Species Generators and Reservoirs for Long-Lasting Self-Cleaning Textiles

Peng Li、Yao Wang
Fudan University

Biological threats, consisting of broadly acting and highly infectious pathogens, have recently emerged as serious global public safety concerns. As a result, wearable personal protective equipment that is decorated with photoactive self-cleaning materials capable of physically filtering and actively neutralizing biological pathogens before they can enter the body is in high demand. Traditional photoactive self-cleaning materials typically generate reactive oxygen species (ROS) driven by light absorption on the surface of the material, but they quickly lose their sterilization ability under dark conditions, so ROS storage materials remain undeveloped. Here, we developed a series of solution-processable, crystalline porous materials capable of addressing this challenge. Textiles coated with these materials exhibit a broad range of functionalities, including spontaneous oxygen enrichment from air, ROS generation upon absorption of daylight, and long-term ROS storage in dark conditions. Furthermore, the ROS generation and storage abilities of these materials can be further improved through the incorporation of electron-donating or -withdrawing groups onto the molecular building blocks, which enables tuning of the electronic structures and photophysical properties of the material without altering the three-dimensional assembled superstructures. In comparison with commercial TiO2 or C3N4 self-cleaning materials, the fluorinated molecular coating material HOF-101-F shows a 10- to 20-fold enhancement of ROS generation and 10-fold greater ROS storage ability, which allows for the rapid deactivation of highly infectious pathogenic bacteria under both daylight and light-free conditions for multiple cycles.

INVITED LECTURE

Semiconductor Fiber for Smart Clothing

Gang Wang
State Key Lab for Modification of Chemical Fibers and Polymer Metreials, Donghua University
College of Materials Science and Engineering, Donghua University

Flexible semiconductor electronic devices have important applications in wearable electronics, information technologies, and medical care. How to obtain both satisfactory flexibility and knittability while maintaining excellent semiconducting performance, and then integrate industrial manufacturing technology, is the key for applications of smart wearable fabrics. It's significant to obtain multifunctional semiconductor fibers is to design an efficient transportation pathway of electron-ion-photon on the surface of the one-dimensional fiber. In this work, we will focus on three aspects: (1) Micro-nano structure regulation of semiconductor nanofiber film: Fetch liquid crystal state with highly oriented conjugated polymer nanofiber fluid through the synergistic effect of UV light and microfluidic shear stress; (2) Microfluidic printing of large-area and highly oriented flexible thin film transistor devices: high-precision microfluidic printing equipment based on the idea of microfluidic shear orientation film formation, then through shearing and manifold design, the printing preparation of nanofiber-based flexible transistor arrays is realized; (3) Semiconductor fiber filaments: Proposing and using the idea of adjusting the micro-nano structure via "Microfluidic shear-Proton exchange", which brings the continuous preparation of semiconductor hybrid fibers at the kilometer level into reality. Furthermore, the fibers have their unique application in signal amplification, logic operation and so on. In addition, we will also briefly describe the progress based on semiconductor fiber materials in smart clothing integrated design and human-computer interaction applications.

Wearable Thermoelectric Materials and Devices for Self-Powered Electronic Systems

Qinglin Jiang、Yuguang Ma
South China University of Technology

The emergence of artificial intelligence and the Internet of Things has led to a growing demand for wearable and maintenance-free power sources. The continual push toward lower operating voltages and power consumption in modern integrated circuits has made the development of devices powered by body heat finally feasible. In this context, thermoelectric (TE) materials have emerged as promising candidates for the effective conversion of body heat into electricity to power wearable devices without being limited by environmental conditions. Driven by rapid advances in processing technology and the performance of TE materials over the past two decades, wearable thermoelectric generators (WTEGs) have gradually become more flexible and stretchable so that they can be used on complex and dynamic surfaces. In this report, the functional materials, processing techniques, and strategies for the device design of different types of WTEGs are comprehensively covered. Wearable self-powered systems based on WTEGs are summarized, including multi-function TE modules, hybrid energy harvesting, and all-in-one energy devices. Challenges in organic TE material, interfacial engineering, and assessments of device performance are discussed, and suggestions for future developments in the area are provided. This report will promote the rapid implementation of wearable TE materials and devices in self-powered electronic systems.

Intrinsically Stretchable Conducting Fibers for Adaptive Sensing

Shengtong Sun
Donghua University

Highly conductive and stretchy fibers that could be easily knitted into fabrics with high air permeability and unnoticeable size are the indispensable components for smart fabrics and wearable electronics. Based on the tortuosity management of conducting pathways, we focus on modulating the mechano-electric response of conductive fibers towards more advanced and diversified sensing applications. For example, we utilized a coaxial wet-spinning process for continuously fabricating intrinsically stretchable, highly conductive yet conductance-stable, liquid metal sheath-core microfibers. The microfiber with highly tortuous liquid metal percolating pathways can be stretched up to 1170%, and a very high conductivity of 4.35×10^4 S/m and resistance change of only 4% at 200% strain were realized. Moreover, we also designed a highly robust ionotronic fiber by synergizing ionic liquid and liquid crystal elastomer with alternate rigid mesogen units and soft chain spacers. Due to the formation of microphase-separated low-tortuosity ion-conducting nanochannels guided by aligned smectic mesophases, the ionotronic fiber shows an unprecedented strain-induced ionic conductivity boost (~103 times enhanced as stretched to 2000% strain). It is anticipated that our findings may contribute to the understanding and material design of more customized conductive fibers for advanced electronics and human-machine interfacing.

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INVITED LECTURE

Wearable Electrochemical Biosensors towards Self-powered Devices

Nan Zhu
Dalian University of Technology

Wearable energy storage and flexible body biomolecules detection are two key factors for real-time monitoring human healthcare in the practical fields, and it would be rather exciting if one wearable system could carry out both energy storage and biomolecules detection. Herein, wearable self-powered enzyme-free electrochemical martsensors has been proposed, simply remotely continuous detecting ions (Na+, K+, et al), metabolites (glucose, lactate, uric, et al) and special metabolites (cortisol, et al). In prospective studies, the design of wearable self-powered smartsensors, a demo of energy storage and enzyme-free biosensors in one system, provides a promising method in detecting body biomolecules and potentially implemented in the artificial intelligent fields.

INVITED LECTURE

Organic Memristor for Neuromorphic Edge Computing

Gang Liu
Shanghai Jiao Tong University

The exponential data outburst projected by the emergence of artificial intelligence (AI) and Internet of Things (IoTs) techniques requires higher computing power, which relays on the synergistic interplay of the more advanced nanoelectronic devices, very large-scale integrated circuit (VLSI) chips and complex algorithms, to handle the data-centric tasks. With the non-volatile resistive switching capability that makes the in-memory computing paradigm possible, memristor devices and their crossbar architectures are promising candidates for highly parallel neuromorphic processing units and offer brilliant solutions for the communication bottleneck problems of the post-Moore era. Many application scenario, including object recognition, natural language processing, decision making and etc, have been demonstrated with this blossoming electronic device during the past decade. In particular, organic memristor devices, with their low-cost manufacturing potential, mechanical flexibility and biocompatibility of the soft materials, and more importantly the inherent molecular level design of device electronic characteristics and functionaliaties, make themselves attractive building blocks towards the development of high-performance biology-related and brain-inspired AI systems. This talk will report the latest progress of organic memristor for high-density storage, in-memory neuromorphic computing and optoelectronic in-sensor computing in flexible edge applications.

INVITED LECTURE

Constructing high performance organic semiconductor devices via interface modulation

Lizhen Huang、Lifeng Chi
Soochow University

Organic semiconductor based optoelectronic devices have received tremendous attention owing to their tailoring chemical composition, simple fabrication and flexibility. Particularly, with the fast development of smart electronics, explore high performance chemical/biologic/physical sensors become a dynamic topic. One critical property of semiconductor sensor lies on the sensitivity upon exposure to the simulus, which is closely related to the structure, morphology and conductivity of the organic films. Herein, we introduced the constructing of a series of chemical/physics sensor via the interface property modulation. Through tailoring the interface morphology, electronic structure and charge transfer interaction, we obtained films with different charge transport ability and constructed devices with response to difference chemical species. Furthermore, the detailed relationship between charge transport property and the sensing performance was investigated.

INVITED LECTURE

Design of organic fluorescent materials and their application in trace hazardous chemicals vapor sensing

Yanyan Fu
Shanghai Institute of Microsystem and Information Technology, CAS

Organic fluorescent materials used for thin-film vapor sensors have received widespread attention in many areas such as public safety, environmental protection, and public health due to their high sensitivity, rapid response, and no pollution to analytes. Although in the past few years, scientists have developed many intelligent strategies in material design and device fabrication, the development of fluorescent vapor sensors is still lagging. The main challenges are: 1) Lots of fluorescent materials show weak luminesce in solid state because of ACQ (aggregate concentration quenching) effect; 2) Conventional film forming methods such as spin coating and evaporation often result in a densely packed surface morphology which lead to long response time and low sensitivity.
In order to meet the demand for high-performance detection equipment in the fields of anti-terrorism and anti-narcotics, we design and synthesize serials of organic sensitive materials and explore their application. The main work include: 1) A design strategy for improving the performance of fluorescent sensitive materials through the synergistic effect of the skeleton and the side chain is proposed for detection explosives. By activating the sensitive materials, the detection rate for of peroxide explosives is increased by 40 times and the detection limit is as low as 4.1ppt. A portable explosive detection instrument was prepared based on designed materials. The instrument has played an important role in major events such as the G20, the National "Two Sessions" and the Youth Olympic Games; 2) A new sensing mechanism of "heavy atom suppression effect" for the detection of methamphetamine has been proposed. 3) Various methods are used to control the surface aggregation state and microscopic morphology of the fluorescent sensitive material such as oxygen plasma treatments and breath figure method in order to improve the sensing performance.

INVITED LECTURE

Kilometers Long Graphene-Coated Optical Fibers for Fast Thermal Sensing

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The combination of optical fiber with graphene has greatly expanded the application regimes of fiber optics, from dynamic optical control and ultrafast pulse generation to high precision sensing. However, limited by fabrication, previous graphene-fiber samples are typically limited in the micrometer to centimeter scale, which cannot take the inherent advantage of optical fibers—long-distance optical transmission. Here, we demonstrate kilometers long graphene-coated optical fiber (GCF) based on industrial graphene nanosheets and coating technique. The GCF shows unusually high thermal diffusivity of 24.99 mm2 s-1 in the axial direction, measured by a thermal imager directly. This enables rapid thermooptical response both in optical fiber Bragg grating sensors at one point (18-fold faster than conventional fiber) and in long-distance distributed fiber sensing systems based on backward Rayleigh scattering in optical fiber (15-fold faster than conventional fiber). This work realizes the industrial-level graphene-fiber production and provides a novel platform for two-dimensional material-based optical fiber sensing applications.

INVITED LECTURE

Fibre Surface and Interfacial Engineering on Wearable Electronics

Xuqing LIU
the University of Manchester

The functionalization of fibre surface is an important technology for the development of functional textiles and fibre-reinforced composite materials. The conventional functionalization strategy is modified by covalent bonding, but it will damage the original structure of the fibre, especially for high-performance fibres such as carbon fibre. In recent years, our research group has developed new fibre surface modification strategies, π-π stacking， using polydopamine, tannic acid and curcumin and other aromatic compounds to modify the fibre surface, and a series of results have been obtained. We developed a series of conductive fibres and advanced fibre-reinforced composite materials. And based on these new conductive fibres, a series of wearable devices are integrated through advanced textile technology, including gesture control gloves, wearable inductive sensors, voice recognizers, and rehabilitation medical equipment. Our research provides a new type of functional fibre surface molecular engineering that can be industrialized in the future.

INVITED LECTURE

High-performance all-polymer solar cells: materials and devices

Huiliang Sun
Guangzhou University
Southern University of Science and Technology

Bulk-heterojunction polymer solar cells (PSCs) as a clean and renewable energy resource have attracted great atten- tion from both academia and industry. Recently non-fullerene PSCs based on polymer donors and small molecule acceptors have achieved remarkable success with the power conversion efficiencies over 18%. Among various PSCs, all-polymer solar cells (all-PSCs) consist of polymer donors and polymer acceptors, showing unique merits including superior stability and mechanical robustness. How- ever, the development of all-PSCs lag behind SMAs-based PSCs due to the scarcity of high-performance polymer acceptors. Recently, benefiting from the emergence of excellent electron-deficient monomers and the introduction of small molecule acceptor polymerization strategies, the power conversion efficiency of All-PSCs has exceeded 15%. This proposed report will introduce the development and challenges faced by All-PSCs and the latest research progres from our group.

INVITED LECTURE

Metal Oxide Semiconductors via Polymer Incorporation for Flexible Transistors

Wei Huang、Yuhua Cheng
University of Electronic Science and Technology of China

Metal oxide (MO) (semi)conductors have attracted great attention for next-generation flexible electronics because of their high carrier mobilities, optical transparency, and air stability. Nowadays, commercialized metal oxide (semi)conductors are fabricated by physical vapor deposition techniques, which are expensive and require photolithographic patterning, thus limiting roll-to-roll fabrication. In recent years, solution processing has emerged as an alternative way to deposit/pattern metal oxide (semi)conductors, but transistor performance is below that of physically deposited MOs. Polymer incorporation in metal oxide matrices holds the potential to yield enhanced performance on solution-processed metal oxide. Incorporating the functionalities of polymers into MO semiconductors can be achieved, leading to metal oxide transistors with mechanical flexibility, transparency, and high mobility. Moreover, polymer incorporation is an effective way to manipulate the solution rheological properties, making the precursors compatible with various printing techniques.

INVITED LECTURE

Nanomesh electrodes and sensors for wearable electronics

Binghao Wang
Southeast University

Too difficult to see a doctor and too expensive to see a doctor" has become one of the major public complaints in China today. In addition to relying on government support (such as appointment systems, centralized procurement of medicines), the improvement of laws and regulations, and the popularization of medical knowledge, wearable electronic technologies for health monitoring through the identification of common diseases (such as colds, fever), the early detection of serious diseases and an emergency SOS call for sudden illness can greatly reduce people's dependence on doctors.
Electrodes and sensors are the core components in the wearable electronics. Besides outstanding functionality and long-term stability, the large-area manufacturing and compatibility to human body are also critical issues. Thus, this report is divided into two parts: 1) In order to meet wearability requirements, metal oxide semiconducting nanofibers, fabricated by high-throughput blow-spinning technology, are integrated with soft substrates to achieve flexible/stretchable devices. These wearable devices are demonstrated for detection those related to human activities such as UV, pressure, temperature, exhalation, etc. 2) Fabricate gas-permeable nanofilm electrode (~150 nm thick) that can continuously monitor electrocardiogram signals for one week without delamination.

Color Carbon Fiber and Its Discoloration Response

Jing Hou、Zhen Zhu、Fan Wu、Peijun Xu
Changan University

Carbon fiber is widely used in various industries because of its excellent mechanical properties, low density and good electrical conductivity. Gradually, thedemands of carbon fiber have transformed from its excellent mechanical properties to functional or intelligent properties. If a carbon fiber has high strength, high modulus, excellent electrical or thermal conductivity, and color responsiveness, it would provide inspiration for the design of intelligent responsive carbon fiber composite materials.Graphene oxide (GO) is a two-dimensional material, which can orderly stack togetherand self-assemble into a lamellar stacked structure. Because this structure is analogousto one-dimensional photonic crystals, GO self-assemble film can exhibit structural color. In this paper, color carbon fiber with GO one-dimensional photonic crystal coating (colored-CF) is prepared by uniformly depositing on the surface of the carbon fiber by vacuum filtration method. Coloring mechanism of the colored-CF microstructure and intelligent color response are investigated. Moreover, the colored_x0002_CF has characteristics of color response under different solvents, temperature and stress.The results show that colored-CF can change color by the stimulation of different solvents, and this behavior is reversible. With the change of temperature, the cyclic discoloration behavior of the colored-CF can be realized by heating MgSO4·7H2O to continuously release crystallization water. Moreover, when the colored-CF is embedded in epoxy resin and the resin is stretched at both ends, which can realize the color response of the stress. Therefore, the color change response of colored-CF shows promise for a variety of potential applications in the temperature, humidity and strain detectors of carbon fiber preparation.

MXene and MWNTs-COOH Synergistically Synergize Poly(vinylidene fluoride)@Poly-L-lactic Acid-based Hybrid Tribo/Piezoelectric With Ultra-high Electrical Power Density

Xuan Li[1]、Yuzhou Wang[2]、Haihui Liu[1]、Na Han[1]、Xingxiang Zhang[1]
1. Tiangong University
2. Henan University of Engineering

Technologies that enable efficient nano energy harvesting are becoming one of the necessary technologies to better cope with future energy crises. In recent years, hybrid tribo/piezoelectric nanogenerators (HTPENG) have attracted attention for their ability to effectively combine frictional and piezoelectric effects. Conductive nano-fillers play significant roles in nucleation, aligning the dipoles, micro-capacitor formation, stress reinforcing, etc. for the performance enhancement of piezoelectric nanogenerators (PENG). In this research, we report a 132-fold increase in the electrical power density of Poly (vinylidene fluoride) nanofibers-based PENG using the synergy of the novel two-dimensional material MXene with the one-dimensional carbon material carbon nanotubes. Finite element simulations were used to determine the optimum triboelectric layer thickness as well as the optimum triboelectric layer spacing for constructing an HTPENG, and a PVDF@PLLA -based HTPENG was built, with power density of 18.08 W/m^2, which are enough to light up multiple light-emitting diodes in 10 seconds.

Large-scale assembly of highly stretchable and conductive polydopamine-generated poly (ethylene terephthalate)/ polyurethane fabric through the self-assembly intercalation strategy for superior sensing

Shuqiang Zhao、Peixiao Zheng、Honglian Cong、Ailan Wan
Jiangnan University

Smart wearable electronic devices with superb sensing performance have aroused superb attention in recent years. However, designing an admirable strain sensor with the excellent balance between superior sensitivity and excellent stretchability remains a major challenge. Herein, we developed a conductive polydopamine (PDA)-coated poly (ethylene terephthalate)/ polyurethane (PET/PU) fabric as the wearable strain sensor with the layered generating structure and the cooperative effect of carboxylated carbon nanotubes (CNTs-COOH) and reduced graphene oxide (rGO) via self-assembly intercalation process. Obviously, the cooperative conductive effect of conductive fillers endowed the fabric with a superb integration of tunable strain sensitivity (0-265.48), outstanding electromechanical performance, great stretchability (0-220 %), excellent heating performance, and long-term stability and repeatability under different strains over 2500 cycles. Especially, the as-prepared sensor was used for the detection of tiny body movements and vigorous human motions, indicating its further impressive prospect in wearable smart electronics. Therefore, such the proposed sensor with the layered generating structure exhibited remarkable potential for developing the flexible wearable electronic device of integrated sensing property and excellent electromechanical performance.

ORAL PRESENTATION

Ultra-stretchable, self-adhesive, transparent, and ionic conductive organohydrogel for flexible sensor

Chuanyue Sun[1]、Chengyi Hou[1]、Hui Zhang[1]、Yaogang Li[2]、Qinghong Zhang[2]、Hongzhi Wang[1]

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Conductive hydrogels are an ideal bio-integrated soft material and show great potential in soft sensors. However, it remains a great challenge to develop an integrated conductive gel combining excellent environmental stability and mechanical properties. Herein, we synthesize a transparent, self-adhesive conductive organohydrogel with excellent environmental stability and UV-blocking performance by constructing multiple cross-links between tannic acid, polyacrylamide, and polyvinyl alcohol. The addition of vinyl hybrid silica nanoparticles can promote dynamic cross-linking of polymer networks and endow organohydrogels with superior mechanical performance (>1800%, 320 kPa). Concurrently, the binary solvent system comprising water and ethylene glycol enables organohydrogels to accommodate different application environments (from -40 ○ C to 40 ○ C). Notably, with the incorporation of tannic acid, organohydrogels exhibit lasting and repeatable adhesion (80 kPa), as well as good UV-blocking (>90%). Furthermore, these conductive organohydrogels with great strain sensitivity were used as strain sensors to monitor and distinguish large movements (soft robot movements) and subtle human movements (smiling and electrocardiograph signal) at different temperatures. The conductive organohydrogels have great potential in healthcare monitoring and smart wearable soft electronic devices.

The continuous and scalable fabrication of organohydrogel fibers by wet spinning for wearable electronics

Shuo Chen[1,2]、Fan Zhang[1]、Zhengwei You[2]
1. Shanghai Jiao Tong University
2. Donghua University

Stretchable conductive fibers are key elements for next-generation flexible electronics. Most existing conductive fibers are electron-based, opaque, relatively rigid, and non-biodegradable. Accordingly, soft, stretchable, and biodegradable ion-conductive hydrogel fibers have attracted significant attention. However, hydrogel fibers are difficult to manufacture and easy to dry and freeze, which significantly hinders their wide range of applications. Herein, we developed a wet spinning strategy to achieve continuous and scalable fabrication of organohydrogel fibers to address these challenges. First, a newly designed hybrid crosslinking strategy continuously wet-spins hydrogel fibers, which are transformed into organohydrogel fibers by simple solvent replacement. The organohydrogel fibers show excellent antifreezing (< -80 °C) capability, stability (>5 months), transparency, and stretchability. Accordingly, strain sensors made from the organohydrogel fibers accurately capture high-frequency (4 Hz) and high-speed (24 cm s-1) motion and are powerful for detecting rapid cyclic motions such as engine valves and are difficult to reach by previously reported conductive fibers. Then, gelatin-based organohydrogel fibers are developed by a wet spinning approach based on the Hofmeister effect. According to the Hofmeister effect, we selected kosmotrope ion solution as the coagulating bath to achieve the fast and controllable gelation of gelatin-based hydrogels by the mechanism of salting-out of proteins. Beyond that, we also use the solvation effect of chaotrope ions to break the inter-chain hydrogen bonds, slowing down the spontaneous gelation of gelatin solutions and making the processing at room temperature available. Thus, we successfully established a continuous and scalable approach to spin pure gelatin-based hydrogel fibers without changing their chemical structures. We demonstrated their excellent biodegradability, biocompatibility, and edibility, which is difficult to achieve by existing stretchable and conductive fibers. The corresponding organohydrogel fibers with excellent anti-freezing capability and water retentivity were fabricated to demonstrate the application of wearable electronics. The organohydrogel fibers could work at −80 °C and be stored stably in the ambient environment for relative long time. The application potential as strain sensors, transient devices and optical fibers was demonstrated.

Transparent Metal–Organic Framework-Based Gel Electrolytes for Generalized Assembly of Quasi-Solid-State Electrochromic Devices

Zhiyuan Bai、Ran LI、Kerui Li、Chengyi Hou、Qinghong Zhang、Yaogang Li、Hongzhi Wang
Donghua University

Metal–organic framework (MOF)-based electrolytes under gel/solid states have been widely used for electrochemical devices recently due to their designable metal centers/ligands and diffusion channels in the porous structures. Therefore, it is always desired to apply the MOF-based electrolytes in electrochromic (EC) fields. Yet, challenges exist in realizing their high optical transparency to satisfy the unique optical requirements of EC devices. Herein, a transparent MOF-based gel electrolyte (MGE) is demonstrated through the incorporation of 2-methylimidazole among MOF nanocrystals to prevent the strong light scattering of MOF nanocrystals. As a result, the gel electrolyte showed an improved average transmittance of ca. 82.2% compared with the MOF electrolytes without 2-methylimidazole (ca. 59.2%). In addition, because of the designed large channels in the porous MOF structure, the gel electrolyte exhibited a high ionic conductivity of 2.66×10^{-3} S cm^{-1}. At last, we used the transparent MGEs to assemble two types (rigid and flexible) of quasi-solid-state EC devices based on inorganic WO_3 and organic poly(3,4-ethylenedioxythiophene) (PEDOT), respectively. Both devices showed great EC performances, and the flexible devices exhibited high mechanical stability under the bending state or even after being cut and punched, advancing the general applications of our transparent MGEs in EC fields.

ORAL PRESENTATION

Scalable production of ultrafine polyaniline fibers

Bo Fang、Xiaoming Tao
The Hong Kong Polytechnic University

Combined with the advantages of lightweight, flexibility and electron transport properties, conducting polymers have demonstrated great potentials in multiple structural and functional integrated applications, such as flexible light-emitting diodes, electrochromic displays and conducting glasses, etc. To lead this vision into reality, there is an urgent need to process conducting polymers into mechanical durable macroscopic materials. Among of them, conducting polymer fibers with mechanical and electrical durability offer advantages over other materials in the field of flexible and wearable electronics. However, limited by the rigid backbones and poor dispersibility, conducting polymers are generally difficult to be spun into fine fibers. Here we propose a strategy of good solvent exchange to fabricate continuous ultrafine polyaniline fibers using a modified wet spinning protocol. Due to the small diameter (below 5 micrometers) and fine microstructures, the ultrafine polyaniline fibers show an unrivalled mechanical strength, a high area capacitance and an impressive charge storage capacity. Based on their aggressive merits above, we extended the applications of ultrafine polyaniline fibers to several frontier fields, including fibrous supercapacitors and organic bioelectronic devices.

Wrinkled Polymer Fibers Composed of Carbon Nanotubes for Flexible and Highly Sensitive Strain Sensors

Enping Liu、Lele Li、Conghua Lu
School of Materials Science and Engineering, Tianjin University

Flexible and wearable sensors have attracted growing attentions with various of applications, such as wearable electronics, artificial skins, health-monitoring devices and so on. Distinguished from traditional membrane-based strain sensors, fiber-based strain-sensitive sensors have outstanding flexibility, integrated performance and strong adaptability to various complex activities of the human body, which are the essential component of wearable electronics. However, many existing fiber-based strain sensors are lack of abilities to perceive or respond to huge strains on human bodies. In our work, we developed a novel and convenient one-step method to produce the polydimethylsiloxane (PDMS) fiber-based strain sensor. Sonicated in the carbon nanotubes (CNTs)/cyclohexane dispersion, the PDMS fibers can be inserted or deposited by CNTs and form the wrinkled CNTs@PDMS fibers. The surface structures, conductivities and sensitivities of PDMS@CNTs fibers can be easily regulated by the ultrasonic time. Importantly, the CNTs@PDMS strain sensor can suffer a strain of 300% and the conductive CNTs layer has an excellent combination with the PDMS fiber because of the sonication process, endowing the CNTs@PDMS fibers with flexibility and usability. Therefore, the CNTs@PDMS fiber strain sensors have potential applications in wearable electronics.

Thermal-assisted brush printing of water-based In-Ga-Zn oxide transistors

Chenhong Zhang、Yanping Chen、Chengyi Hou、Gang Wang、Qinghong Zhang、Yaogang Li、Hongzhi Wang
Donghua University

As an environment-friendly technique, the water-based solution process has attracted numerous attention. Due to the ability to fabricate oxide semiconductor films for transistors with acceptable electric properties at relatively low temperatures (~200 °C lower compared with organic solvent), it has great potential in future display technology, and various correlation technologies are keeping emerging. Here, an efficient and facile water route thermal-assisted brush printing is demonstrated, which can be applied to fabricate the semiconductor layer of indium gallium zinc oxide (IGZO) thin-film transistors (TFTs) by the solution process. The synergistic effects of thermal-annealing and brush printing on the film formation process were comprehensively investigated, implying the synergistic effects induce the acceleration of the evaporation of the precursor solvent and promotes the lower surface roughness of as-prepared thin-film, resulting in improved transistor properties. Mechanically, the proposed film-forming model of thermal-assisted brush printing is also elaborated. This technique is expected to be a general guideline for the solution processing of metal-oxide thin-film transistors which could be applied in low-energy consumption wearable devices.

Graphene Enhancement of Regenerated Wool Keratin Hybrid Fiber for Muscle-like Training Actuator

Liang Zhang、Yuanlong Shao
Soochow University

Compared with rigid robots, soft robots have attracted extensive attention by the virtue of their higher compliance, higher degree of freedom and excellent ability to interact with human beings [1,2,3,4]. One of the critical reasons that limit the broad application of soft robots is lacking of appropriate soft materials with synchronous properties of actuating and programming functions [5,6]. Recently, keratin based biomass active materials have raised increasing attentions according its intrinsic great biocompatibility, abundant source and astonishing deformation mechanisms originate from the secondary structure transformation[7]. As a result, constructing keratin based filament is a promising approach to build artificial muscle containing both of great driving capability and biocompatibility[8].

Herein, we developed a graphene enhanced keratin hybrid fiber via wet-spinning approach and demonstrated its great property as self-programmed humidity responsive fibrillar actuator. The hybridization of low-defect graphene significantly enhanced its mechanical strength and moisture absorption and subsequent deformation capability. The thus-prepared hybrid fibrillar actuator exhibited a series of astonishing properties of a response speed of 1.25% S^{-1}, an actuating stroke of > 100%, and a volumetric energy density of 544.4 kJ m^{-3}. The fabricated keratin fibrous actuator is promising to serve as artificial muscle of soft robot and assisting the disabled in their daily life.

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Reinforcing Wool Keratin Fibers via Secondary Structure Transformation from "Snowing" Graphene Hybridization

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Beijing Graphene Institute

Keratin secondary structures, such as α-helix and β-sheet are the dominant components for constructing wool and other natural fibers, such silk and spider silk. The superior tensile strength of natural silk is mainly attributed to the tough mechanical feature of β-sheet, which is the leading secondary structure. For both of regenerated and natural wools, the relative low ratio of the β-sheet is the one of main critical reasons for determining the moderate mechanical strength rather than silk fiber. Graphene, as a hexagonal honeycomb single-atom laminate structure consisting of carbon atoms, exhibits a series of astonishing mechanical properties, such as great tensile strength and Young's modulus. In addition, graphene has been demonstrated to promote the transformation of low strength α-helix to tough β-sheet structure via non-covalent shear sliding actions, such as Van der Waals force and π-π conjugation. Thus, graphene introducing could be a promising strategy to enhance the mechanical properties of regenerated wool keratin fiber.
Herein, we developed an approach to hybridization of "snowing" graphene into all-wool-keratin fiber to significantly enhance the mechanical strength, while realize the large-scale production of graphene/keratin hybrid fiber via a wetting spinning strategy. Graphene hybridization achieved remarkable tensile strength enhancement (from 93 MPa of keratin fiber to 158 MPa of graphene/keratin hybrid fiber) according to the π-π conjugation between graphene flakes and amino from keratin. By the virtue of intrinsic low defect feature of "snowing" graphene, there is no steric hindrance from the oxygen-functional groups. In addition, the confinement space produced from the alignment of graphene flakes introduces the transformation from α-helix to tough β-sheet of the secondary structures. This work could shed the lights not only in the field of wool keratin fiber but also for the extended field of natural regenerated fiber for functional fabric and smart textiles.

Stretchable wrinkled RGO@PDMS fiber strain sensor for human motion detection

Lele Li、Conghua Lu
Tianjin University

Wearable strain sensors have important application prospects in the fields of human motion detection, health monitoring and human-computer interaction, but they still face poor stretchability and complicated preparation. In this paper, we have developed an RGO/PDMS fiber strain sensor with a labyrinth wrinkled structure that significantly improves the stretchability of the strain sensor. The wrinkle morphologies, conductivity and the sensing behaviors can be well regulated by adjusting the ultrasonic time. SEM observations have found that RGO is closely integrated with the PDMS fiber, and the wrinkles perpendicular to the fiber axis gradually vanish during stretching while the wrinkle structure along the fiber axis still retain. The fiber strain sensor can detect up to 128% strain and its maximum sensitivity (GF) is 2803. The fiber strain sensor has excellent cycle stability and repeatability, with a response time of 213 ms and a recovery time of 393 ms. Finally, the application of fiber strain sensor in human joint movement, micro-expression recognition and throat phonation is studied.

POSTER PRESENTATION

Flexible and Stretchable Thermoelectric Cooling Devices by Liquid Metal

Yunhe Xu
Donghua University

Temperature regulation has important significance to human comfort and health. Stretchable thermoelectric generators (TEGs) can meet personalized refrigeration needs, which may transform centralized refrigeration to personalized refrigeration, thus greatly reducing energy consumption and improving human comfort. However, progress depends on the integration of stretchable electrodes for robust electrical wiring. Here, we demonstrate a wearable stretchable TEGs that can provide cooling in excess of 8°C. Due to the integration of liquid metal conduction, silicone matrix and high rigidity thermoelectric leg novel design, the stretchable high flexible active cooling is achieved. In addition, they do not suffer electrical or mechanical failures when stretched to strains above 20%, making them ideal for human temperature management.

Carbon-based thin-film actuator with 1D to 2D transitional structure applied in smart clothing

Yangmin Jing
Donghua University

Flexible actuating materials play an important role in soft robots and wearable devices. Searching for the way to improve strength, sensitivity and controllability is one of the directions of efforts of actuators to meet the growing demands in smart electronics and smart clothing. Herein, a kind of thin-film actuator with transitional carbon structure is developed by ordered filtration of carbon nanotubes and graphene oxide. The properties can be adjusted by changing the amount of either component. The fastest responding time in this work is 0.4 s, and the highest contractile stress is up to 15.1 MPa. Inspired by the origami technique, it can perform rotating behavior after simple stress treatment. A kind of body temperature and humidity regulating cloth functionalized by such film actuators is also demonstrated based on the moisture-driven property.

An integrated flexible multifunctional wearable textile-based composites for personal healthcare

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2. Isfahan University of Technology

In this work, novel fiber-based sensing-shielding integrated multilayer composites (PCS) was fabricated by UV laser scribing and electroless plating. APTMS (silane coupling agent, 3-Aminopropyl)trimethoxysilane) modified carbon nanotubes exposed on PET substrate were used as the active layer for alloy deposition, and the carbon nanotube-silica gel mixture was considered as the shielding layer in the multilayer structure of composite. The microstructures and morphologies of composites were characterized by scanning electron microscope, X-ray diffraction spectrum, Fourier transform infrared spectrum and X-ray energy spectrum, respectively. Electrochemical performance and electromagnetic shielding effectiveness (SE) were investigated to show the sensing and shielding properties of composites. The conductive composite demonstrated satisfactory electrocatalytic performance for glucose oxidation under optimized conditions, with linear range (LR) of 1.0 mM - 5.5 mM and sensitivity of 6699.0 μA mM−1 cm−2 at high concentrations, while LR of 10 μM-60 μM and sensitivity of 7140.0 μA mM−1 cm−2 at low concentrations. Simultaneously, the composite exhibited admirable SE up to 43.64 dB in electromagnetic band of 30-6000 MHz. In addition, tensile test was conducted to validate excellent serviceability and stretchability of the composite. Such multilayer composites with integrated sensing-shielding function endow great potential in personal healthcare including physiology monitoring and electromagnetic interference (EMI) shielding.

Continuous Wet-spinning of Wool-Keratin fiber with silk-like toughness via Dithiol Chain Extending

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By the virtue of its natural origin, robust mechanical properties, low-cost and great biocompatibility, wool keratin has drawn increasing attention and developed for broad applications[1]. More intriguingly, silk contains the similar hierarchical secondary keratin structures as wool, namely α-helices and β-crystalline sheets[2-3]. Thus, reconstructing biomimetic silk fiber via assembly of wool keratin secondary structure has been considered as a promising approach to large-scale fabricate all-protein artificial fiber with low cost and great mechanical strength[4-5]. However, due to intrinsically limited molecular weight and water solubility, there still lack of a versatile approach to achieve continuous preparation of tough fibber with regenerated wool keratin.

Herein, we develop a continuous wet-spinning strategy to reconstructing all-protein fiber with regenerated wool keratin via disulfide re-bonding. First, concentrated L-Cysteine solution have been utilized to break the disulfide bonds within wool to extract wool protein without damaging the main chain structure. The chain length and molecular weight are the crucial parameter to determine the mechanical strength and other intrinsic physical features of the final regenerated wool keratin fiber. Afterwards, the dithiol chain-extending strategy, such as dithiothreitol (DTT), has been introduced to lengthen protein chain. We find that extension of intrinsic disulfide linkages could not only rebuild the bisulfide bonding inside the secondary structures, but also form covalent bonding between different keratin chains via thiol groups bonding from possible protein backbone collision and molecular chain sliding. Furthermore, we systematically investigated the spinning solution preparation, other detail parameters of wet-spinning process, such as coagulation, oxidation, and final winding. The scalable fabrication of the all-keratin fiber could provide a novel approach to reuse wool waste and produce material for smart textile and bioengineering applications.

Readily fabricated, biodegradable, biocompatible PEDOT:PSS/PGS Electrode for Stretchable Electronics

Sihan Jiang、Shuo Chen、Zhengwei You
Donghua University

Stretchable electronics have gotten lots of attention in recent years for their applications in wearable electronic devices and E-skins. Stretchable electrodes are the key component of the stretchable electronics. Particularly, stretchable electrodes with good durability, degradability and biocompatibility are highly required for the transient and environmental-friendly electronic applications. In this work, we developed a biodegradable and biocompatible stretchable electrode by conveniently spraying the poly(3,4-ethylenedioxythiophene):poly(styrene sulfonate) (PEDOT:PSS) solution onto the pre-stretched poly(glycerol sebacate) (PGS) substrates without additional processing. PGS is one of the most widely used bio-elastomers and has been proved an excellent component for electronics in terms of the elasticity nature and the degradation features. Structurally, a large amount of the hydroxyl groups attach to the PGS elastomers' carbon backbone contribute to the excellent wettability, which makes facile spraying coating of PEDOT:PSS aqueous solution on them. Spraying coating is simple and flexible, and readily to be used to make the stretchable patterned electrodes. The prepared electrode shows high conductivity with a sheet resistance of 90 Ω/□, high stretchability up to 100% strain, and high robustness that keep high conductivity after 500 cycles of stretching. The stretchable electrodes also showed excellent biocompatibility and biodegradability, degrading about 15% of its mass within 6 weeks, which makes them suitable for biomedical applications. Based on the strain-dependent conductivity and biocompatibility, the stretchable electrodes are used to monitor a variety of bioelectrical signals, including electrocardiogram (ECG) and human motions with high sensitivity.

基于磁粉/硅胶/液态金属线的柔性磁电纤维的制备与应用

杜卓林、吴振华、 苏彬
华中科技大学

生物机械能是一种非常稳定且环保的能源体系。如果能利用柔性可穿戴体系，将人体运动时产生的生物机械能转换为电能并加以利用，那么就能将人体本身变成稳定的能源供应体系。本文以磁电材料作为研究对象，将磁性粉末与纤维制备技术相结合，采用液态纺丝法制得了一种柔性磁性纤维。研究表明，磁电纤维以一定的拉伸速率和形变量进行往复拉伸运动时能够产生稳定的感应电压，是一种理想的自供能传感器件，具有良好的力学、磁学和电学性能，在智能感知及可穿戴器件等领域有着广阔的发展前景。

Origami Silk Fibroin Film Enabled by Gradient Structure

Jie Chen、Haoyang Xu、Rongliang Wu、Suna Fan、Yaopeng Zhang
State Key Laboratory for Modification of Chemical Fibers and Polymer Materials, College of Materials Science and Engineering, Donghua University, Shanghai, 201620, China

As one of paper art techniques, origami points out the development direction of biomaterials as flexible substrates, and meets the development of personalized medical monitoring, which has put forward flexibility demand for wearable and transplant monitoring devices. Here, we propose a gradient structure strategy to simultaneously endow silk fibroin (SF) film with foldability and strength. Specifically, solvents with different polarities are used to regulate the condensed structure of SF. As a result, a buffer layer and a barrier layer on the surface are formed, which resist the transformation of the internal secondary structure during the process of ethanol post-treatment. Notably, the SF film can fold into a paper crane and paper boat. In addition, SF these films can afford nearly 2000 times their weight in the air.

POSTER PRESENTATION

Highly transparent, stretchable, and self-healable ionogel for multifunctional sensors, triboelectric nanogenerators, and wearable fibrous electronics

Hongfei Huang、lijie sun、qingbao guan、zhengwei you
Donghua University

Ionogels with high transparency, stretchability and self-healing capability show great potential for wearable electronics. Here, a kind of highly transparent, stretchable and self-healable ionogels are designed using double physical cross-linking including hydrogen bonding and dipole-dipole interaction. Owning to the dynamic and reversible nature of the ion-dipole interaction and hydrogen bonds of polymeric chains, the ionogel possesses good self-healing capability. The multifunctional sensors for strain and temperature are fabricated based on ionogel. The ionogel can serve as strain sensor that exhibited high sensitivity (gauge factor (GF) = 3.06) and durability (1000 cycles) to a wide range of strains (0-300%). Meanwhile, the ionogel shows rapid response to temperature, due to the temperature dependence of its ionic conductivity. Furthermore, the ionogel fibers with excellent antifreezing (-20 °C) capability are fabricated, and the fibers show the good sensing performance to human motions and temperature. Importantly, the antifreezing ionogel-based triboelectric nanogenerator (ITENG) is assembled for efficient energy harvesting. The ITENG shows a short circuit current (ISC) of 6.1 μA, open circuit voltage (VOC) of 115 V, and instantaneous peak power density of 334 mW m-2. This work provides a new strategy to design ionogels for the advancement of wearable electronics.

KEYNOTE SPEECH

Electrospun fibers for drug delivery: Some recent advances

Gareth Williams、Karolina Dziemidowicz、Ziwei Zhang、Hend Abdelhakim
University College London

Electrospinning is a powerful method for generating fibres with diameters on the nano-to-micro scale from polymer solutions. Electrospun fibres have been very widely explored for drug delivery applications, most commonly as a method to accelerate the dissolution of poorly soluble active pharmaceutical ingredients (APIs). There exist however a range of other possibilities, including targeted, delayed, and stimulus-responsive release. In this presentation, we will discuss some recent advances in the development of electrospun fibres able to release drug in response to pH, thermal, or biochemical stimuli. We will explore fibres combining APIs with diagnostic agents, with the aim of providing simultaneous diagnosis and treatment of a disease (so-called theranostics). Approaches to post-fabrication surface modification to impart the fibres with additional functionality will be also considered. Finally, we will briefly discuss the patient acceptability of electrospun formulations, a key issue that needs to be taken into account prior to their clinical adoption.

KEYNOTE SPEECH

Liquid Metal-Polymer Composites for Wearable and Implantable Bioelectronics

Xingyu Jiang
southern university of science and technology

By confining liquid metals into polymeric composite (MPC), we can make robust flexible electronic devices that highly biocompatible. These MPC-enabled devices can be directly attached to the skin, as well as attached to internal organs and tissue. We have made epidermal electronics for monitoring motion, sensing sweat biochemistry, as well as for recording electrical signals from the heart, the brain and skeletal muscles. Combined with our expertise in microfluidics, we can carry out high throughput analysis of biological entities for improvement of outcome in quality of diagnosis, such that many diseases can treated early or prevented. Miniaturization allow diagnostics to become de-centralized such that many types of assays can be done in point-of-care settings, instead of in centralized laboratories. These point-of-care applications allow many of these assays to become more like the blood sugar tests, which are increasingly done at home. An idea in the making is to further miniaturize these devices such that they can be wearable. MPC) can be really an enabling technology for such an effort.

KEYNOTE SPEECH

Research Experience on Textile-based Implantable Device in Soft-tissue Reconstruction

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This presentation focus on textile-based implantable devices in the fields of tissue-induced regeneration. Textile materials can be matched to the natural tissue in terms of morphology, scale, and viscos-elastic mechanical characteristics by adjusting the structural parameters. Fibers assembly formed uniform and controllable space grid structures, which provided space for the transportation of nutrients, gas, wastes of cells, and could induce functional tissue regeneration. There are several basic properties of those devices (e.g., composition, topographical substrates, mechanical stimulation, 3D microenvironments), which are closely associated with cell behaviors and tissue/organ functions. High-performance devices for soft tissue replacement with appropriate mechanical support can be achieved through textile structure design (e.g., fiber or yarn design, two-dimensional or three-dimensional scaffold design). Additionally, functional modification can provide those devices specific biocompatibility such as anti-inflammatory, anti-fibrosis, or stimulate regeneration. This presentation discussed textile-induced regeneration mainly from two levels. Firstly, summarize the factors of the textile-based devices that may influence cell behaviors and tissue regeneration. Then, illustrate specific textile scaffolds design and development process, such as blood vessel, tendon, bone et al. Hopefully, the discussion of challenges and perspectives on the development of textile-based tissue-engineered devices can serve as an inspiration for researchers who want to work with textiles and providing a perspective from human tissue structure.

KEYNOTE SPEECH

Tumor microenvironment responsive nano systems for diagnosis and treatment

Tao Yi
Donghua University

Compared with normal tissue, the physical and chemical properties of cancer regions are significantly abnormal. In particular, the tumor microenvironment (TME) tends to exhibit a series of unique characteristics, such as lower pH and higher reactive oxygen species (ROS) levels. In order to improve the treatment efficiency of malignant tumors and reduce the side effects in the treatment process, we developed a series of responsive nano diagnosis and treatment systems that could be activated by specific biological enzymes, pH and ROS in TME. These materials could combine detection, imaging and treatment according to the differences between tumor and normal cell microenvironment. As a result, the TME activated multi-mode cancer therapies could substantially improve the therapeutic eff ectiveness with few side eff ects.

KEYNOTE SPEECH

Near-Field Electrospun Vascular Template/Graft Designed for In Situ Regeneration

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2. University of Memphis

Background: The ideal “off the shelf,” synthetic, bioresorbable, small-diameter (< 6 mm inner diameter (ID)) vascular graft hinges on designing a structure to act as a template that facilitates transmural ingrowth of capillaries to regenerate a neointima. Objective: This study aimed to design the next generation, small diameter, vascular graft to support in situ vascular regeneration. Methods: This study utilized an NFES device to semi-stable write novel polydioxanone (PDO) microfiber-based vascular conduit templates. The template fabrication as programmed was then verified, followed by uniaxial mechanical testing, template wall permeability, and acute, in vitro neutrophil extracellular trap induction evaluations. Results: The semi-stable polymer spinneret was programmed to translate in a stacking grid pattern, resulting in a template with highly aligned grid fibers intercalated with low density, random fibers. Because of this semi-stable process, increasing the grid dimensions resulted in a lower density of fibers in the center of each grid in the template and a lower density of “rebar-like” stacked fibers per unit area. The NFES templates were tailorable to have greater ultimate tensile strength, percent elongation, yield stress, and yield elongation compared to traditional electrospun templates of the same fiber diameter yet higher fiber density. These improvements are primarily due to the programmed, reinforcing grid structure. The acute neutrophil response demonstrated that the NFES templates significantly attenuated NET induction relative to traditional electrospun materials. Conclusions: NFES allows for unprecedented control over template fabrication. This fiber control was further leveraged to create a novel geometry of highly ordered, stacked fibers and low-density random infill. The biologically relevant pore sizes and mechanical properties can be tailored as a function of programming to create the next generation vascular regeneration template capable of regeneration that is promoted by the acute, interacting neutrophils.

KEYNOTE SPEECH

Bio-inspired multiscale adhesive interfacial materials

Shutao Wang
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Bio-interfacial adhesion has become a frontier hot in interfacial chemistry. It is not only helpful for us to understand the mystery of living systems, but also important for the development of new functional interfacial materials and related technologies. Leaning from nature, our group has recently investigated several special adhesion phenomena on biointerfaces and developed a series of bio-inspired adhesive interfacial materials. 1) We discovered the superdurability of bird feathers against tears originated from their cascaded slide-lock system, not from the "hook–groove system" proposed centuries ago; Inspired by the arrester system of dragonfly, we developed a new mechanical interlocker with a nylon pestle instead of the traditional hook, which breaks the limitation of traditional Velcro with undesirable deformation, breaking and noise. 2) Inspired by immune system, we proposed the concept of synergistic effect of biointerface adhesion based on structural matching and molecular recognition for detecting circulating tumor cell (CTC). We have developed a series of CTC detecting biochips by chemical etching, vapor deposition, electrochemical deposition, template replication, electrospinning and others; We also developed an emulsion interfacial polymerization strategy to fabricate bio-inspired immunomagnetic bead (spanning from Janus to porous) with controllable topology and surface chemistry. 3) We disclosed the microstructure of wound blood scab and developed a series of wound dressing, greatly promoting wound healing.

Engineering PNAGA and its variant hydrogels for diverse biomedical applications

Wenguang Liu、Ziyang Xu、Chuanchuan Fan、Rong Yang、Chunyan Cui
School of Materials Science and Engineering, Tianjin University

It has been fifty-four years since N-acryloyl glycinamide (NAGA) monomer and its polymer (PNAGA) were reported in 1964. It is characterized by two amides in its side chain. The concentrated aqueous solution of PNAGA has been shown to form supramolecular polymer (SP) hydrogels which are physically crosslinked by dual-amide hydrogen bonds, and the SP hydrogels' mechanical properties can be tuned by varying initial monomer concentration, substitution groups as well as feature monomer copolymerization. Recently, our group has reported on high strength and soft PNAGA SP hydrogels by modulating hydrogen bonding density, and these SP hydrogels are developed as 3D printing bioinks for regeneration of osteochondral defect, an autolytic high strength instant adhesive hydrogel for emergency self-rescue, and a Janus hydrogel wet adhesive for internal tissue repair and anti-postoperative adhesion. The Janus hydrogel wet adhesive with strikingly distinct adhesive/nonadhesive properties on its two sides is fabricated by gradient polyelectrolyte complexation via one-sided dipping of carboxyl-containing hydrogel in cationic oligosaccharide solution. This Janus hydrogel demonstrates an instantly robust adhesion to soft tissues under water, and is successfully used for repairing perforated stomach of rabbits, meanwhile preventing post-operative tissue adhesion in vivo.

Electrospun Nanofiber and Nanoyarn for Hard and Soft Tissue Regeneration

Xiumei Mo
Donghua University

Electrospinning nanofiber can biomimetic Extracellular Matrix and suitable for tissue scaffolding. In our research silk-P(LLA-CL) complex nanofibers tube scaffold have been fabricated for nerve tissue engineering, collagen-P(LLA-CL) nanofibers tube scaffold have been fabricated for blood vessel tissue engineering. Coaxial electrospinning has been used to spin the growth factor into nanofibers to promote the tissue regeneration, NGF in nanofiber promoted nerve regeneration, VEGF in nanofiber promoted endothelia cell proliferation.

Here, we report various types of an active wound dressing with extensive physicochemical and biological evaluation. In the first study, we fabricated poly-(L-lactide-co-caprolactone) (PLCL/ silk fibroin (SF) based electrospun nanofibers loaded with Phellodendron. The obtained nanofibers were capable to prevent bacterial growth. Moreover, the nanofibers successfully closed the diabetic wound with complete epithelialization and collagen deposition. The nanofibers mediated gene expression including upregulation of TGF-β, α-SMA, Col1, Col3, and downregulation of proinflammatory cytokines such as IL-1β and TNF-α was observed. Similarly, PLCL/SF based electrospun nanofibers loaded with oregano essential oil (OEO) and PLGA/SF based nanofibers loaded with ZnO nanoparticles were also fabricated. We demonstrated multifunctionality including antibacterial, antioxidant, and in vivo wound healing capabilities. In a subsequent study, we employed a novel strategy to load a volatile compound, OEO, into the core of nanofiber and ZnO into the shell thus enabled dual bioactive agent delivery on the wound site. Physicochemical and mechanical characterization confirmed the nanofiber structure was suitable for wound healing applications. In vitro, biological evaluation confirmed the antibacterial, antioxidant, and cytocompatibility of the nanofibers. Moreover, we demonstrated the diabetic wound healing potential with early wound closure, complete epithelialization, angiogenesis, collagen deposition, and granulation tissue formation. VEGF expression was also studied via immunochemical staining. Moreover, the nanofibers were found to play substantial roles in downregulating the pro-inflammatory cytokines.

Electrospinning fabrication technique most commonly produces relatively 2D mats and the construction 3D structure nanofibers with higher porosity is still a major challenge. In our research, two methods were used to fabricate the 3D nanofiber scaffolds. A dynamic electrospinning method were developed to fabricate the nanoyarn scaffold. The nanoyarn scaffold contained 3D aligned microstructures with larger interconnected pores and higher porosity comparing with nanofiber scaffold. The nanoyarn scaffold have been successfully used for tendon tissue regeneration of rabbit. The nanoyarn has also used to prepare bilayer blood vessel scaffold to be as out layer to regenerate the smooth muscle tissue. Gelatin/PLA nanofiberous 3D scaffold was fabricated by using combined electrospinning and freeze-drying methods. Thus obtained 3D nanofiber scaffold could promote cells infiltration in three dimensionally, it also been succeeded for tissue engineering in rabbit articular cartilage. Gelatin/PLA nanofiberous 3D scaffold also be immobilized with BMP-2 peptides and used for bone tissue regeneration, it helped for critical skull regeneration in rat.

KEYNOTE SPEECH

Long-Lived Phosphorescent Probes for Time-Resolved Luminescence Bioimaging and Photodynamic Therapy

Qiang Zhao
Nanjing University of Posts and Telecommunications

Phosphorescent materials have been widely used to design bioprobes and photosensitizers owing to their unique triplet excited-state properties and excellent phosphorescence characteristics. Especially, the long phosphorescence lifetime allows them to use time-resolved luminescence techniques, including photoluminescence lifetime imaging microscopy and time-gated luminescence imaging techniques, to minimize the interference from the short-lived autofluorescence in biological systems. In recent several years, I have continuously focused on the research of phosphorescent probes and their biological applications. In this talk, I will introduce the design, synthesis and biomedical applications of long-lived phosphorescent probes and photosensitizers, including their applications in time-resolved luminescence biosensing, bioimaging and photodynamic therapy in vitro and in vivo.

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KEYNOTE SPEECH

Investigating the EPR effect of EPR effects in human renal tumors via ex vivo perfusion strategy

Linqi Shi
Nankai University

The enhanced permeability and retention (EPR) effect in human solid tumors is being increasingly ques-tioned due to the failure of many nanomedicines in their clinical translation. Herein, we developed an exvivo perfusion model for real-time investigation of the EPR effect in human renal tumors via X-ray com-puted tomography (CT), proving the EPR in human solid tumors and correlating the EPR effect in humantumors with that in animal models. Unexpectedly, more than 87 % of human renal tumors displayed aconsiderable EPR effect, which yet showed significant diversity and heterogeneity in different patients.For the first time, we unraveled that the EPR effect in renal tumors was positively correlated with thetumor size, and tumors from male patients exhibited a significantly higher EPR effect. This ex vivo modelprovides an efficient strategy for investigating the EPR effect in human tumors. Our results may providea theoretical basis for the development of anticancer nanomedicines in the future.

KEYNOTE SPEECH

SELF-AMPLIFYING ACTIVE TARGETED DRUG DELIVERY SYSTEM BASED ON CHAIN REACTION

Chaohui Tang
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Active tumor targeting drug delivery has great potency in cancer therapy. However, the targeting efficiency of traditional active tumor targeting nanotherapeutic drugs is limited by the scarcity of their accessible targets/receptors in tumors. Here, a novel self-amplifying tumor-targeting strategy with a chain reaction mechanism is developed. A coagulation targeting peptide (GNQEQVSPLTLLKXC, termed A15)-decorated poly(L-glutamic acid)-graft-maleimide poly(ethylene glycol)/combretastatin A4 conjugate (A15-PLG-CA4) is prepared to obtain a self-amplifying nanotherapeutic platform homing to tumors. After administration to tumor-bearing mice, A15-PLG-CA4 started a chain reaction cycle consisting of intratumoral hemorrhage, target FXIIIa amplification, blood clot binding and CA4 release in tumors. In this way, A15-PLG-CA4 increased the level of its accessible targets (FXIIIa) in a manner of chain reaction. The FXIIIa activity at 8 h was 4.1-fold more than the one at 0 h in the C26 tumors treated with A15-PLG-CA4. The total CA4 concentration at 24 h was 2.9-fold more than the control. A15-PLG-CA4 showed a significantly higher antitumor effect against large C26 tumors (~500 mm3) thanks to the remarkable tumor-targeting ability compared with the control. This report highlights the high efficiency of A15-PLG-CA4 in tumor-targeting drug delivery and the potential of the self-amplifying strategy in the development of next generation active tumor targeting nanotherapeutic drugs for tumor therapy.

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KEYNOTE SPEECH

Fibronectin-encapsulated nanocomplexes for cancer therapy through ferroptosis-enhanced immunogenic cell death

Xiangyang Shi
Donghua University

Traditional chemotherapeutic drugs have the disadvantages of side effects, poor selectivity, etc., and to a certain extent have a destructive effect on the body's immune system, which makes it impossible to fundamentally solve the problem of recurrence and metastasis of cancer cells. Therefore, it is of great significance to develop a new multifunctional nanosystem that has tumor-specific targeting and combines all-in-one multiple treatment modes. Herein, we have constructed a theranostic nanoplatform of DOX-loaded nanocomplexes coated with fibronectin (FN), which can cause immunogenic death of tumor cells through chemotherapy and ferroptosis to achieve multiple therapeutic effects. First, the tannic acid/iron nanocomplexes loaded with the chemotherapeutic drug DOX (DOX-TAF) were prepared by a one-pot method, and then the FN with a unique RGD sequence was coated onto the surface of the nanocomplexes through hydrogen bonding to obtain the FN-coated drug-loaded nanocomplexes (DOX-TAF@FN). The prepared DOX-TAF@FN can target tumor cells with high expression of αvβ3 integrin. On the one hand, they can trigger the lipid peroxidation of tumor cells, leading to ferroptosis of tumor cells. On the other hand, DOX can cause the tumor cell apoptosis. Both can cause tumor cells to release corresponding antigens to cause immunogenic cell death. The formulation of DOX-TAF@FN can be supplemented with PD-L1 antibody to achieve enhanced immunotheraputic effects, which can effectively solve the tricky problems such as tumor recurrence. In addition, the DOX-TAF@FN can also be utilized as a contrast agent for high-efficiency T1-weighted MR imaging of tumors. The DOX-TAF@FN nanocomplexes prepared in this study have good biocompatibility and application potential in the field of MR imaging and tumor combination chemo-immunotherapy.

KEYNOTE SPEECH

Quantitative particle uptake by cells

Wolfgang Parak
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Nanomaterials play a promising role in the advancements of technology and health care. Their nanometric size combined with particular optoelectronic, magnetic, or plasmonic properties makes them suitable candidates for theranostics, biosensing, and bioimaging applications. This led to intensive investigation of the interaction of nanoparticles (NPs) with cells. Whereas most studies are focused on how the physicochemical properties of NPs will influence their uptake by cells, much less is known about their potential excretion from cells. However, to control and manipulate the number of NPs in a cell both, cellular uptake and excretion need to be studied quantitatively. Monitoring the intracellular and extracellular amount of NPs, after residual non-internalized NPs have been removed, over time enables to disentangle the influence of cell proliferation and exocytosis, which are the major pathways for the reduction of NPs per cell. Proliferation depends on the type of cells, and exocytosis depends on the size of the NPs. Examples are given on the role of these two different processes for different cells and NPs.

INVITED LECTURE

Biomimicking PEDOT Materials and Devices with Selective Electro-Coupling to Cells

Bo Zhu
上海大学

Bioelectronic devices, which extract precise biological signals and regulate the tissue function by applying tuned electrical stimuli, can close the gap of electronic devices with tissues and play a crucial role in neural prostheses, bioelectronic medicine, and built-in sensors. However, the foreign-body reaction induced scar formation and the interference of the nonspecifically bound proteins/cells to the signal extraction are challenging their long-term stable electrocoupling with tissues. The long-term bioelectronic device should combine softness, protein resistance, and targeted electrocoupling to ensure the required biocompatibility and efficient signal trade-offs between devices and tissues. Being driven by this aim, we have adopted a biomimicking design for the electronic materials of devices, including the conducting and insulating polymers. We synthesized a series of bio-mimicking PEDOTs with either static, dynamic, or 3D cell interaction of high selectivity and low impedance during the past several years. These conductive polymers have demonstrated an intimate, stable, and efficient electrical electrocoupling with targeted cells by integrating nonspecific-binding resistance, specific interaction, and low-impedance. As the insulating surface is the central part of the device surface, we further synthesized protein-resistant Parylene polymers to ensure the biocompatibility of electronic devices. We utilized the cell-selective PEDOT polymer and the cell-resistant Parylene polymer to construct a fully biomimicking OECT array device. It has demonstrated a spatially resolved and selective electrocoupling to targeted cells. Recently, we also initialized the implantation evaluation for these biomimicking devices and hope that our biomimicking materials design would endow them with long-term implantation stability.

INVITED LECTURE

Chiral Hydrogels Biomaterials

Chuanliang Feng
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Chirality is one of life's most distinctive biochemical signatures and has great influence on many biological events, e.g. maintaining normal functions for living cells. How nanofibrous chirality influences cell behaviors in three dimensional (3D) extracellular matrix (ECM) is especially important, since it is only the 3D ECM nanofibrous structure can really mimick the necessary biophysical environment for tissue engineering and helical nanofibrous structure is closely related with the relevant biological events. To explore this, supramolecular gelators are of particular interest candidate because their assembly arises from non–covalent interactions. With the rational design of chemical composition and molecular structures, surpramolecular gelators can be efficiently self-assemble into two or three dimensional chiral microstructures, showing a big potential as biomimetic scaffold for multi-dimensional cell culture. With variation of physical or chemical properties, the chiral structures with the varied surface composition, mechanical strength, and surface wettability can be constructed and chirality regulated cell adhesion can be obtained in 3D.

INVITED LECTURE

Light/ultrasound-triggered organic-inorganic nanocomposites for efficient tumor theranostics

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Donghua University

Cancers pose a serious threat to human health, and thus cancer therapies with high efficacy and low side effects are highly desired. The novel therapies with photothermal/chemo/sonodynamic functions are emerged, and the key is to develop multifunctional nanomaterials. We early prepared several kinds of semiconductor nanoagents (CuS, $W_{18}O_{49}$) which could produce high local temperature to thermally ablate cancer cells under near-infrared laser irradiation for several minutes [1, 2]. In order to improve therapeutical efficiency, we then integrated photothermal agents with thermal-sensitive nanogels, and the obtained smart nanocapsules (G-CuS-DOX) could be switched by near-infrared laser to control drug releasing behavior [3]. To guide tumor treatment, several all-in-one type nanomaterials (Fe_2S, Bi) with clinical imaging and therapeutical capacity were synthesized via morphology control and elemental doping, achieving efficient tumor theranostics [4, 5]. Furthermore, to break through tissue penetration limitation of light, we currently developed a series of ultrasound-responsive metal-organic frameworks (MOF). For instances, Fe-HMME MOF can generate singlet oxygen to inhibit the growth of tumors once exposed to ultrasound with 2 cm pork-barrier [6], and Mn^{3+}-HMME can modulate tumor microenvironment to release HMME and Mn^{2+} ions to simultaneously augment magnetic imaging contrast and sonodynamic efficiency [7]. Therefore, these light/ultrasound-triggered organic-inorganic nanocomposites have great potential for tumor theranostics.

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INVITED LECTURE

Designing smart and biocatalytic materials for antibacterial and antiviral biomedical applications

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Diseases caused by pathogenic microorganisms (bacteria, viruses, etc.) are considered to be one of the world's greatest health challenges, and the high variability of microorganisms, such as bacterial resistance and high mutation of RNA viruses, pose serious problems for the maintenance of public health. Therefore, the research and development of broad-spectrum antibacterial and antiviral agents have become a common goal for researchers all over the world. In recent years, our team has designed and screened a large number of low-dimensional functional materials engineered by coordination polymers and nanotechnology. We have constructed a variety of intelligent and efficient broad-spectrum antibacterial and antiviral nanostructures or targeted inhibitors, and proved their large-scale preparation and anti-pathogen mechanisms (1-3). In addition, by combining novel coordination polymers, organic conjugate coordination molecules, metal-organic frameworks, conjugated organic frameworks, and other new low-dimensional functional materials, our team has constructed abundant biomimetic catalytic materials that can be used for diverse biomedical fields, including anti-tumor, arthritis, stem cell protection, anti-inflammatory, and tissue regeneration (4-5). These studies have expanded the material type, clinical application scope, and transformation values of the intelligent and bionic nanomaterials and polymeric biomaterials.

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Cell mechanoresponse

Qiang Wei
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Chemical and physical cues at cell-material interface mediate various of cellular behaviors, including adhesion, migration, differentiation, etc. Cells mechanically sense and respond to these cues to initiate mechanotransduction pathways and alter cellular phenotype and function. The profile of cell mechanoresponse and the molecular levels of such regulations are not yet well understood. Here, we systematically investigated cell mechanical behaviors at the interfaces with different ligand diversity, spatial ligand patterning, and mechanical properties. The crosstalk between mechanotransduction pathways and growth factor signaling was further revealed. Understanding cell mechanoresponse at cell-material interface will allow for the guided design of new biomaterials for regenerative therapies, as well as inform the use of chemical and physical cues as therapeutic tools for enhancing clinical success.

INVITED LECTURE

Bio-mimic extracellular matrix fabricated with electrospinning to reduce thrombotic complications of vascular implants

Qiang Shi、Zehong Xiang、Zhifang Ma、Xinghua Guan、Jinghua Yin
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Thrombotic and inflammatory complications induced by vascular implants remain a challenge to treat cardiovascular disease due to the lack of self-adaption and functional integrity of implants . The physiological extracellular matrix (ECM) exhibits self-adaptive and self-regulation merits in establishment, separation and maintenance of differentiated tissues and organs. The ECM is three-dimensional, non-cellular structure that is mainly composed of collagens, proteoglycans, glycoproteins, and smaller amounts of other proteins. Biomedical implant mimicking the physiological extracellular matrix (ECM) is a new strategy to modulate the cell microenvironment to improve implant integrity and longevity.

Oxidative damage to cells by overproduction of reactive oxygen species (ROS) is the fundamental mechanism for thrombotic and inflammatory complications . Inspired by the antioxidant defense system of cells, we constructed a biocompatible and ROS-responsive architecture on the substrate of styrene-b- (ethylene-co-butylene)-b-styrene elastomer (SEBS). The strategy was based on fabrication of architectures through reactive electrospinning of mixture including SEBS, acylated Pluronic F127, copolymer of poly(ethylene glycol) diacrylate and 1,2-ethanedithiol (PEGDA–EDT), and ascorbic acid-2-glucoside (AA-2G) and ROS-triggered release of AA-2G from microfibers to detoxify the excess ROS. The bioinspired architecture not only reduced mechanical and oxidative damage to cells but also maintained normal ROS level for physiological hemostasis. Then, we fabricated ROS and K+ dual-responsive micro-/nanofibers that encapsulate AA-2G with electrospinning. The strategy is based on the fact that ROS and K+ dual responsiveness enhance the sensitivity of the ECM to pathological changes and delivery of AA-2G from the ECM to cell membrane promotes reactivating Na/K-ATPase and shifting cellular diseased conditions to the normal state .

Furthermore, we constructed a bio-mimic ECM with a dual-layer nano-architecture on the implant surface to render the surface adaptive to inflammatory stimuli and remodelable possessing long-term anti-inflammatory and anti-thrombotic capability. The inner layer consisted of PCL-PEG-PCL/Au–heparin electrospun fibers encapsulated with indomethacin while the outer layer was composed of polyvinyl alcohol (PVA) and ROS-responsive polymer fibers (PBA). In response to acute inflammation after vascular injury, the outer layer reduced ROS rapidly by PBA degradation for inflammation suppression. The degraded outer layer facilitated inner layer reconstruction with enhanced hemocompatibility through the H-bond between PVA and PCL-PEG-PCL. Moreover, chronic inflammation was effectively depressed with the sustained release of indomethacin from the inner layer. The substantial enhancement of the functional integrity of implants and reduction of thrombotic and inflammatory complications with the self-adaptive ECM were demonstrated both in vitro and in vivo . Our work paves a new way to develop long-term antithrombotic and anti-inflammatory implants with self-adaption and self-regulation properties.

INVITED LECTURE

Implantable glucose fuel cell based on mesoscopic flexible silk fibroin nanofibril complex electrodes for an ultrahigh volumetric power density

Naibo Lin、Zaifu Lin、Xiang-Yang Liu
Xiamen University

Implantable glucose fuel cells (IGFCs) that can operate with endogenous oxygen and glucose in body fluids are an essential part of power supply systems for personal electronics; however, the practical applications of IGFCs are inhibited by their low power densities and poor flexibility, biocompatibility, and durability. In this work, a compact IGFC is prepared based on silk fibroin nanofibrils (SFNFs) in terms of an integrated design to maximize the volumetric power density. This novel cell consists of SFNF and a carbon nanotube (SFNF/CNT) composite layer as the cathode, a Pt nanoparticle-modified SFNF/CNT layer as the anode, and a pure SFNF layer as the separator. After the crosslinking of poly(N,N-dimethylacrylamide) (PDMA), the continuous sandwich structure can be further compressed to 60% of its original thickness, resulting in a robust IGFC with a high maximum power density of 64.7 μW/cm3. For in vivo experiments, an implant containing a multiwall tube-like IGFC was inserted into the subcutaneous layer of a Sprague-Dawley (SD) rat and successfully harvested electricity with a maximum power density of 8.38 μW/cm3. This highly integrated IGFC with high flexibility and biocompatibility has great potential as a biomedical implant.

INVITED LECTURE

Metal-Phenolic Networks (MPNs) - Multifunctional Biomedical Nanoplatform

Yunlu Dai
University of Macau

Introduction: Metal polyphenols networks (MPNs), which make use of the coordination between metal ions and phenolic molecules, have emerged as promising materials for nanomedicine. Compared with other materials, MPNs have several potential advantages, including pH responsiveness, negligible cytotoxicity. Additionally, the phenolic groups in the materials can be functionalized to meet specific applications.
Methods and Result: We constructed a serious of polyphenol-based nanoplatform for combination cancer immunotherapy. These nanoplatforms were stable under normal physiological environment and release therapeutic agents in the tumor site. The MPNs can enhance anti-tumor immune response by various strategies by exploiting the tumor microenvironment.
Conclusion: MPNs based nanoplatforms can evoke highly efficacious cancer immunosurveillance while minimizing systemic side effects.
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INVITED LECTURE

Construction of a nanofiber network within 3D printed scaffolds for vascularized bone regeneration

Chuanglong He
Donghua University

Three-dimensional (3D) printed scaffolds provide promising perspective in bone tissue engineering. 3D printed scaffolds with micro- and nano-fibrous structure that facilitates the cell adhesion and migration, and combined vascularization and osteoinduction bioactivity will be ideal implants for bone defect repair. Here, we fabricated a 3D printed biodegradable poly (glycerol-co-sebacic acid-co-L-lactic acid-co-polyethylene glycol) (PGSLP)-based scaffold that internally filled with gelatin nanofibers and locally allowed deferoxamine (DFO) release, which is essential for angiogenesis and osteogenesis in bone regeneration. The nanofibrous structured Gelatin/PGSLP (NGP) scaffold was fabricated using a thermally induced phase separation (TIPS) technique. The in vitro experiments demonstrated that DFO-loaded NGP scaffolds can promote the migration and tubular formation of human umbilical vein endothelial cells (HUVECs), and enhance the mineralized nodule formation and osteogenic-related genes expression during osteogenic differentiation of bone marrow-derived mesenchymal stem cells (BMSCs). In the rat critical-sized calvarial defect model, the results suggested that the scaffolds with DFO loading significantly promote the vascular formation and accelerate bone regeneration. Therefore, the constructed PGLSP-based scaffold with micro- and nano-fibrous structure would be a promising candidate to match the structural and functional requirements for vascularized bone regeneration.

INVITED LECTURE

Magnetic guidance hemostats to complex bleeding wounds for instant hemostasis

Shi Zhenghui、Guangqian Lan、Ruiqi Xie
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Capable hemostats for complex bleeding wounds (narrow, perforating, and irregular) remains a challenge as existing commercial products halt bleeding at the wound surface rather than at the injured vessels.To circumvent this limitation, we produced a hemostat (MS@Fe4-BT) guided by magnetic fields (MFs) to deliver therapy into a targeted site. MS@Fe4-BT was fabricated by a Fe3O4 loaded microporous starch particle with dual surface functionalization - bovine serum albumin as the medium for drug loading, and thrombin as the hemostatic drug. The resultant MS@Fe4-BT can spontaneously assemble into microparticle chains to move under the application of MFs and can be directed into narrow and bent wound channels to halt bleeding instantly according to self-assembly experiments and animal test. The hemostatic times for the “V”- and “J”-shaped wounds in the liver and the V-shaped wounds in the femoral artery are 37, 44, and 152 s, respectively. Moreover, the excellent biosafety of MS@Fe4-BT is demonstrated with systematic assessments (hemolysis, cytotoxicity, biodegradation). Collectively, these findings suggested that the MS@Fe4-BT may hold promise as a capable hemostat for the hemorrhage control of bleeding wounds in complex environments.

INVITED LECTURE

Electrospun Fibers as a “Patch” for Tissue Regeneration

Wenguo Cui、Juan Wang
Shanghai Jiao Tong University

The micro/nano structure of electrospun fibrous membrane can mimic the natural extracellular matrix (ECM) with remarkable accuracy. Through the surface modification of micro/nano fibrous membrane, loading drugs, active molecules, living cells etc., to achieve 2D fibrous membrane functionalization, and then implanted into the diseased tissue to realize the local treatment of the disease, tissue regeneration and reconstruction. In the early stage, we developed a series of electrospun fibrous membrane "patches" to realize its application in skin, periosteum, cartilage, tendon, flap, pelvic floor and other fields. To reverse the imbalance fundamentally, a recently developed treatment, gene therapy, came to attention. However, the efficiency of the approach is limited because long-term localized presence and bioactivity are difficult to achieve. Here, reconstituted LOXL1 plasmids were loaded into nanoliposomes by a microfluidic chip, followed by encapsulation into the core layer of core-shell nanofibers by microsol-electrospinning to achieve local accumulation and biological availability of the constructs and enable to rapid ECM response. Results showed that the pLOXL1-Lipo@PLCL-HA achieved the sustained release of pLOXL1 over a 30day period, with its transfection efficiency maintained above 50%. In a rabbit model of abdominal hernia, the long-term collagen remodeling density was raised by over 90% in the pLOXL1-Lipo@PLCL-HA implanted animals compared to the control animals. The expression levels of ECM gene (COL1A1, COL3A1, Elastin, Fubilin5) were significantly increased. Collectively, this study established that pLOXL1-Lipo@PLCL-HA accelerated local ECM reconstrucation via effective and reliable gene delivery as a potential base material of a “patch” for tissue repairment, and identified the key principles for design of LOXL1-incorporated scaffolds for ECM regeneration.

INVITED LECTURE

AIE-active nanosystems for biodetection and therapy

Shuizhu Wu、Juan Ouyang、Lihe Sun、Junjie Chen、Fang Zeng
South China University of Technology

Chromophores with aggregation-induced emission (AIE) feature exhibit such advantageous features as strong fluorescence in the aggregated state that is quite common in biological aqueous milieu. Herein, we develop multifunctional nanosystems based on AIE chromophores for activatable imaging and on-demand therapy against inflammatory diseases, as well as for diagnosing herbal-medicine-induced liver injury by detecting hepatic NO with NIR-II fluorescence and multispectral optoacoustic tomography (MSOT) imaging. The chromophore-drug dyad (QBS-FIS) was synthesized by linking a near-infrared chromophore and an Nrf2 activator fisetin through boronate bond which serves as fluorescence quencher and ROS-responsive linker. The probe QY-N includes a bismethoxyphenyl-amine-containing dihydroxanthene serving as electron donor, a quinolinium as electron acceptor, and a butylamine as recognition group and fluorescence quencher. To further improve therapeutic efficacy, a NF-kB inhibitor thalidomide is co-encapsulated with macrophage cell membrane to afford the QBS-FIS&Thd@MM nanosystem. As for QBS-FIS&Thd@MM, upon activation by biomarker, the released chromophore exhibit fluorescence and optoacoustic signals for imaging, and the released drugs exhibit high efficacy against inflammatory disease. As for QY-NO, hepatic level of NO reacts with butylamine, thereby generating the activated probe QY-NO which exhibits a red-shifted absorption band (700–850 nm) for optoacoustic imaging and generates strong emission (910–1110 nm) for NIR-II fluorescence imaging. The 3D multispectral optoacoustic tomography imaging is applied to precisely locate the inflammatory foci in a spatiotemporal manner.

INVITED LECTURE

Peptide Mimicking Antimicrobial Polymers

Runhui Liu、Yueming Wu、Min Zhou
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Drug-resistant microbial infection has been a majorchallenge to human health. Therefore, considerable effort has been devoted todiscovery of new types of antimicrobial agents to battel with drug-resistantmicrobes. Natural Host defense peptides (HDP) display broad-spectrumantimicrobial activity and low possibility for microbes to develop resistance.However, HDP normally only have moderate activity against bacteria, lowstability due to hydrolysis by protease, and high price in preparation. Westudied peptide mimicking polymers to address above limitations of HDP. Theoptimal polymers display potent activity against multiple drug-resistantbacterial species, and low toxicity toward mammalian cells in hemolytic andcytotoxic studies.

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INVITED LECTURE

Speckle-like phenomenon and surface functionalization

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The development of versatile materials and engineering devices requires multifunctional conformal coatings that gains increasing interests. However, few methods can achieve a stable, large-area and colorless coating on substrates with different structure, composition and shapes. We report the one-step aqueous coating of virtually arbitrary material surfaces using self-assembled macroscopic bionanofilm made by pure lysozyme. The unfolding and subsequent phase transition of commercially available lysozyme initiates the spontaneous formation of amyloid-like nanofilm at a vapor/liquid or liquid/solid interface with a macro-scale size (e.g. 20 inches) and shape in a few minutes. The attachment of the nanofilm onto various surfaces could be accordingly achieved by the amyloid-mediated adhesion. In this talk, our newest understanding on the assembly and adhesion mechanism for such a new biomaterial would be addressed including the first example on macromolecular mesocrystals and novel amyloid-like biomaterials with excellent biocompatibility and multi-functions towards biointerface, micro/nano-fabrication and so on. It is expected that this study may offer a universal and mild surface chemistry for virtually arbitrary material surfaces to surpass conventional polydopamine and polyphenol/Fe(III) systems.

INVITED LECTURE

The effect of electrospun fibrous membrane with ROS clearance and vascular remodeling properties on diabetic wound healing

Zhengwei Mao、Zheqian Sheng
Zhejiang University

Diabetes can cause poor wound healing, because of abnormal activities of inflammatory cells and cytokines and peripheral vascular diseases. In this paper, a multifunctional electrospun fibrous membrane of polycaprolactone loaded with vascular endothelial growth factor (VEGF) protected by sulfonated chitosan was prepared by electrospinning, while polydopamine nanoparticles were electrosprayed on the surface. Through 1,1-diphenyl-2-trinitrophenylhydrazine (DPPH) assay and enzyme linked immunosorbent assay (ELISA), the ROS scavenging and subsequent anti-inflammatory effect were verified in vitro. The sustained release of VEGF was achieved to promote angiogenesis. In vivo experiments have proved that the dressing is effective for promoting wound healing in diabetic mice. This study provides new design criteria for multifunctional wound dressing based on advanced fibrous membrane.

INVITED LECTURE

Engraving the Surface of Electrospun Microfibers with Nanoscale Grooves Promotes the Outgrowth of Neurites and the Migration of Schwann Cells

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The outgrowth of neurites and the migration of glial cells both play important roles in the repair or regeneration of injured nerves. In this regard, topographic guidance, biochemical cue, electrical stimulation, or a combination of them are often taken into consideration when designing a nerve guidance conduit (NGC). It is documented that the outgrowth of neurites can be regulated at both subcellular and cellular levels by acting on the growth cones and axons, respectively. As such, the substrate most effective in promoting neurite outgrowth should contain topographic features with two different sizes, about 1 μm and 200 nm, to match the dimensions of typical axons and the filopodia of growth cones. For the same reason, it is expected that microfibers engraved with longitudinal nanoscale grooves should outperform nanofibers in promoting neurite outgrowth. Here we report a simple method based upon coaxial electrospinning for the fabrication of aligned microfibers engraved with nanoscale grooves to promote neurite outgrowth and cell migration. The success of this method relies on the immiscibility between polycaprolactone (PCL) and poly(vinyl pyrrolidone) (PVP) in 2,2,2-trifluoroethanol (TFE) for the generation of PVP/TFE pockets on the surface of a PCL jet. The pockets are stretched and elongated along with the jet, eventually resulting in the formation of nanoscale grooves upon the removal of PVP. The presence of nanoscale grooves greatly enhances the outgrowth of neurites from both PC12 cells and chick embryonic dorsal root ganglia (DRG) bodies, as well as the migration of Schwann cells. The enhancements can be maximized by optimizing the dimensions of the grooves for potential use in applications involving neurite extension and wound closure.

INVITED LECTURE

Enzyme laden Biomedical Polymer Hydrogels

Qigang Wang
Tongji University

Due to its 3D crosslinked networks and adjustable physicochemical properties, hydrogels have been widely applied in tissue engineering, drug-delivery system, pollution regulation, polymer electrolyte, agricultural drought-resistance, cosmetic and food area. However, the harsh prepared conditions and high chemical residues of traditional hydrogel both seriously limited their bio-related applications. We introduced the recent advances on tandem enzyme complex for the radical polymerization and the biomedical application of the enzyme-laden hydrogel by the controllable regulation of biochemical signals in body. The results are shown as followed: 1) Developed the biomimetic self-initiated polymerization by multienzyme complex and introduced supramolecular assembled components to solve the undisturbed enzyme immobilization and the optimization of biocatalytic channel; 2) Verified the multi-enzymatic hydrogelation within tissue microenvironment and explored the application for in-situ tissue repair and in vivo imaging; 3) Applied hydrogel integrated multienzyme for the metabolic regulation of reactive oxygen species on tumor sites and established a redox homeostasis based tumor biocatalytic or physical-biochemical combined therapy strategies. In the future, we plan to introduce activated control switch within the enzyme-laden polymer hydrogel for their controllable preparation and external signal transition.

INVITED LECTURE

Biomimetic elastomers, 3D printing and their biomedical applications

Zhengwei You
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Aiming at the bottleneck problems that the widely used biomedical elastomers are difficult to mimic the mechanical and self-healing properties of natural tissues, and difficult to be processed, we have carried out systematic studies. A multi-bond interaction molecular mechanism of synergistic strong bonds and weak bonds has been proposed. Synergistic three mechanisms of "mechanically invisible" weak bonds and forming copper coordination bonds for strengthening and catalyzing the recombination of dynamic covalent bonds constructs a multi-bond hybrid cross-linking molecular network, which solves the conflict that high mechanical strength, low modulus, and self-healing are difficult to balance. This work provides a universal molecular design for the development of soft, strong, and self-healing bionic elastomers. A general molding strategy of "creating strength from weakness" in synergetic multi-bond systems is proposed. Utilization of the weak non-covalent interaction between food materials and polymers forms a strong covalently cross-linked network, which overcomes the difficulty of thermoset elastomers processing. Accordingly, a series of new medical devices with outstanding performance for tissue engineering and biomedical flexible electronics have been fabricated.

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Silk fibroin based biomaterials: Functional fiber, film and scaffold

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Silk fibroin from the animal silk owns excellent inherent properties, such as good mechanical property, biocompatibility and biodegradability, and hence becomes one of the most important biomaterial to be studied and utilized. Based on the extraction and purification of silk fibroin from silkworm cocoons, a few kinds of novel biodegradable optical fibers, conductive silk films, and porous silk scaffolds were constructed by unique material processing and forming processes. These functional 1D-3D silk fibroin based biomaterials all show great application potentials in the biomedical field. In the microfluidic biomimetic spinning, regenerated silk fibroin (RSF) aqueous mixed with cellulose nanofibers (CNF) were used as spinning solution. By simulating the shape features of spider large cystic gland for the microfluidic designing, we fabricated a kind of biodegradable optical fiber with low light loss and high strength by wet spinning and continuous post stretching. This kind of biological optical fiber shows unique advantages and potential in the fields of photothermal therapy. In addition, RSF and PEDOT and its derivative materials were respectively selected as the matrix material and conductive functional material to fabricate functional silk films for nerve repair. A modified chemically oxidative polymerization and a novel method of macromolecular embedding were proposed. As a result, new types of conductive RSF/PEDOT film with good electroconductive property, transparency, and cell adhesion property were fabricated. And the application potential of the conductive films in nerve tissue engineering was demonstrated by in vitro culture of rat PC12 cells. Moreover, by studying the new biomimetic forming method of animal silk protein fiber, corresponding structure and comprehensive properties enhancing mechanisms were carefully investigated. Using different kinds of advanced material processing and forming technologies (such as electrospinning and 3D printing), newly forms of RSF porous scaffold with enhanced mechanical properties were constructed and their applications in biomedical fields such as urethral repair, bone tissue engineering, nerve regeneration, liver repair and so on were explored.

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Implantable flexible fiber biosensors for long-term monitoring

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Implantable biosensors represent a rapidly developing direction with a wide range of applications in biotechnology and life science. The in vivo acute detection of chemicals has been developed for decades of years, but there are few reports about in vivo chronic monitoring of chemicals, probably due to unstable interfaces between biosensors and tissues resulting from the mechanical mismatch between them and unstable device performance from electrode deteriorations associated with degradation and fouling of functional materials in dynamic environment. Although some flexible probes consisting of polymer and metal composite fibers have been employed in chronic electrophysiological recording, they are rarely employed for chronic monitoring of chemicals. Here, we report our efforts toward flexible and miniaturized implantable fiber biosensors based on carbon nanotube fibers for stable interfaces in vivo. We first summarize the assembly structure of carbon nanotube fiber electrodes and their mechanical, electrical, electrochemical and biocompatible properties. Then we present a family of fiber biosensors by modifying with different recognition materials to detect multiple chemicals in vivo. After that, all-in-one fiber organic electrochemical transistors are described with higher sensitivity and lower detection limit, aiming to detect chemicals with low concentrations and trace changes in the deep brain. All these fiber biosensors are soft with mechanical properties matching biological tissues, keep stable under deformation and show high biocompatibility for long-term in vivo applications.

Phototoxicity manipulation of Highly-photosensitive Phytochlorin

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Phototoxicity of photosensitizers is a double-edged sword with one edge beneficial for destroying cancers while the other detrimental to normal tissues. In contrast to previous 'off-on' methods with temporary phototoxic inhibition, we herein provide a strategy to convert PSs into 'single-edged knife' ones with persistent phototoxic inhibition and alternative multiple therapeutical activation. The phytochlorin as the model PS assembles into nanoscale frameworks (nFs) with paramagnetic Cu2+ ions, thus inhibiting >92% phototoxicity while activating 3.5-fold photothermal efficacy and tumor microenvironment modulation, because of not only the aggregation-boost nonradiative transition but also Cu2+-coordination-induced energy transfer and redox activity. Given these merits, the nFs achieve none retina injury under sunlight and high therapeutical output. The present strategy opens up a possibility of converting numerous highly-phototoxic porphyrins into safe and efficient ones.

Functional Nanomaterials and Peripheral Nerve Regeneration

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Neuronal microenvironment imbalance is associated with successive and irreversible pathophysiological changes and insufficient functional restoration after peripheral nerve injury. Conventional neural-supporting scaffolds result in unsatisfactory curative effects due to lack of biomimetic nanotechnology designs and biochemical or physicochemical modifications. Consequently, they fail in rational and facile remodeling of the imbalanced growth microenvironment, and cannot recover neural structure and function. In recent years, with the increasing knowledge in neuronal injury-associated microenvironment, a number of novel strategies are applied in enhancing the biochemical and physicochemical natures of biomimetic nanomaterial-based scaffolds for nerve tissue engineering. These nanoscale scaffolds can trigger growth factor secretion and aggregation through surface modification, regulate ATP synthesis and hydrolysis, switch between oxidation and reduction states, and activate ion channels and stimulate electrical signals under certain biophysical cues. Consequently, they can determine neuronal cell fate by modulating their viability, development and cell cycles during the regeneration process. In this work, we systematically summarize the studies on the biomimetic scaffold design of functional nanomaterials, their basic topological, biochemical and physical properties, and nanotechnology-based restoration of a balanced nutritional microenvironment regarding four key neural regeneration factors, including immune response, intraneural vascularization, bioenergetic metabolism and bioelectrical conduction in order to provide ideas and inspiration for the nanomedicine-based neuronal regeneration therapy.

Self-pumping functional textiles for accelerated wound healing and thermal management

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Fluid transportation on skin surface plays an important role in wound healing and body surface thermal management. Excessive moisture on the skin surface will produce a sense of damp and wet adhesion. The excessive exudates around wound will make the wound soft and hinder wound healing. Limited by the hydrophilicity of the traditional textile itself, the liquid on the skin surface will accumulate on the skin surface and continue wetting the skin, which is easy to cause wound overhydration. At the same time, the decrease in the external temperature will also quickly transmit to the skin surface through the adhesive liquid layer in the textile, resulting in a sudden cold sensation. Therefore, we report a self-pumping textile that can directionally drain skin surface fluid out from the skin surface to avoid taking away large amounts of heat. When applied on wound, the self-pumping dressing can effectively drain the wound exudate and result in an accelerated healing rate than conventional dressing. When applied as clothing, the highest one-way liquid transmission capacity of the self-pumping textile can reach 1246% of traditional textile. These self-pumped textiles are expected to be the next generation of wound dressings and clothing, promoting wound healing and providing effective body surface thermal management.

Effect of core-to-shell flowrate ratio on morphology, mechanical properties and wettability of poly(lactic acid) fibers prepared via modified coaxial electrospinning

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Modified coaxial electrospinning (CE) was employed to improve electrospinnability and to tailor surface morphology and bead formation of poly(lactic acid) (PLA) fibers by means of core-to-shell flowrate ratio variation in this study. Chloroform/N,N-dimethylformamide (DMF) mixture was used as sheath solution which serves as a protective layer to prevent rapid solidification of PLA droplet which caused needle clogging. Five different core-to-shell flowrate ratios yielded bead-on-string PLA fibers with distinctive fiber and bead properties where these diverse morphologies were characterized in terms of fiber diameter (Df), fiber percentage (Pf), number of beads (nb), bead area (Ab), bead aspect ratio (Lb/Db), ratio of bead-to-fiber diameter (Db/Df) and surface roughness. These data were analyzed and related to the tensile and wettability properties of the PLA electrospun fibers. Core-to-shell flowrate ratio of 1:3 resulted in PLA fibers with the least nb, smallest Db/Df and highest Lb/Db (spindle-like shape), which correspond to the highest tensile properties and minimum hydrophobicity among bead-on-string fibers studied, as indicated by effective stress-strain curve and water contact angle measurement. Further, this paper revealed that Db/Df was the dominant factor which affecting tensile properties while Lb/Db (bead shape) was the key aspect which influenced the wettability of the PLA bead-on-string fibers.

Self-pumping dressing with gas flow structure and exudate management

Hai Zhu、chao zhi、yong zhen wang、ling jie yu
Xi'an Polytechnic University

The microclimate near the wound plays an important effect during wound healing. In addition, excessive biofluid around the wound would cause infection and hinder wound healing. However, the intrinsic hydrophilicity of the conventional dressing inevitably retains excessive biofluid at the interface between the dressing and the wound. In order to increase the air circulation and exudation absorption capacity around the wound, we constructed the Janus structure by combining the hydrophobic electrospun nanofiber membrane and the hydrophilic fabric. This kind of structure can unidirectionally remove excess biological fluid from the wound and transfer it through the special liquid transport channel between spacers to the aerogel absorbing layer which posses high capacity of water absorption. The hydrophilic upper layer of spacer fabric provides a drainage force to pump excess exudate through the hydrophobic nanofiber network and further prevent these pumped fluids from re-wetting the wound; thus ultimately accelerating the wound healing. The results of characterization test show that the proposed wound dressing has excellent air permeability, mechanical supporting and water absorption. This unique self -pumping dressing has great potential in biomedicine industry.

Process of melt electrowriting and prospects in tissue engineering

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Beijing University of Chemical Technology

Orderly and precisely deposition of micro-nano fibers is greatly expected in tissue engineering. Melt electrowriting is a combination of processes of melt electrospinning and 3D printing to achieve orderly deposition of fibers. Melt electrowriting eliminates the use of solvent and enables the spinning of micro fibers that tissue scaffold favors, while solution electrowriting mostly prepares sub-micro fibers and 3D printing (usually called fused deposition molding, FDM) prepares sub-millimeters fibers. In previous studies, the materials that can be printed by melt electrowriting are limited to the materials with high fluidity and low melting point such as polylactide (PLA) and Poly (ε-caprolactone) (PCL). In this research, by reversing the electric field and improving the receiving device, the intensity of the electric field is increased, the melting time of the jet in the electric field is prolonged, the bonding strength between fibers is improved, and the materials such as thermoplastic polyurethane (TPU) and Polyvinylidene Fluoride (PVDF) can be printed. Thus, a fiber structure with better mechanical properties and piezoelectric properties can be designed. The melt electrowriting technology has broad prospects in the fields of biological tissue engineering scaffolds, flexible electronics, and micro-nano manufacturing.

Composite polymer fibers for displaying patterns

Sunny Shulei Peng
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Displaying patterns that are widely used in our daily life have evolved from rigid panels to flexible thin films. However, the configuration and fabrication of electronic textiles that represent a booming direction to satisfy wearable facilities, artificial intelligence and new information technology are different from conventional film devices such as organic light-emitting diodes (OLEDs), a currently used technology to construct flexible displays. On the one hand, textiles are produced by weaving various fibers with rough and porous structures that may thus deform and fit the curved surfaces of the human body. On the other hand, OLEDs are generally made by depositing semiconducting organic layers between both planar cathode and anode electrodes. Therefore, when they are attached onto the rough and deformable textiles, these film lighting devices often perform poorly or even fail to work. It is very difficult to deposit organic thin films on fibers for displaying textiles. The current evaporation method for OLEDs is not applicable to large-scale fabrication of fiber electrodes.

In our study, we have prepared a polymer fiber with ZnS phosphor as active material on the surface. Unlike OLED devices, ZnS phosphor dispersed in an insulating polymer matrix is activated by alternating electric field across polymer matrix. Therefore, it is possibly to continuously make these light-emitting composite fibers at large scale. These light-emitting composite fibers are highly flexible and strong, and they have been woven into displaying textiles for a variety of applications such as in biomedical field. The displaying textile may help disable people for communications and patients for monitoring biomarkers during treatment.

MoS2/PLA composite nanofiber membrane with photothermal /photodynamic function for synergistic antibacterial activity

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Zhejiang Sci-Tech University

The infection of drug-resistant bacteria, which is usually caused by the abuse of antibiotics, is a great threat to human life and health. Nowadays, antibacterial treatment based on non-antibiotic strategies has attracted the attention of scientists. In this work, molybdenum disulfide (MoS_2) particles were introduced onto polylactic acid (PLA) nanofiber membrane via gravity driven deposition, followed by being crosslinked by sodium carboxymethyl cellulose (CMC) and glutaraldehyde (GA). It was found that the binding stability of MoS_2 as well as the mechanical property of the composite membrane were improved significantly by crosslinking. Under the irradiation of near infrared (NIR) light at 808 nm, the composite nanofibrous membrane exhibited a good photothermal effect. Moreover, the production of active oxygen (ROS) was accelerated and the oxidation of glutathione was enhanced by NIR irradiation. Due to the synergistic effect of photothermal therapy (PTT) /photodynamic therapy (PDT), the antibacterial efficiency of the composite membrane against S. aureus and E. coil achieved higher than 95%. It was confirmed that the composite nanofibrous membrane can kill bacteria more effectively without antibiotics.

Silk medical suture with sustainable antibacterial and anti-inflammatory function

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Medical sutures with antibacterial and anti-inflammation functions are key strategies to prevent surgical site infection. The purpose of this work is to fabricate a kind of drug-loaded silk sutures with sustainable antibacterial and anti-inflammatory effects. The traditional natural ingredients berberine and artemisinin were combined and loaded into silk fibroin coating system to the silk suture to achieve a slow-release property. The physical properties and biological performance were evaluated. The results revealed that the sutures have fair bending stiffness, high knot-pull tensile strength, low cytotoxicity and antibacterial property, etc. In addition, the suture can sustainably slow release the drugs for more than 42 days. The sutures exhibited favorable cytocompatibility with human fibroblasts (Hs 865.Sk), and promote angiogenesis by reducing the expression of pro-inflammatory cytokines interleukin-10 and tumor necrosis fact-α. This work provides a new route for achieving a multi-functional suture, which is of great potential in applications for surgical operations.

Cascaded enzymes-loaded Fe-Hemoporfin framework for synergistic sonodynamic-starvation therapy of tumors

Mei Wen
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Enzyme-loaded nanosystems with multimodal therapeutical functions have received increasing attention in treatment of malignant tumor. Herein, we designed and prepared the cascaded dual-enzyme-augmented Fe-hemoporfin framework nanosonosensitizers for synergistic sonodynamic-starvation therapy of tumors. Amorphous Fe-hemoporfin frameworks (FeHF) with average size of ~85 nm was synthesized by assembling the clinical drug hemoporfin with Fe3+ ions. Then FeHF was used to load dual enzymes (glucose oxidase (GOx) and catalase (CAT)), and modified by PEGylated folic acid-conjugated lipids. The dual-enzyme loaded FeHF (FeHF-GOx/CAT) exhibited higher efficiency not only for glucose depletion but also for ultrasound (US)-triggered 1O2 generation than that of pure FeHF, resulting from the cascaded catalytic reaction from the dual-enzyme system. With the guide of magnetic resonance imaging, the intravenous injected FeHF-GOx/CAT accumulated within tumors. The FeHF-GOx/CAT+US exhibited the highest inhibition effect than the FeHF-CAT+US (only SDT) or FeHF-GOx/CAT (only starvation therapy), due to the synergistic effects of SDT-starvation therapy. Therefore, the cascaded dual-enzyme loading strategy can increase the SDT efficiency of FeHF, which may guide further works in the development of efficient nanosonosensitizers.

Enabling Topical and Long-Term Anti-ROS Properties for Percutaneous Coronary Intervention-Related Complications by Incorporating TEMPOL into Electrospun Nanofibers

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Scavenging reactive oxygen species (ROS) by antioxidants has been demonstrated as the most effective strategy for preventing percutaneous coronary intervention (PCI) -related complications. Herein, a ROS scavenger of TEMPOL is incorporated into electrospun nanofibers to achieve its long-term anti-ROS capability. Such an electrospun membrane with long-term TEMPOL release behaviors, presents a superior ROS-scavenging performance for macrophages. The migration of vascular smooth muscle cells are also effectively inhibited. Thus, it is bravely predicted that the topical use of such a TEMPOL-loaded electrospun system will be a promising pathway for the anti-restenosis therapy, especially when used as a novel coating on stent for long-term and topical delivery of antioxidant drugs.

Sub-5 nm Gd3+-Hemoporfin Framework Nanodots for Augmented Sonodynamic Theranostics and Fast Renal Clearance

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Metal-organic nanomaterials have emerged as promising therapeutic agents to produce reactive oxygen species (ROS) under ultrasound (US) or light irradiation for tumor treatments. However, their relatively large sizes (ranging from tens to hundreds of nanometers) usually lead to low ROS utilization and body metabolism, thus enlarging their long-term toxicity and low therapeutic effect. To solve these shortcomings, herein the ultrasmall Gd3+-hemoporfin framework nanodots (GdHF-NDs, ~5 nm) is reported as efficient nanosonosensitizers. The GdHF-NDs were prepared by the probe sonication to break GdHF aggregation (GdHF-A, ~400 nm) obtained through the assembly of biocompatible hemoporfin with Gd3+ ions. Compared with large GdHF-A, the ultrasmall GdHF-NDs generated 2.3-fold toxic ROS amount under similar conditions, due to shorter diffusion path and larger relative specific surface area. Under US irradiation, the GdHF-NDs/PEG achieved a better sonodynamic therapeutic efficacy for tumors, compared with that from GdHF-A/PEG. More importantly, owing to ultrasmall size, most of GdHF-NDs/PEG could be rapidly cleared through the renal pathway. Therefore, GdHF-NDs/PEG can be used as a biosafety and high performance sonodynamic agent for cancer theranostics.

Multifunctional Fibrous Membrane with Drug-loaded Core-shell Structure for Vascularized Bone Regeneration

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Sichuan University

We demonstrate a simple, effective and feasible method to address the shrinkage of Poly (lactic-co-glycolic acid) (PLGA) and the relatively weak cell responsiveness of poly-caprolactone (PCL) through a core-shell structure fiber strategy. The results revealed that introducing size-stable PCL as the core fiber significantly improved the PLGA-based fibrous scaffold's dimensional maintenance. We further utilized fish collagen to modify the PLGA shell layer (PFC) of coaxial fibers and loaded baicalin (BA) into the PCL core layer (PCL-BA) to endow fibrous scaffold with more functional biological cues. The PFC/PCL-BA fibrous scaffold promoted the osteogenic differentiation of bone mesenchymal stem cells and stimulated the RAW264.7 cells to polarize into a pro-reparative phenotype. Importantly, the in vivo study demonstrated that the PFC/PCL-BA scaffold could regulate inflammation and osteoclast differentiation, favor neovascularization and bone formation. This work tactfully combined PLGA and PCL to establish a drug release platform based on the core-shell fibrous scaffold for vascularized bone regeneration[1,2].
Key words: Coaxial nanofiber, baicalin, inflammation, osteoclast differentiation, vascularized bone regeneration

Figure 1 Schematic diagram of a multifunctional core-shell structured fibrous membrane.

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[2] The invention discloses a multifunctional fibrous membrane for bone tissue regeneration and a preparation method thereof, Patent number: 202010520744.1

Electrospun Fibrous Membrane of Amino Acid-based Poly(ester-urethane-urea) for a Potential Application as Small-diameter Vascular Grafts

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Tianjin University

With the incidence of cardiovascular diseases climbing yearly, there is an increased demand for surgical interventions involving vascular replacement and revascularization. While some satisfactory outcomes have achieved in artificial blood vessels with larger diameters, the current gold standard for small-diameter vascular grafts (SDVGs) less than 6 mm is still autologous vessels clinically because of complicated disease circumstances. As a result, development of SDVGs with long-patency is of great significance. In this work, an amino acid-based poly(ester-urethane-urea) (PEUU) was synthesized and then blended with poly(e-caprolactone) (PCL) in different ratios to prepare tubular grafts via electrospinning for the potential application as SDVGs. In vitro cell culture results suggested that the prepared PCL/PEUU electrospun membranes are biocompatible. More importantly, the PEUU50 electrospun tubular graft with mass ratio of 1/1 has lower Young's modulus and tensile strength, as well as approximately 1.5 times higher elongation to that of neat PCL, exhibiting more suitable mechanical properties matching to the native blood vessels. Overall, amino acid-based PEUU has been successfully prepared and it showed great potential in the application of vascular tissue engineering.

Glycosyl-Functionalized ε-Polylysine with Enhanced Cryopreservation of Human Erythrocytes

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Tianjin University

Ice formation and recrystallization exert severe impairments for cellular cryopreservation. Despite the typical adoption of high dosages of glycerol for clinical cells banking, a specialized deglycerolization apparatus is imperative to undergo lengthy and rigorous washing processes for fear of red blood cells post-transfusion osmotic hemolysis. α,α-Trehalose, a naturally non-reducing disaccharide Generally Recognized as Safe (GRAS), exits abundantly in a plethora of organisms such as yeasts, plants, nematodes, and even insects with tolerance to extreme cold, desiccation and heat stress. This culminates in the manifestation of nonspecific vitrification stabilization for lipid membrane, nucleic acid and labile protein, playing a canonical and pivotal role in cellular cryopreservation. Herein, a novel glycopeptide was synthesized by tethering oligosaccharides onto the ε-polylysine backbone via Borch reductive amination on the basis of previous works. On account of the intrinsic icephilicity, such glycosyl-functionalized ε-polylysine glycopeptides demonstrated potent ice recrystallization inhibition and extraordinary cryosurvival of human erythrocytes by immersion into liquid nitrogen in the co-presence of membrane-impermeable trehalose, with which cryogenic synergy of the glycopeptides was witnessed by differential scanning calorimetry and microscopic laser Raman spectroscopy. This trehalose-associated chaperone foreshadows a pathway to serve as a candidate in practical human erythrocytes cryopreservation.

Combination therapy based on selenium-containing polymers

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Tsinghua University

Immunotherapy has emerged as a promising new approach for cancer treatment. However, clinically available drugs have been limited until recently, and the antitumor efficacy of most cancer immunotherapies still needs to be improved. Herein, we develop diselenide-containing assemblies that combine nature killer (NK) cell-based cancer immunotherapy with radiotherapy and chemotherapy in a single system. We revealed cancer immune activity of seleninic acid, which downregulated human leukocyte antigen E (HLA-E) in cancer cells and then activated the immune activity of nature killer (NK) cells. We developed diselenide-pemetrexed assemblies by co-assembly between cytosine-containing diselenide and a chemotherapeutic drug pemetrexed. Under mild γ-radiation, diselenide bonds were cleaved and oxidized to seleninic acid, which evoked cancer immune activity of NK cells. The chemotherapeutic drug pemetrexed was released at the same time, achieving a combination of cancer immunotherapy, radiotherapy and chemotherapy. The combination therapy exhibited improved antitumor efficacy against both primary tumor and tumor metastasis with low side effects. Additionally, diselenide-containing polymeric nanoparticles were used for combination therapy by encapsulating the chemotherapeutic drug DOX. DOX exhibited synergistic effect in combination with diselenide-containing polymers and γ-radiation. The combination therapy downregulated HLA-E expression and upregulated IFN-γ generation in both primary tumor tissues and tumor metastases, which confirmed the improved immune activity. These studies revealed the potent cancer immune activity of selenium-containing molecules, providing new opportunities for selenium-containing nanomaterials in cancer immunotherapy.

INVITED LECTURE

Smart chromophore based nanosystems for biodetection and therapy

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South China University of Technology

Smart chromophores hold great potentials for applications in biomedical field. Herein, we have developed multifunctional nanosystems based on smart chromophores for activatable imaging and on-demand therapy against inflammatory diseases, as well as for diagnosing herbal-medicine-induced liver injury by detecting hepatic NO with NIR-II fluorescence and multispectral optoacoustic tomography (MSOT) imaging. The chromophore-drug dyad (QBS-FIS) was synthesized by linking a near-infrared chromophore and an Nrf2 activator fisetin through boronate bond which serves as fluorescence quencher and ROS-responsive linker. The probe QY-N includes a bismethoxyphenyl-amine-containing dihydroxanthene serving as electron donor, a quinolinium as electron acceptor, and a butylamine as recognition group and fluorescence quencher. To further improve therapeutic efficacy, a NF-kB inhibitor thalidomide is co-encapsulated with macrophage cell membrane to afford the QBS-FIS&Thd@MM nanosystem. As for QBS-FIS&Thd@MM, upon activation by biomarker, the released chromophore exhibit fluorescence and optoacoustic signals for imaging, and the released drugs exhibit high efficacy against inflammatory disease. As for QY-NO, hepatic level of NO reacts with butylamine, thereby generating the activated probe QY-NO which exhibits a red-shifted absorption band (700–850 nm) for optoacoustic imaging and generates strong emission (910–1110 nm) for NIR-II fluorescence imaging. The 3D multispectral optoacoustic tomography imaging is applied to precisely locate the inflammatory foci in a spatiotemporal manner.

INVITED LECTURE

Mechanically and biologically skin-like elastomers for bio-integrated electronics

Shuo Chen、Luzhi Zhang、Zhengwei You
Donghua University

The bio-integrated electronics industry is booming and becoming more integrated with biological tissues. To successfully integrate with the soft tissues of the body (eg. skin), the material must possess many of the same properties including compliance, toughness, elasticity, and tear resistance. In this work, we prepare mechanically and biologically skin-like materials (PSeD-U elastomers) by designing a unique physical and covalent hybrid crosslinking structure. The introduction of an optimal amount of hydrogen bonds significantly strengthens the resultant elastomers with 11 times the toughness and 3 times the strength of covalent crosslinked PSeD elastomers, while maintaining a low modulus. Besides, the PSeD-U elastomers show nonlinear mechanical behavior similar to skins. Furthermore, PSeD-U elastomers demonstrate the cytocompatibility and biodegradability to achieve better integration with tissues. Finally, piezocapacitive pressure sensors are fabricated with high pressure sensitivity and rapid response to demonstrate the potential use of PSeD-U elastomers in bio-integrated electronics.

INVITED LECTURE

Inflammation-modulating polymers for tissue repair and regeneration

Changyou Gao
Zhejiang University

The degree of tissue injuries such as the level of scarring or organ dysfunction, and the immune response against them primarily determine the outcome and speed of healing process. In the tissue repair and regeneration processes, different types of biomaterials are implanted either alone or by combined with other bioactive factors, which will interact with the immune systems including immune cells, cytokines and chemokines etc. to achieve different results highly depending on this interplay. Several types of polymers including polyurethane elastomers and hydrogels responding to reactive oxygen species (ROS) have been synthesized and fully characterized in terms of ROS-responsiveness, mechanical properties, degradation and ROS elimination in our lab. By integrating with other functional molecules such as methylprednisolone (MP), dexamethasone, dimethyl itaconate (DMI), and catalase etc., therapeutic materials systems such as nanofibrous patches and injectable hydrogels and nanoparticles were designed and prepared for the treatment of myocardial infarction, osteoarthritis (OA) and lung inflammation etc. in vivo. These materials systems could effectively alleviate the inflammation microenvironment of tissues, and modulated the macrophages toward anti-inflammatory M2 polarization, and thereby could better restore the normal tissue microenvironment and achieve better tissue repair and regeneration outcome. For example, they effectively improved the reconstruction of cardiac functions including increased ejection fraction, decreased infarction size, and enhanced revascularization of the infarct myocardium.

INVITED LECTURE

Peptidoglycan-inspired autonomous ultrafast self-healing bio-friendly elastomers for bio-integrated electronics

Luzhi Zhang、YuePeng Wang、ZhengWei You
Donghua University

Elastomers are essential for stretchable electronics, which have become more and more important inbio-integrated devices. To ensure high compliance with the application environment, elastomers areexpected to resist, and even self-repair, mechanical damage, while being friendly to the human body.Herein, inspired by peptidoglycan, we designed the first room-temperature autonomous self-healingbiodegradable and biocompatible elastomers, poly(sebacoyl 1,6-hexamethylenedicarbamate diglyceride)(PSeHCD) elastomers. The unique structure including alternating ester-urethane moieties and bionichybrid crosslinking endowed PSeHCD elastomers superior properties including ultrafast self-healing,tunable biomimetic mechanical properties, facile reprocessability, as well as good biocompatibility andbiodegradability. The potential of the PSeHCD elastomers was demonstrated as a super-fast self-healingstretchable conductor (21 s) and motion sensor (2 min). This work provides a new design and syntheticprinciple of elastomers for applications in bio-integrated electronics

INVITED LECTURE

Engineering of Hybrid Nanovesicles for Cancer Theranostics

Zhihong Nie
Fudan University

Nanoscale vesicles (e.g., liposomes, polymersomes) have made a great clinical impact in controlled release of therapeutic drugs or vaccines. To meet the rising need for better theranostic tools, great efforts have been made to incorporate inorganic nanoparticles into the organic vesicular membranes to endow the system with new functionalities. Recently, we have developed a strategy to fabricate hybrid nanovesicles with tailored collective optical and magnetic property. Both imaging and therapeutic agents can be efficiently encapsulated and retained in the hollow cavity of the vesicles with minimal leakage, compared with organic vesicles. The release of payload can be controlled in space and time by internal or external triggers (e.g., near-infrared light, alternating magnetic field). We systematically assessed the potential of the hybrid vesicles as signal amplifier in ELISA-based cancer diagnosis, contrast agents in multimodality cancer imaging (e.g., photothermal, photoacoustic and magnetic resonance imaging), as well as delivery vehicles for cancer therapy (e.g., photodynamic therapy, chemodynamic therapy).

INVITED LECTURE

Immunologically Active Fibrous Scaffolds for Advanced Bone Regeneration

Weifeng Zhao
Sichuan University

Electrospun nanofibers have been extensively explored as scaffolds for bone regeneration due to their ability to mimic the architecture of an extracellular matrix. Traditional biological principle for developing bone biomaterials is to directly stimulate osteogenic differentiation. However, inconsistencies between in vitro and in vivo studies are widely observed. Immune response dominated by immune cells plays a vital role in regulating bone dynamics, neglecting the importance of the immune response is the major shortcoming of the traditional strategy. Different from traditional inert materials, we proposed novel immunologically active fibrous scaffolds for advanced bone regeneration here. We first fabricated a Janus guided bone regeneration membrane (JGM) by sequential electrospinning. The aligned poly(caprolactone) (PCL) nanofibers are designed as the outer layer to resist epithelia invasion, and the oriented fibrous structure can construct a favorable osteoimmune microenvironment by regulating the behavior of macrophages; meanwhile the random gelatin fibers loaded with hydroxyapatite (HAP) are designed as the inner face to promote the osteoblasts' adhesion, proliferation and osteogenic differentiation. Subsequently, we focused on more precise regulation of the immune microenvironment. An amphipathic nanomedicine TA/IND was prepared by esterification of tannic acid and indometacin and incorporated into PCL nanofibers. The unique feature of this system is the water-driven spatial migration of the nanomedicine in hydrophobic substrates, enriching hydrophilic TA on the scaffold surface, which enable the scaffold to manipulate the immune response in a staged manner. In the early stage, the excessive initial acute inflammation is moderately controlled relying on the surface exposed TA to scavenge the surrounding reactive oxygen species, thus facilitating the recruitment and osteogenic differentiation of pre-osteoblasts. During the accelerated degradation stage, additional shielded nanomedicine molecules are exposed to esterase, leading to inflammation-responsive enzymolytic release of TA and IND, which efficiently promotes the transition from inflammation phase to regeneration phase. This work provides a novel platform to design novel bone scaffolds, displaying great potential applications in tissue engineering.

INVITED LECTURE

Self-healing polyurethane-elastomer with mechanical tunability for multiple biomedical applications in vivo

Chenyu Jiang[1]、Zekai Wu[2]、Luzhi Zhang[2]、Xiaofeng Ye[1]、Zhengwei You[2]
1. Shanghai Jiao Tong University
2. Donghua University

The unique properties of self-healing materials hold great potential in the field of biomedical engineering. Although previous studies have focused on the design and synthesis of self- healing materials, their application in in vivo settings remains limited. Here, we design a series of biodegradable and biocompatible self-healing elastomers (SHEs) with tunable mechanical properties, and apply them to various disease models in vivo, in order to test their reparative potential in multiple tissues and at physiological conditions. We validate the effectiveness of SHEs as promising therapies for aortic aneurysm, nerve coaptation and bone immobilization in three animal models. The data presented here support the translation potential of SHEs in diverse settings, and pave the way for the development of self-healing materials in clinical contexts.

INVITED LECTURE

Bionic design and performance of functional sutures for tendon repair

Jifu Mao、Qian Zhang、Chaojing Li、Fujun Wang、Lu Wang
Donghua University

The unsatisfactory therapeutic effect of repaired tendons after surgery is inextricably linked to surgical sutures. High re-tear rate and severe inflammation and infection are two major issues that hinder tendon healing. Besides, scar healing and infection of the skin incision caused by the sutures often make people suffer from tremendous physical and psychological stress. Herein, to promote tendon healing, the bamboo-inspired tape sutures were designed and prepared, followed by chitosan-gelatin/tannic acid (CS-GE/TA) multifunctional decoration. To accelerate skin regeneration, conductive component polypyrrole (PPy) was further introduced to construct the electroactive and antibacterial sutures. The results showed that the pristine bamboo-inspired tape sutures ensured the required mechanical properties and decreased stress concentration to 60% of traditional round and solid sutures. Compared to the pristine suture, the CS/GE-TA decorated suture (TA100) presented a 332% increase in pull-out force from the tendon, indicating alleviate stress concentration, superior load transfer, and potentially decreased re-tear rates. Meanwhile, TA100 showed outstanding anti-inflammatory and antibacterial performances as well as enhanced tissue integration, which showed great significance for tendon healing. Furthermore, the synergistic effects of CS-GE/TA and PPy offered the sutures stable physiological electrical signal transmission among cells and initiative in regulating cell behaviors, superior antibacterial rates of over 99% against *E. coli* and *S. aureus*, and the remarkable ability in promoting skin regeneration. This study may provide new insights into the bionic design of functional sutures to obtain the improved therapeutic effect of tendon repairs.

INVITED LECTURE

Polymer vesicles for delivery of protein and nucleic acids

Jianzhong Du
Tongji University

Biomacromolecules such as proteins and nucleic acids play fundamental yet vital roles in all organisms. Therefore, to deliver biomacromolecules safely and effectively is a significant challenge in biomedical fields such as protein therapy, tissue repair, and gene editing. However, traditional carriers are often positively charged, showing relatively high toxicity and suffering from short circulation time. In addition, non-cationic carriers including polymer vesicles which can avoid these problems face the challenge of low loading efficiency. Therefore, constructing non-cationic polymer vesicles with high biomacromolecule encapsulation efficiency is an important challenge.

In this talk, two general strategies based on polymer vesicles were developed for loading protein and nucleic acids, including in situ loading and post-assembly-loading. To greatly increase the loading efficiency and strike a balance between stability and biodegradability, two novel principles are proposed for the judicious design of polymer vesicles with ultrahigh loading efficiencies for various biomacromolecules: (1) acid-induced adsorption (AIA) for proteins; (2) affinity-enhanced attraction (AEA) for nucleic acids. The former principle (AIA) is assisted by triazole group within the polymersome membrane. The latter principle (AEA) is based on intermolecular interactions, such as anion–π interaction and π–π stacking, which can be achieved by the judicious design of polymersomes with structurally similar repeat units as the biomacromolecular cargo (plasmid DNA and RNA). According to these two principles, a PEO45-b-PCTCL90 block copolymer was prepared and self-assembled into polymersomes by directly dispersing the polymer in water. This approach allowed simultaneous polymer self-assembly and ultrahigh biomacromolecular loading efficiencies for hemoglobin (79%), plasmid DNA (75%), and RNA (85%). Moreover, this novel polymersome has a biodegradable membrane with photo-cross-linkable groups; this solves a long-standing problem in balancing electrosteric stability and biodegradability.

INVITED LECTURE

In Vivo Identification and Quantification of Sequence-Defined Nanofibers

Shiyong Liu
University of Science and Technology of China

We report the controlled synthesis of self-immolative polymers with a precise molecular weight and
predetermined sequence. Unexpectedly, the seqence could be direclty read by the LIFT module of MALDI
TOF-TOF MS, exhibiting a cleaning pattern with the interval between neighboring peaks reflecting the
corresponding sequence monomer. For the amphiphilic mini-block copolymer containing PEG dendron and the above self-immolative segment, it was found that the nanostructures (spheres, rods of different length) could be finely tuned by the sequence and DP. We further utilized self-assembled nanostructures to quantify their biodistributions by MALDI TOF and MALDI Imaging for slices of a specific organ, upon intravenous injection of a mixture of several types of nanomaterials.

INVITED LECTURE

Ruthenium-based Metallodendrimers, a Nanotool in Oncology: Synthesis and Pre-clinical Studies

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Cancer has an impressive social and economic impact. For instance, it is estimated that 10 million people died of this disease, and 19.3 million new cases appeared in 2020 globally[1]. Nevertheless, and despite the cumulative knowledge acquired in the last 50 years, cancer remains one of the biggest challenges faced by science.
Metallodrugs, mainly platinum-based complex derivatives, are at the forefront for use in the clinical scenario. However, the common side effects and drug resistance associated with cancer drugs use, particularly those related to metallodrugs, represent a severe limitation for their application. To overcome such drawbacks, different approaches have been considered. Among these, ruthenium complexes emerged as a promising alternative due to the possibility of killing cancer cells through a mechanism of action distinct from platinum derivatives, ability to bind to albumin, and transferrin, which facilitates their uptake into tumor cells without damaging too much the normal tissues[2]. Additionally, their therapeutic activity, solubility, and selectivity can be enhanced if they are incorporated into three-dimensional and hyperbranched globular nanopolymeric architectures (dendritic scaffolds), like dendrimers[3-4].
After showing, for the first time, that the organometallic compound $[Ru(\eta^5\text{-}C_5H_5)(PPh_3)_2Cl]$ (RuCp) had the potential to be used as a metallodrug in anticancer therapy[5], our group started a research program to deliver the RuCp moiety in cancer tissues using different families of dendrimers. The first family studied was based on nitrile poly(alkylidene amine) dendrimers with a 1,6-diaminohexane core (G0CN, G1CN, G2CN). In vitro experiments showed that the fragment was released from the metallodendrimers in a sustained manner. The anticancer activity evaluated in vitro by exposing A2780, A2780cisR, and MCF-7 cell lines to different compound concentrations revealed that generation 2 with 16 metallic fragments (G2Ru) was the most cytotoxic, independently of the assayed cell type. In vivo experiments done in collaboration with Shi's group (DHU, Shangai), with G2Ru metallodendrimer in BALB/c female nude mice, showed a substantial reduction in the growth of MCF-7 xenografts, a very low level of ruthenium accumulation in the heart, liver, spleen, lung, and kidney, and a substantial decrease in the ruthenium content at the tumour over time, meaning that the G2Ru is body cleared. More recently, we demonstrated the ability of PAMAM dendrimers with 4, 8, 16, and 32 metallic fragments to deliver in vitro and in vivo RuCp fragments with success. The obtained results revealed that cytotoxicity against MCF-7, A2780 cells, and A2780cisR cells increased with the dendrimer generation, pointing out a different mechanism of action at the molecular level vs. cisplatin that possibly involves multiple targets. In fact, the studied mechanisms showed that the G3Ru seems to generate a high intracellular level of reactive oxygen species (ROS) that, possibly, constitute the leading cause of cell death. In vivo studies also developed in collaboration with Shi's group (DHU, Shangai) confirmed the antitumor efficacy of this G3Ru in a resistant breast tumor xenograft model (4T1), a good biosafety profile, and accumulation mainly inside the tumor. Even if the use of metallodendrimers in cancer is still relatively unexplored (until now, only pre-clinical data is available), our results, together with the knowledge already produced by other groups on the field, foresee a promising future of metallodendrimers for nanotheranostic applications.

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Acknowledgments
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INVITED LECTURE

Controlling Macromolecular Self-Assembly by Reactions and Structures of Saccharides

Guosong Chen
Fudan University, China

In the study of the self-assembly of biomacromolecules into regular structures driven by noncovalent interactions, how to control their noncovalent interactions in order to form well-controlled assembled structures becomes the most important mission. In this talk, I will first introduce the concept that we proposed for glycopolymer self-assembly, i.e. DISA (i.e., deprotection-induced glycopolymer self-assembly). We initiated this new strategy with diblock copolymers. Such copolymers with a carbohydrate block having protected pendent groups exist as single chains in organic media. The self- assembly can be initiated by the deprotection of the pendent groups. The process was nicely controlled by introducing various protective groups with different deprotection rates. Later on, the DISA process has been proven practical in water and even in the cellular environment, which opens a new avenue for the development of polymeric glycomaterials. The strategy was pushed forward by taking glycosyltransferase as the trigger to induce morphology transition. In the end, I report our recent progress on contribution of saccharide structures on self-assembly of glycopeptides for fibril association.

INVITED LECTURE

Biodegradable occluder of polyester fibers for closure of atrial septal defect in heart

Jiandong Ding
Fudan University

Interventional treatment has been one of the main stream stretgies to deal with congenital heart disease. While the next-generation closure device for interventional treatment of heart disease is regarded to be biodegradable, the corresponding biomaterial technique is still challenging. We designed and fabricated a biodegradable occluder for atrial septal defect (ASD) by knitting poly(L-lactic acid) (PLLA) fibers, etc. In spite of no hyperelasticity of the NiTi alloy, our polymeric occluder can be folded up into a narrow sheath, released out of the sheath, and locked in an interventional operation. The resultant transcutaneous ASD occluder has been proven to work well in a piglet model with 3-year-follow-up and has been confirmed in the first clinical implantation into the heart of a 4-year boy with two-year follow-up.

KEYNOTE SPEECH

Silk fibroin fibers and functional materials

Yaopeng Zhang
Donghua University

Silk fibroin is one of important bio-materials with excellent performance and wide application. This report firstly introduced the multiple bioinspired spinning platform integrated with protein concentration, shearing, stretching, ion regulation, and spinning, discovered the fiber reinforcement mechanism based on hierarchical structures of SF, and obtained biomimetic SF fibers with mechanical properties which exceeded those of natural silkworm silk. Secondly, we proposed a theory of confined crystallization of SF micro-region, developed a strategy to regulate the interface between SF tissue engineering scaffolds and cells, and obtained tough tissue engineering scaffolds integrated with electrical properties and physiological activities. Thirdly, we proposed a novel model of hierarchical structure of silk based on single molecular layer silk nanoribbon, invented a silk modification method through feeding silkworm with nanomaterial modified diets, resulting in the large-scale fabrication of high-value functional silk.

KEYNOTE SPEECH

Engineering of Carbon and Silk Materials toward Soft Electronics

Yingying Zhang
Tsinghua University, China

Flexible and wearable electronics are attracting wide attention due to their potential applications in wearable human health monitoring and care systems. It is of great importance to explore low cost and scalable preparation approaches for high performance flexible electronics. Carbon materials have combined superiorities such as good electrical conductivity, intrinsic and structural flexibility, and light weight, enabling them to be promising candidate materials. In the past several years, we have been working on the rational design and controlled fabrication of flexible electronics based on carbon nanotubes, graphene, silk and their hybrid materials. We found that the hierarchical structure of the carbon materials plays important roles in achieving flexible devices with desired performance. At the same time, we have also explored the application of silk in flexible sensors by developing a carbonization strategy of silk nanofibers and fabric and by combing nanocarbons with natural silk materials. Based on the above, the applications of the obtained electronics in human health monitoring, human motion tracking, and human-machine interfaces have been demonstrated. These strategy provide new approaches for the low-cost production of high performance flexible and wearable electronics, which may promote the development of next generation smart electronics.

KEYNOTE SPEECH

Silk sericin-based hydrogel as an in situ forming technology for wound healing and regeneration

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Universidade Católica Portuguesa
CBQF - Centro de Biotecnologia e Química Fina – Laboratório Associado, Escola Superior de Biotecnologia, Porto, Portugal

Diabetic wounds, mainly chronic and/or complex wounds, are considered one of the most common complications associated to diabetes mellitus (DM) and contributes to the higher morbidity in patients. The choice of the adequate dressing is of great importance and it needs to reflect the requirements of a particular wound according to its stage, going from films/membranes (adherent or non-adherent), hydrogels, hydrocolloids, composite dressings, foams, etc. Currently there are also many skin substitutes available in the market for clinical use. However, most of these are formed from reconstituted extracellular matrices (ECM) and must undergo numerous processing steps in order to remain immunogenically inert. They can serve as protective barriers but do not allow for any higher order skin processes to take place and are usually undernourished due to decreased vascular permeability.
Recently, several new biopolymer hydrogels have been proposed, incorporating a diversity of bioactive agents with the purpose of unblocking the healing process. Hydrogel formulations enclose high quantities of water and therefore, are specific for dry or low exudative wounds, where they stimulate the cellular re epithelization.
Amongst the new generation of natural-based biopolymers being proposed for wound healing and regeneration, silk proteins are particularly interesting due to their exceptional properties, such as biocompatibility, oxygen and water vapor permeability, enzymatic degradability, processing versatility and diversity of side chain chemistries available for 'decoration'. In this work, an overview on silk hydrogels is provided, focusing on a novel silk-based hydrogel as a state-of-the-art wound dressing technology able to deliver in situ, i.e., directly onto the wound site, a construct that perfectly fits the size and shape of the wound and is capable of promoting healing and regeneration.

INVITED LECTURE

A high-efficiency, energy-saving and green route for fabrication of chitin-based materials

Jie Cai
Wuhan University

Crystalline polysaccharides, such as cellulose, chitin/chitosan are useful for important and rapidly growing applications ranging from advanced energy storage, green electronics and catalyst or enzyme supports to tissue engineering and biological devices. However, the potential value of chitin in such applications is currently neglected because of its poor solubility in most commonly used solvents. Herein, a high-efficiency, energy-saving and "green" route for the fabrication of chitin-based hydrogels, films, fibers and derivatives is described in which chitin is dissolved in an aqueous KOH/ urea solution. The dissolution mechanism of chitin in the aqueous KOH/urea solution was proposed. The structure and properties of these chitin-based materials were characterized. The simplicity of the process and the widely tunable properties of the chitin-based materials make them promising candidates for applications in various fields in the future. The method developed here should contribute to the utilization of seafood waste and, thereby, to the sustainable use of marine resources.

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INVITED LECTURE

Determining the critical size of secondary nuclei of polymer lamellar crystals

Jun Xu、Shujing Zhang、Baohua Guo
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Nucleation is a fundamental step of crystallization and its mechanism still remains unclear. Determination of the size of the critical nucleus is a key for understanding the mechanism of nucleation and allows testing theories. However, it has been a great challenge for both experimentalists and theorists to quantify this size. We proposed a method to determine the size of the critical secondary nuclei on the lateral growth front of polymer folded chain crystals [1,2]. For the secondary nucleation, the slope of the log-log plot of the spherulitic radial growth rate versus the content of crystallizable units in the random copolymers gives the number of units in the critical secondary nuclei. This method is based on the stochastic feature of nucleation and is independent of the detailed nucleation pathway. Our results on the poly(butylene succinate-co-butylene methylsuccinate) random copolymers showed that a critical secondary nucleus consisted of 15 to 27 butylene succinate units, corresponding to 5 to 8 chain stems when the polymers were isothermally crystallized from quiescent melt at the temperatures ranging from 70 to 95 °C[1]. The method was further applied to poly(L-lactide) (PLLA) and poly(L-lactide-co-D-lactide) random copolymers. At crystallization temperatures ranging from 120 to 140 °C, a critical secondary nucleus of PLLA α-form crystal contained around 32 to 52 L-lactide units [2]. From the final lamellar thickness, the lower limit of the number of stems in a critical nucleus was estimated as 1.6 - 2.1. Considering the lamellar thickening coefficient, the upper limit of the number of stems in a nucleus ranged from 4.1 to 5.4. The results contradict the classical Lauritzen-Hoffman theory, which predicted that the critical secondary nucleus should be a single chain stem. Our method can be generally applied to other flexible polymers and would be beneficial for understanding the nucleation mechanism of polymer folded chain crystals.

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INVITED LECTURE

Two-dimensional field-effect transistor sensors

Dacheng Wei
Fudan University

Two-dimensional field-effect transistor (2D-FET) sensors are one of the frontier research fields of advanced sensing technologies. These materials have large surface area and ultra-thin thickness approaching the physical limit, which give rise to remarkably enhanced sensitivities. On the other hand, all of the electron processes take place at the material surface or interfaces. The interfaces will largely influence the performances. Thus, the interfacial modulation is an important scientific question. This research is focused on the interfacial modulation of the 2D-FET sensors. Main results include: new methods are developed to controllably produce high quality 2D sensing materials and the interfaces of the 2D-FET sensors; a new approach is demonstrated to improve the interface between the semiconductor and the dielectric substrate by using conformal h-BN[2]; new mechanisms such as giant photoelectrical-gating effect, photoelectrical enhancement effect of molecular crystals at 2D limit, controllable charge doping at the sensing interface, etc. are developed to modulate the electron processes at the sensing interface, which improves photoelectrical or chemical sensing performances of 2D-FET sensors.

INVITED LECTURE

Efficient bidentate metal complexes for ROP of cyclic esters

Wenjuan Zhang
Beijing institute of Fashion Technology, Beijing, China

The past decades witnessed the rapid progress of the biodegradable and biocompatible polymers such as polylactides (PLA) and poly(ε -caprolactone) (PCL) due to people's increasing conscious about environmental protection and successful preparation of the biodegradable polymer in industry [1]. Typically, such aliphatic polyesters can be prepared by ring-opening po-lymerization (ROP) of cyclic esters in the presence of metal compounds such as those based on Al, Ca, Sn and rare earth metals [2]. Among them, multidentate metal complexes have attracted much attention due to their relatively high Lewis acidity, good controllability in the ROP of cyclic ester [3]. There are still relatively limited examples of bidentate metal complexes as efficient catalyst for the ROP of cyclic. Recently, we have developed several series of bidentate metal (such as Al, K, Fe or Zn) complexes, which displayed very good efficiency for ROP of ε-caprolactone and lactides [4]. The detail information will be presented in the conference.

INVITED LECTURE

Functional cellulose materials: Molecular design and applications

Ruigang Liu
Institute of Chemistry, Chinese Academy of Sciences

Cellulose is the most abundant natural biopolymers and is produced up to thousands billion tons each year via photosynthesis of higher plants. Cellulose is considered as an inexhaustible resource for the increasing demand for environmentally friendly and biocompatible products and the promising candidate for conversing into bio-based chemicals and energy. In this talk, we will discuss the research progress in our group on the design and synthesis of cellulose functional materials, including cellulose based graft copolymers and derivatives with different chemical structure and properties. The applications of the cellulose functional materials will be discussed and in some cases is on the way of commercialization.

INVITED LECTURE

Investigation on surface modification of bagasse fiber: rheological properties of asphalt mortar

Zuzhong Li
Changan University

Bagasse has achieved wide applications in the field of papermaking, composite materials and road engineering in recent years. Various surface modifications for plant fibers are designed to deal with the problems, such as high absorption of moisture and poor interfacial bonding with polymer matrix. The aim of this work focuses on investigating the surface modification of bagasse fiber and rheological properties of asphalt mixtures blended with bagasse fiber or lignin fiber. The bagasse fiber was subjected to single modification, binary composite modification and ternary composite modification by mixing hydrochloric acid, sodium hydroxide and sodium chlorite. The morphology, chemical component variation and oil absorption of modified and unmodified bagasse fiber were investigated by SEM, FT-IR and oil absorbing test, respectively. The rheological properties of asphalt mortar with bagasse fiber and lignin fiber were analyzed by the DSR test and BBR test. In conclusion, it could be found that the chemical modification could eliminate impurities on the surface of fiber, partially remove the hydrophilic functional groups and facilitate the degradation of different fiber components. As a result, the fibrillation was promoted while the specific surface area of fiber increased as well. The loose structure of microfibril was conducive to the absorption of light components in asphalt, thus improving the high-temperature deformation resistance of asphalt mortar, but moderately lowering its performance in cold climate environment. In comparison with other modification schemes, the ternary composite modification for bagasse fiber exerted the most significant impact on the structure and oil absorption of fiber and the rheological properties of corresponding asphalt mortar.

INVITED LECTURE

Killing Seven Birds with One Stone: Oral Nanotherapeutics Based on Antheraea pernyi Silk Fibroin for Effective Treatment of Ulcerative Colitis

Bo Xiao
State Key Laboratory of Silkworm Genome Biology, Southwest University

Ulcerative colitis (UC) with rapidly increasing incidence has become an emerging challenge for public health. The favorable treatment platforms against UC require that therapeutics are specifically delivered to target cells (colonic epithelial cells and macrophages) and controlled release drugs to their cytoplasms, resulting in wound healing and inflammation alleviation. Here, Antheraea pernyi silk fibroin (ApSF) was engineered to nanoparticles (NPs) loading with anti-inflammatory drug (resveratrol, Res). The obtained Res-ApNPs showed a desirable particle size (182.7 nm), high colloidal stability, and negative-charged surface (-21.4 mV). It is surprising to see that these polymeric NPs presented colonic epithelial cell/macrophage-targeting properties, lysosome escape potential, and pH/reactive oxygen species (ROS)/glutathione-responsibilities, suggesting that they could achieve on-demand release of Res molecules in the target cells. These intrinsic features of Res-ApNPs were found to be attributed to their functional units (RGD tripeptide, α-helix, β-sheet, and disulfide bond). Moreover, Res-ApNP treatment greatly restored the damaged colonic epithelial barriers, decreased the secreted amounts of anti-inflammatory factors, polarized macrophages to type M2, and eliminated the intracellular ROS. Further in vivo experiments demonstrated that oral administration of chitosan/alginate hydrogel-embedding Res-ApNPs could substantially relieve the symptoms of UC, which was evidenced by decreased colonic inflammation, increased expression levels of tight junction proteins, and rebalanced gut microbiota. These findings suggest that these ApSF-based NPs with colonic epithelial cell/macrophage-targeting, lysosome escape, multi-bioresponsible, wound healing, antioxidation, anti-inflammatory, and microbiota modulation properties could be developed as a promising therapeutic nanoplatform for UC treatment.

INVITED LECTURE

Modification of polysaccharide and the eco-friendly fiber fabrication

Yumei Gong、Fangjun Wang、Tongyao Zhao、Linlin Chang
Dalian Polytechnic University

With the increasing demand for textiles, the pollution of textile microplastics to environment has become an imminent problem. At present, common synthetic fiber depending on depleting petroleum in market has a long natural degradation cycle and great harmful to environment and hence design and fabrication of natural biodegradable fibers becoming a research hotspot. Besides cellulose, nature polysaccharides such as starch, sodium alginate, and chitosan et al attract much attention due to their natural regeneration and annual numerous yield. We have prepared starch/polyacrylonitrile composite fiber with high strength by in-situ compatibilizing starch and polyacrylonitrile and pectin/chitosan derivatives (PEC/QAC) composite fiber by mixed the two polysaccharide polyelectrolytes via solution spinning process. The starch composite fiber exhibits excellent property with breaking strength of 3.41 cN $dtex^{-1}$, breaking elongation of 48.35%, sonic orientation factor of 0.625, moisture recovery ratio of 10.53% under standard condotion (1 atm, 22 ^{o}C, RH 65%), boiling water shrinkage ratio of 9.60%, and biodegradation ratio of 57.6% after four weeks in 0.1 mmol L^{-1} phosphate buffer solution. The PEC/QAC composite fiber has breaking strength ~ 2.33 cN·$dtex^{-1}$ and excellent degradability, the biodegraded mass loss rate is ~ 61.9% during four weeks. It has excellent bacteriostasis against Escherichia coli and Staphylococcus aureus. It also has a good adsorption effect on protein. The fiber adsorption performance of bovine serum protein reaches 218 mg·g^{-1} at pH ~ 7.2 as adsorption equilibrium. Obviously, the prepared composite fibers were better than common viscose fiber with 2.11 cN·$dtex^{-1}$ and expected to be used in the fields of medical gauze, bandage, protective clothing, et al.

INVITED LECTURE

Biodegradable devices for environmental and medical applications

Jie Zhao
Fudan University

The proliferation of electronic products generates million tons of electronic waste every year. To address these issues, transient electronics have emerged as a new class of technologies whose key feature is that they completely “disappear” after a period of stable operation. Aside from the environmental benefits, transient electronics open a new application field as implantable medical devices that are resorbable in the human body, thus bypassing the need for surgery to extract them. Specific examples include wireless bioelectronic devices with the controlled operation and degradation time for therapeutic stimulation to accelerate neuroregeneration in damaged peripheral nerves. The tuning of biodegradable polymer-based encapsulation creates an opportunity to trigger the decomposition of electrical components of peripheral nerve stimulators at an ultrafast degradation rate. The transient engineered technologies serve as “bioelectronic medicines” that can complement or replace pharmaceutical treatments for a variety of medical conditions in humans.

INVITED LECTURE

Silk fibroin-based flexible conductive and functional materials

Suna Fan、Yaopeng Zhang
Donghua University

Silk fibroin (SF) has displayed great potential in optic and electronic devices since its excellent biocompatibility and biodegradability. However, the performance of SF-based functional materials still needs to be further improved. Herein, we fabricated a series of SF-based flexible conductive and functional materials with excellent performances through regulating the condensed structure of SF and exploiting new conducting block. Firstly, egenerated silk fibroin (RSF)/cellulose nanofibers (CNF) hybrid fibers were wet-spun through a microfluidic channel that mimics the shape of spider's major ampullate gland. The generated RSF/CNF fibers showed a low light loss of 1.0 dB/cm, which was much lower than that of degummed-silk and most commercial waveguides. Additionally, the fibers had high sound velocity and was knittable. The break strength of the RSF/CNF fiber was as high as 710 ± 33 MPa, which was significantly higher than that of silkworm silk fiber. In addition, in order to maintain the original meso/nanoscale structure of silk, silk nanoribbons (SNRs) with a thickness of 0.38 nm are directly exfoliated from natural silk. Then, a SNR-based bio-TENG is fabricated using a nascent SNR film (SNRF) and RSF film. The output performance of the bio-TENG with the maximum voltage, current, and power density (PD) reach up to 41.64 V, 0.5 μA, and 86.7 mW/m2, respectively. With its high sensitivity and the ability to generate power from just a human pulse, the all silk-based bio-TENG may be an attractive power source for implantable self-powered electronic devices, such as pacemakers and implantable sensors. Furtherly, new conducting wire with excellent conductivity, bio-absorbability, biocompatibility, and low weight was prepared from natural polymer and chromium/aurum (10/140 nm), providing the possibility to construct a fully bioabsorbable implantable device. Compared with conventional metallic wires, this conducting wire has a higher transmission efficiency and biodegradability, better biocompatibility, and is more lightweight. These SF-based materials may be used in the fields of wearable electronics and implantable bioelectronics.

INVITED LECTURE

Spectroscopic Characterization of Conjugated Polymer Interfaces for Organic Electronics

Qinye Bao
East China Normal University

Conjugated polymers have been promising semiconductors with favorable optoelectronic properties for eco-friendly fabrication of efficient organic electronic devices. The basic physics involved electronic structures at conjugated polymer interface plays a role in controlling charge injection/extraction, charge recombination and exciton dissociation, in turn a prerequisite for achieving highly efficient devices.

In this talk, we will highlight our latest explorations on conjugated polymer interface by photoelectron spectroscopy: the effect of integer charge transfer states created as a consequence of Fermi level equilibrium at organic donor-acceptor interface on the power efficiency conversion of ternary polymer solar cells, and interface effects of conjugated polymer-electrode interface. Finally, we also shortly introduce the energetics of organic-inorganic perovskite interfaces.

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Dual-functional dithiol chain extender for regenerated keratin filaments tougher than natural feathers

Mi Xiang
Minjiang University

A dual-functional dithiol chain extender was used to obtain regenerated keratin filaments tougher than natural feathers. Due to the high degrees of intermolecular disulfide crosslinking, natural keratin materials, especially feathers and animal hairs, intrinsically have dry and wet tensile properties better than most protein materials. However, regenerated keratin materials developed by various approaches have tensile properties much lower than their natural counterparts. The disparity was due to damages of backbones and unsuccessful reconstruction of intermolecular disulfide crosslinking. In this work, disulfide crosslinking is efficiently reconstructed using a dithiol reducing agent. The regenerated keratin filaments retained the tenacity of natural feathers, and furthermore, demonstrated much higher stretchability in dry and wet states than natural feathers. Based on molecular analysis, the reaction between dithiothreitol, the dithiol reductant, and keratin was not only the thiol-disulfide exchange reaction, but also a dithiol chain-extending process. Comparing with L-cysteine, a monothiol reductant, dithiothreitol functions as a “bridge” to connect thiol groups in keratin, allowing a higher degree of intermolecular reconstruction of disulfide bonds and formation of lengthy crosslinkages in the regenerated keratin filaments. The new approach has great potential in regeneration of highly-crosslinked materials with much-improved ductility and high retention of tenacity.

Design of polysaccharide polyelectrolyte systems and fabrication of bicomponent eco-friendly fibers

Yumei Gong、Tongyao Zhao
School of Textile and Material Engineering, Dalian Polytechnic University

With the increasing demand for textiles, the pollution of textile microplastics to environment has become an imminent problem. At present, common synthetic fiber in market has a long natural degradation cycle and great harmful to environment. Therefore, design and preparation of natural biodegradable fibers is a research hotspot. Pectin (PEC) is a kind of acidic heteropolysaccharide widely derived from plant cell wall. PEC and its derivatives are natural, widely available, cheap, biodegradable and other excellent properties. On the other hand, Chitosan (CTS) is a deacetylated derivative of chitin in shells of crustaceans such as shrimp and crab. Chitosan quaternary ammonium salt (QAC) is a cationic polyelectrolyte produced after chemical modification of natural polysaccharide CTS. Here, PEC blending with QAC polysaccharide polyelectrolyte composite system was designed to research the blending of anionic and cationic polyelectrolytes and to characterize its properties. PEC/QAC bicomponent biodegradable fiber was prepared via wet spinning and the fiber structure and performances were determined by XRD, FT-IR, SEM, and fiber tensile meter. The results showed that different mass ratios of PEC and QAC in the PEC/QAC polyelectrolyte composite solution produced different phenomena, and the solution was a shear-thinning fluid. When the mass ratio of PEC to QAC was 10:1 and the stretching temperature was 50 oC, the morphology of the composite fiber was uniform, the structure was dense, the diameter ~ 95 μm, the moisture recovery ~ 15.69%, and the breaking strength ~ 2.33 cN·dtex-1. The PEC/QAC composite fiber has excellent degradability, the biodegraded mass loss rate is ~ 61.9% during four weeks. It has excellent bacteriostasis against Escherichia coli and Staphylococcus aureus. It also has a good adsorption effect on protein. The fiber adsorption performance of bovine serum protein reaches 218 mg·g-1 at pH ~ 7.2 as adsorption equilibrium.

Synergistic effect of reduced graphene oxide and carbon nanotube on cellulose-based solar steam generator

Mengtian Jin
Donghua University

The emerging water purification technology represented by solar water evaporation has developed rapidly in recent years and is widely used in seawater desalination. However, the high reflectivity of sunlight and low efficiency of photothermal conversion greatly hinder its application prospects. In this paper, through the addition of carbon materials in the process of bacterial cellulose culture, the hierarchical structure of the film was designed and optimized. Cellulose-based composite film material with heterojunction structure was obtained, which can improve the photothermal conversion rate from the structural principle; optimize the micro cross-section structure, improve the physical and chemical stability of the film, so as to achieve recycling; use bacterial cellulose as a three-dimensional carrier, reduced graphene oxide (RGO) and carbon nanotubes (CNT) were combined to form 1D / 2D composite films for solar evaporation. Adding a small amount of CNT-RGO (21.8%), resulting in prominent properties in the photothermal evaporation rate and photothermal conversion efficiency. Through in situ culture of bacterial cellulose, not only the heterojunction bilayers with tight structure can be obtained, but also there are a lot of hydroxyl groups on the surface of bacterial cellulose, which provides many active sites for loading photothermal materials. The photothermal conversion efficiency is 90.2 %, and the photothermal evaporation rate is 1.85 kg m^{-2} h^{-1} to achieve efficient solar interface evaporation. The superior photothermal performance of this hybrid film is attributed to the synergic effect between the components.

One-pot synthesis of aminated cellulose nanocrystals

Jiayin Wu[1,2]、qilin Lu[1,2]
1. Minjiang University
2. Fujian Agriculture and Forestry University

In order to realize the green preparation of nanocellulose derivatives, ammonium persulfate was used to oxidize bamboo pulp fibers to obtain carboxylated nanocellulose (CNC) under microwave-hydrothermal condition based on mechanochemical chemistry. Then conden-sation reaction between CNC and diethylenetriamine was carried out in the aqueous phase to realize the "one-pot" synthesis of aminated nanocellulose (ACNC), and its properties were explored. The results show that ACNC is rod-shaped with a diameter of 10-40 nm and a length of 50-300 nm, and the grafting ratio of ACNC is 6.29%. The crystal form of ACNC is still cellulose type I, besides the crystal-linity increases from 59% to 79%. The preparation method is green and efficient, and the property of nanocellulose derivatives is enhanced. Furthermore, epoxy resin composites were obtained by compounding ACNC with epoxy resin. ACNC can act as both reinforcing agent and curing crosslinking agent in epoxy resin composites. ACNC improved both the mechanical properties and flexibility of epoxy resin. The mechanical strength of the epoxy resin composite enhanced 143% when the ACNC loading was 0.1 wt%, and the flexibility was also improved significantly.

Improving the stability of polymer complex beads by thermal treatment

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Center for Advanced Low-dimension Materials, State Key Laboratory for Modification of Chemical Fibers and Polymer Materials, Donghua University, Shanghai 201620, China

Carboxymethyl cellulose (CMC) and chitosan (CHI) are two well-known natural polymer derivatives, as such the CMC@CHI complex beads fulfill many requirements for bio-related and safety required applications, but they lack the necessary stability for applications. In this work, we investigate the effects of a thermal treatment during the bead preparation on the stability of the formed beads. After the beads were formed in solution, they were treated in CHI solutions with a temperature ranging from 25 °C to 75 °C. The thermally treated beads were then characterized using SEM, XPS and FTIR, analyzing the changes in morphology, beads diameter, shell thickness and structure. The stability of the beads was studied by the mechanical test and swelling experiments. Results show that the beads treated with a temperature of 75 °C were not ruptured until the rupture force was increased to 0.87 N. The swelling experiments showed that while heating helped the beads to withstand the swelling, being able to contain more water with an enlarged size, the swelling degree started to decrease when the heating temperature was higher than 55 °C. This approach provides us a simple method to improve the stability of the complex beads, as well as to balance the “large swelling” and “good mechanical behavior”. It is useful for application of theses core-shell beads in an aqueous environment.

Scalable bacterial cellulose biofilms with improved ion transport for high osmotic power generation

Zhuotong Wu、Shiyan Chen
Donghua University

With the increase in energy demand and the increasing pollution of fossil fuels, the development of clean, abundant, and sustainable energy is urgent for mankind and modern society. The osmotic energy that derived from sea water and fresh water is in ubiquitous existence on Earth and has been identified as a renewable and sustainable source of energy, popularly known as blue energy. The reverse electrodialysis (RED) is one of the most promising approaches for blue energy harvesting. It is consisted of cation- and anion- selective membranes, which converts the salt concentration gradient into electric energy. Recently, the RED devices based on nanofluidic channels are considered as the high-performance osmotic energy generators. However, the high cost and the difficult processing of these materials used in RED devices restrict their development in the field. Herein, we develop negatively charged carboxymethyl bacterial cellulose membranes (BC-CMC) and positively charged chitosan quaternary ammonium bacterial cellulose membranes (BC-HACC) with adjustable charge density and nanochannel size by in situ culture. The scalable membranes are suitable for rapidly ion selective transmission process. When applying the charged BC membranes for an osmotic energy harvesting device, an output power density of 2.25 W m-2 can be reached. Further connecting 15 units of the charged BC device, the output voltage can reach up to 2.53 V, which can directly power the electronic devices. This work highlights the advantage of large-scale preparation by the biosynthesis method, which can simultaneously tune the surface properties and nanochannel size of BC to regulate the ion transport behavior. We offer an easy and scalable method to obtain low-cost membranes for high osmotic energy conversion device, providing the feasibility for their large-scale application.

Iron ions-coordinated poly(acrylic acid) fiber as a stable Fenton catalyst for methylene blue decolorization

Yanxin Zhang、Naiku Xu、Jiao Han、Jinghong Wang
Tiangong University, Tianjin

Wet-spinnable poly(acrylic acid) (PAA) was synthesized using free radical polymerization with maleic anhydride as a chain transfer agent. Iron ions-coordinated PAA fiber was prepared by wet spinning with a dilute acid solution containing iron ions as coagulant. Both stretching and heat setting were applied to optimize the physical property of as-spun fiber such as strength, dimensional stability and water-resistance. In addition, the carboxyl groups exposed outside in the process of stretching and heat setting enabled the fiber to quickly re-coordinate the iron ions leached out by methylene blue (MB) aqueous solution during application, which could minimize the loss of iron ions. Due to the low leaching out of iron ions, the obtained fiber showed a stable activity in catalyzing H_2O_2 to decolorize MB aqueous solution. The research results showed that the prepared fiber could decolorize more than 90% MB within 4 minutes during 40 cycles and did not show any attenuation in MB decolorization efficiency. During 40 cycles, the average concentration of eluted iron ions was only 4.89mg/L. Additionally, the iron ions-coordinated PAA fiber prepared by combining stretching and heat setting showed a breaking strength of 1.215cN/dtex, which was increased by 2070% in comparison with that of unstretched fiber. Thanks to the enhanced strength, low leaching out of iron ions and stable catalytic activity, the fiber prepared in this work is expected to show a great potential for the application in the field of dye wastewater treatment.

A Dynamically Hybrid Crosslinked Elastomer for Room-temperature Recyclable Flexible Electronic Devices

Yifan Guo、Lei Yang、Zhengwei You
Donghua University

The rapid development of flexible electronic devices has resulted in serious pollution in the form of electronic waste. Accordingly, recyclability is highly desirable for these devices, but this remains a significant challenge, especially for the thermosetting resins that are extensively used in electronics. A dynamically hybrid crosslinked polyurethane (FPU) elastomer was designed in this study to address this challenge. Distinctive Diels–Alder (DA) adducts with suitable dissociation and reassociation dynamics were designed as crosslinking units to provide an efficient time frame for recycling. The FPU was maintained in a state with a low crosslinking density for several hours after heating at 120 °C for 5 min. FPU-based electronics could therefore be dissolved in chloroform under ambient conditions to separate the electronic components and polymers for the refabrication of new electronic devices. This is the first reported thermoset elastomer that can be completely recycled at room temperature without the need for chemical treatment to decompose the polymer chain. The design concept was applied by demonstrating the fabrication by recycling of three different FPU-based flexible electronic devices: a position sensor, a flexible keyboard, and a motion sensor. Furthermore, the FPU has many advantages as a material for flexible electronics in terms of its biomimetic mechanical properties, room-temperature selfhealing, and facile processability. This study provides promising new design principles to develop materials for promoting sustainable flexible electronics.

KEYNOTE SPEECH

Functional Fibers and Nanofibers for Energy Storage: Past, Present, and Future

Xiangwu Zhang
North Carolina State University

Research and development in textiles have gone beyond the conventional applications as clothing and furnishing materials; for example, the convergence of textiles and energy technologies opens up the opportunity to take on one of the major challenges in the 21st century energy. Among various energy technologies, batteries, supercapacitors and fuel cells are promising candidates for storing and converting energy in a clean manner because they can provide electricity without thermal combustion and the pollutants associated with burning fossil fuels. Novel functional fibers and nanofibers with functional properties can dramatically alter surface reaction rates and charge transport throughout these energy storage and conversion systems, thereby leading to significantly improved batteries, supercapacitors, and fuel cells. The design of functional fiber and nanofiber materials for alternative energy systems is, therefore, a way to develop a wide range of new technologies for a healthy future. This presentation focuses on the past, present, and future of the research and development of advanced fibers and nanofibers for next-generation batteries, supercapacitors, and fuel cells.

KEYNOTE SPEECH

High-performing fiber lithium-ion batteries

Huisheng Peng
Fudan University

Fiber lithium-ion batteries are pioneering as flexible power solutions because they can be woven into textiles. Textile batteries offer a convenient and seamless way to power future wearable electronics. However, current fiber lithium-ion batteries are only centimeters long because longer fiber lithium-ion batteries are difficult to produce and they are thought to have significantly higher internal resistances that compromise electrochemical performance. Here, we unexpectedly discovered that the internal resistance of fiber lithium-ion battery has a hyperbolic cotangent function relationship with fiber length, where it firstly decreases before leveling off as length increases. Systematic studies confirm this is true for different fiber batteries. We produced meters of high-performing fiber lithium-ion batteries via an optimized industrial process. Our mass-produced fiber lithium-ion batteries had a certified energy density of 85 Wh/kg based on the total weight of full battery including packaging. Over 80% capacity can be maintained after bending for 100,000 cycles. We show these fiber lithium-ion batteries woven into safe and washable textile by industrial rapier loom can wirelessly charge cellphones or power health management jackets integrated with fiber sensors and textile display.

KEYNOTE SPEECH

Colloidal synthesis approach for energy materials

Yan Lu
Helmholtz-Zentrum Berlin für Materialien und Energie

Colloidal route is one of the favored ways toward cost-effective large scale production of various nanostructures, which allows well control over the electrode architecture from the nanoscale to macroscale. [1]. In our study, functional nanoparticles with defined shape and composition have been designed and synthesized via colloidal approach, which can be applied as electrode materials for various battery systems, e.g. Li-S [2], aqueous Li-ion batteries [3].

For example, multifunctional Ti4O7 particles with interconnected-pores structure have been synthesized by using porous PS-P2VP particles as soft template [4]. In order to improve the conductivity of the electrode, a thin layer of carbon has been coated on the Ti4O7 surface without destroying its porous structure. The porous Ti4O7 particles as well as carbon-coated Ti4O7 particles show significantly improved electrochemical performances as cathode material for Li-S batteries as compared with that of TiO2 particles. The scale-up of the synthesis of cathode material with well-defined structure is one of the main challenges in battery manufacture. More recently, we have managed to upscale the synthesis of hollow Ti4O7 nanoparticles using spherical polyelectrolyte brushes as the template by using the minipilot reactor (5 L). The obtained Ti4O7 hollow particles have been successfully used as cathode materials for Li-S batteries in the form of pouch cells.

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KEYNOTE SPEECH

Gold Nanowire Electronic Skins, Tattoos and Fibres for Sensing and Energy Applications

Wenlong Cheng
Monash University

Sensitive, specific yet multifunctional soft electronics are ideal wearable systems for health monitoring anytime anywhere because they are virtually becoming parts of Human skins offering burdenless “unfeelable” wearing experience. Here, I will present the skin-like, multifunctional electronic skins, tattoos and fibers using gold nanowires. Among various materials of choices, gold has advantages of biocompatibity, chemical inertness, facile synthesis/Surface functionalisation and band-gap-matching with a lot of semiconductors materials. I will discuss our newly developed standing gold nanowire-based soft biosensing platform in the forms of patches, fibers and tattoos. Combining it with local cracking technology, we can arbitrarily fine-tune desired sensitivity and stretchability of a gold nanowire electronic tattoos by programming localized crack size, shape and orientations. Furthermore, we demonstrate in-plane integration of strain/pressure sensor, anisotropic orientation-specific sensors, strain-insensitive stretchable interconnects, temperature sensors, glucose sensors, and lactate sensors without the need of soldering or gluing. Combining gold nanowire coating and dry spinning technologies, we can produce soft golden fibers for wearble sensing and energy applications.

INVITED LECTURE

Novelty — Dealing with the Abstract Concept

Tianyu Liu
Wiley

Lack of novelty has become the most common reason for manuscripts rejected by high-impact journals. What is novelty? How can we understand this abstract concept? After we comprehend novelty, what can we do to maximize the novelty of our works?

This presentation will discuss the above questions from the perspective of a journal editor. The first part will address four common pitfalls leading to insufficient novelty. The second part will take porous carbon fiber as an example, demonstrating how the way of writing impacts the delivery of novelty. The last part will briefly introduce a high-tier, multidisciplinary journal published by Wiley — Small Structures. The talk aims to provide audience writing strategies to enhance novelty.

Emerging Zn Anode-Based Electrochromic Devices

Haizeng Li
Shandong University

The development of electrochromic materials has opened the door to the development of numerous devices including smart windows, color displays, optical filters, wearable camouflages, among others. Although the current electrochromic devices do not consume energy while maintaining their colored or colorless states, their bistable operation requires external electrical energy to be consumed during switching. To reduce the energy consumption of an electrochromic device, an emerging Zn anode-based electrochromic device concept was recently introduced to partially retrieve the consumed electrical energy. In this talk, key technological developments and scientific challenges will be presented for a broad range of Zn anode-based electrochromic device configurations with emphasis on the inherent distinctions between the Zn anode-based and conventional electrochromic devices.

INVITED LECTURE

Functional Organic/Inorganic Fibers for Advanced Lithium Secondary Batteries

Jianwei Nai
Zhejiang University of Technology

Developing new energy materials is an urgent need and fundamental way to solve the increasingly serious problems of fossil energy crisis and environmental pollution. The lithium secondary battery (LMB) is an important technology for electrochemical energy storage. With respect to the LMB, although lithium metal is an ideal anode material, the non-uniformity of its electrodeposition, the growth of lithium dendrites, and other critical issues lead to an unstable and poor performance of the lithium metal anode (LMA), which greatly hinders its commercialization. The reporter has worked on the basic theory and application research of micro-nano materials for a long time. To address the above challenges, the reporter aims to the exploitation of high-performance LMAs, which is started from the functional organic/inorganic fibers design and control in material synthesis. The reporter here shows some of his research achievements related to the title's topic, focusing on the reveal of the mechanism of micro/nanofibers in improving LMAs, and their applications in other aspects of LMB, for example as the free-standing electrodes for either anode or cathode.

INVITED LECTURE

A highly alkaline-stable metal oxide@metal-organic framework composite for high-performance electrochemical energy storage

Huan Pang
Yangzhou University

Most of metal-organic frameworks (MOFs) hardly maintain their physical and chemical properties after exposure to alkaline aqueous solutions, thus precluding their use as potential electrode materials for electrochemical energy storage devices. Here, we present the design and synthesis of a highly alkaline-stable metal oxide@MOF composite, Co3O4 nanocube@Co-MOF (Co3O4@Co-MOF), via a controllable and facile one-pot hydrothermal method under a highly alkaline condition. The obtained composite possesses exceptional alkaline stability, retaining its original structure in 3.0 M KOH for at least 15 days. Benefiting from the exceptional alkaline stability, unique structure, and larger surface area, the Co3O4@Co-MOF composite shows a specific capacitance as high as 1020 F g-1 at 0.5 A g-1 and a high cycling stability with only 3.3% decay after 5000 cycles at 5 A g-1. The asconstructed solid-state flexible device exhibits a maximum energy density of 21.6 mWh cm-3.

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INVITED LECTURE

High performance flexible lithium battery based on organic/inorganic composite electrolyte

Qiuwei Shi
Nanjing University of Information Science & Technology

Solid state lithium battery can greatly improve the safety of the battery and is expected to improve the energy density of the battery. It is considered to be the next generation of high energy density electrochemical energy storage technology with great potential. However, a single polymer solid electrolyte is often trapped in the problems of low ionic conductivity at room temperature, unsatisfactory electrochemical stability and poor interface compatibility, resulting in the unsatisfactory performance of the constructed solid-state battery system in capacity, cycle stability and complex service environment. Herein, PMMA/ LLZN, PVDF-HFP/LLZN composite solid electrolytes composed of PVDF framework and garnet LLZN inorganic nano fibers were successively prepared.Based on the organic/inorganic composite polymer electrolyte, a polymer solid-state lithium battery with good cycle stability and rate performance is prepared. The prepared soft pack battery also shows good stability and excellent safety.

INVITED LECTURE

Biomass-based carbon nanomaterials for electrochemical energy storage

Lifeng Chen
Department of Thermal and Energy Engineering, School of Engineering Science, Hefei National Laboratory for Physical Sciences at the Microscale, University of Science and Technology of China

Because of the ever-increasing global population, the rapid growth of industrial production, and the accelerated consumption of fossil energy, energy shortages, and environmental pollution have become bottlenecks restricting the development of human society. As a result, governments all over the world attach great importance to develop new energy and environmental protection technologies. Among them, electrochemical energy storage is regarded as one of the key technologies to realize the efficient, convenient, and sustainable use of new energy. In electrochemical energy storage systems, energy storage devices such as supercapacitors, lithium/sodium-ion batteries, and lithium/sodium-sulfur batteries have shown broad application prospects, and they have also attracted widespread attention. The electrochemical properties of energy storage devices mainly depend on the used electrode materials. Owing to rich morphology, excellent mechanical properties, good electrical conductivity, and chemical stability, carbon materials are considered to be the important component for constructing electrodes of high-performance electrochemical energy storage devices. Therefore, continuous exploration of suitable and efficient new carbon-based electrode materials is essential to improve the electrochemical performance of energy storage devices.
Biomass is the greatest treasure given to humans by nature. It has the advantages of abundant sources, environmental friendliness, renewable, and low cost. The use of biomass to prepare carbon-based electrode materials for electrochemical energy storage devices has many advantages. This report will mainly introduce our research progress of carbon-based nanomaterials derived from biomass used in electrochemical energy storage devices such as supercapacitors, secondary batteries, and lithium-sulfur batteries.

INVITED LECTURE

Enhanced polysulfide conversion using amorphous FeOx/carbon nanofibers for efficient lithium-sulfur batteries

Xiaoqing Zhang、Ming Xu、Jingyu Feng、Yuzhi Ke、Yang Yang、Wei Yuan
South China University of Technology

The lithium-sulfur (Li-S) battery has emerged as one of the most promising next-generation energy storage devices owing to its high theorical specific capacity (1675 mAh g^{-1}) and high energy density (2600 Wh kg^{-1}). However, the performance and application of Li-S batteries have been impeded by the notorious shuttle effect of soluble lithium polysulfides (LiPSs) intermediates. Herein, defect-rich amorphous FeO_x/carbon nanofibers (FeO_x/CNFs) are designed and proposed as functional interlayers for Li-S batteries, aiming at improving the anchoring and conversion of LiPSs during the cycling process. The experimental results reveal that the amorphous FeO_x in FeO_x/CNFs affords abundant active sites to strengthen the adsorption of LiPSs and facilitate their transformation to Li_2S simultaneously, thus alleviating the shuttling of LiPSs and enhancing the electrochemical performance of Li-S batteries. Consequently, the functional FeO_x/CNFs interlayers enable Li-S batteries to deliver a high specific capacity with an excellent cycling stability. This work offers a facile yet promising strategy to construct efficient Li-S batteries using functional nanofibers.

INVITED LECTURE

CSIRO amine based CO2 capture and utilisation technology development for industrial decarbonation

Kangkang Li
CSIRO Australia

CO2 capture, utilization and storage (CCUS) has been widely recognized as a crucial part of CO2 emission reduction strategy to mitigate carbon-induced climate change. The role of CCUS in industrial decarbonisation is evolved and extended to almost all energy-related products and services, including power, steel, cement, chemical/petrochemical, transport sectors. Commonwealth Scientific and industrial Research Organisation (CSIRO) has been devoted to developing and advancing amine-based CO2 capture technology for more than one decade. This presentation will introduce R&D activities on amine-based CO2 capture & Utilisation (CCU) in our group in CSIRO Australia, including the experimental investigation, process modelling, pilot plant activities, commercial pathway of CO2 capture technology development and deployment. It will also introduce our recent advance on the integrated capture and conversion of CO2 into value added products. While advanced fibers and polymer materials are not used in our CCU research, we are expecting this conference would bring such an opportunity to bridge the collaboration between advanced polymer materials and CCU research, with the aim to further advance CCU technology to be commercially viable for industrial decarbonisation.

INVITED LECTURE

Intercalation in Two-Dimensional MXenes toward Electrochemical Capacitor and Beyond

Jianmin Li
Nanjing University of Posts and Telecommunications

Since its discovery in 2011, the new family of two-dimensional (2D) transition metal carbides and nitrides, known as MXenes, have quickly triggered broad research attention, especially in the field of supercapacitors (SCs). Due to the high electronic conductivity (~ 10,000 S cm^{-1}), high packing density (~ 4 g cm^{-3}), and fertile surface chemistry, MXenes can deliver volumetric capacitance up to 1,500 F cm^{-3}, which approaches the previously unmatched volumetric capacitance of RuO_2. The metallic conductivity also induced an excellent rate capability of MXene-based electrode materials. Researches have proved that the high capacitance of MXene is mainly benefited from the high reversible redox reactions followed by the electrochemical intercalation of electrolyte ions. Generally, intercalation is the reversible insertion of guest molecules (or ions) into materials with layered structures, without changing the structure features of the host, which may induce drastically enhanced or changed performance for a wide range of applications. Thus, other phenomena, such as electrochromism and electrochemical actuation, have also been reported accompanying the energy storage process of MXenes. In this talk, the intercalation of different foreign species (ions and solvents) in MXene layers was discussed toward SCs and electrochromic devices.

INVITED LECTURE

Graphene-Based Functional Fibers for the Next Generation Energetic Materials: Predictive Plasma-Driven Activation and Functionalization

Alexander Lukin
Western-Caucasus Research Center

The next generation of aerospace propulsion systems requires energetic and propulsive materials further increase in stored potential energy and thermodynamic performance. In this connection, predictive programming the high energy density storage and release on desired timescales to achieve efficiency and effectiveness has a great value.
Researches of the nanomaterials as an energetic material (EM) began more than twenty years ago with aims as a potential sources of extremely high heat release rates and preset burning rates, extraordinary combustion efficiency, reliability, safety, and reduced sensitivity. Development of new nano-additives and catalysts for the EM and composite solid propellants has always been a thriving research activity among the propellant community.
During the last decades researchers have observed the excitation of the micro- and nano- scale oscillatory networks in the reaction zones of the EMs and the presence of micro-torches over the EMs burning surface. These micro- and nano- scale structures play a role of micro-scale oscillatory networks in the EM reaction zones and has a significant influence on physical and chemical processes and on controllability of ignition and combustion processes.
In this connection, manipulating by micro- and nano-scale architecture and properties of the EM components and additives opens new possibilities for enhancement of the EM performances. Recently suggested transformative energetics concept, based on predictive synthesis at the nanoscale, can be considered as a pathway towards development the next generation EMs. The new class of the advanced propulsion materials, based on this concept, named as transformative energetic materials (TEM), can serve as extremely effective propellants for the hypersonic propulsion technologies and the deep-space-capable small satellites with safe high-performance multimode propulsion systems. This technological concept confers additional energy into the EM system, beyond that which has been possible historically with conventional processing technology. In addition, the use of this approach opens up new opportunities for mutual stabilization of high-energy components inserted into the EM matrix, making it less sensitive to various external influences.
The general concept of the TEMs synthesis includes the following stages:
- Nano-sizing of the EM components with material properties changing; - Resonant acoustic mixing (RAM), and - 3D printing of propelling charges.
The RAM is a relatively new processing technique that uses low-frequency, high-intensity acoustic energy to blend highly viscous materials rapidly and effectively. It's a contactless mixing technique, there are no moving parts in contact with the energetic material and this confers process safety benefits. Such kind of the new mixing affords the potential to incorporate into the EM content a higher proportion of high energy-density solids, including hard to process materials such as nano-energetics.
3D printing allows the creation of complex and truly three-dimensional structures that give superior control over the nature of the energy release.
Within transformative energetics concept, we propose the innovative strategy, connected with the reaction zones behavior programming through enabling of a new synergistic effect at combined application of the graphene-based fibers (GFs) as a catalytic nano-additives along with predictive plasma-driven functionalization them at the stage of nano-sizing of the EM components.

Use of GFs motivated by following considerations. In recent years, graphene, a one-atom-thick planar sheet of sp2-bonded carbon atoms densely packed in a honeycomb crystal lattice, has attracted lots of attentions from researchers. Graphene can be considered as a “miracle material” that could revolutionize our world. Earlier has been proved that graphene can be considered as an ideal material to enhance the performances of the EMs and propellants, because of its excellent physical and chemical properties, such as ultra-strong mechanical strength, low density, large specific surface area, remarkable thermal conductivity, chemical functionality and phenomenal electrical performance. Nano-graphene is flexible, yet stronger than steel. Graphene and its derivatives can enhance the catalytic effect remarkably, which can be attributed to the large specific surface area of graphene that makes the uniformly dispersed catalyst particles and the more catalyst active sites. In particular, previous experimental studies have shown that the addition of graphene-based nano-materials to the composition of the EM matrix makes it possible to increase the combustion rate by 8-10 times, which is of fundamental importance for the development of propulsion systems for promising aerospace systems.

The same basic unit of graphene through the microstructural design can show different morphology, microstructures, and properties and play different roles in the EMs and propellants. The orientation structure can make full use of the in-plane thermal conductivity of graphene and significantly improve the mechanical properties of propellants.

The mechanical properties of the EMs and propellants are directly related to their safety and it is important to make more efforts to enhance the mechanical properties of propellants through the microstructure designing of the GFs. At adding the GFs into the EM matrix the fiber arrays orientation effect can be used both for manipulating and enhancement of the thermal conductivity within the reaction zones and for significantly improve the mechanical properties. Predictive plasma-driven activation and functionalization of the GFs opens up new possibilities for creating new interconnections in the mechanisms of precision programming of processes in the EM reaction zones. Such mechanisms are program the self-organized wave patterns excitation phenomenon and changing localization of the energy release areas in the reaction zones.

Plasma-enhanced surface treatment of the GFs improves their stability against structural degradation and surface chemistry with enhanced electrical and chemical properties and open up possibilities to improve the structure and morphology of the GFs by controlling the plasma discharge parameters.

Within transformative energetics concept, we propose plasma-driven assembling the GFs by carbyne-enriched nanostructured metamaterials that creates a new pathways of heat transfer enhancement within the reaction zones. Such kind of carbyne-enriched nanomaterials, in addition to unique physicochemical and structural properties, have the vacant functional nanocavities that is available for predictive insertion clusters of atoms and molecules of different chemical elements, and in particular, the specific catalytic agents. The simultaneous use of the graphene-based nanostructures and catalytic agents maximizes their catalytic effect. The functionalized GFs also will have a dual use as energetic additives as well its exploitation as a self-assembly-directing agent.

Structural self-organizing and pattern formation are universal and key phenomena observed during growth and cluster-assembling of the carbyne-enriched nanostructured metamaterials at the ion-assisted pulse-plasma deposition. Fine tuning these universal phenomena opens access to predictive designing the micro-architecture and properties of the growing carbyne-enriched nano-matrix.

Graphene is non-piezoelectric. This is obvious when graphene is in its metallic or semi-metallic state. At the same time, recent density functional theory (DFT) calculations have demonstrated the potential of mechanically bent graphene as a piezoelectric energy harvesting material. Moreover, with a small chemical doping, graphene can be transformed into a controllable piezoelectric material. Assembling GFs by the carbyne-enriched nanostructured metamaterials, containing functional nanocavities, along with piezoelectric nanomaterials clusters, for instance, lithium atoms, zinc oxide (ZnO) nanoparticles, can transform GFs into the piezoelectric GFs nano-generators that can be used for control the electric charge distribution within the EM

reaction zones. This effect can also be reversed - applying an electric field to a piezoelectric GFs will cause it to change shape or deform. The deformation generated in the piezoelectric GF is proportional to the magnitude of the electric field applied.
Since the carbyne-enriched nano-matrix is an acoustically sensitive material, we propose the technology for the patterning and control of the nanostructure growth onto acoustically excited piezoelectric active substrates.
Assisting the plasma deposition of the nano-matrixes through generating the Rayleigh-type surface acoustic waves (SAW) leads to patterning phenomena, characterized by substantial lateral changes in nanostructure, thickness and properties. For example, changing the acoustic driving frequency can be employed to modify the pattern size.
Different acoustic driving frequencies and waveforms, generated in the deposition area with assistance of the piezoelectric active substrates excite and creates specific template for grows of the nanomaterial and can be used for programming the required geometric configurations and sizes of the nanostructure of the grown metamaterials. In accordance with universal laws of Cymatics, if you first produce acoustic disturbance into the media then it becomes sensitive to the influence of acoustic waveforms.
Interaction between the inhomogeneous electric field distribution generated on the piezoelectric active substrate and the plasma ions can be considered as the energizing factor controlling the local pattern formation and self-organizing of the nano-structures.
Functionalized GFs will be then used for RAM with other energetic components and for following 3D printing of the EMs.
Our research demonstrates how vibrations, frequency and energy flux can change and program the nano-structure of the growing carbine-enriched nanostructured metamaterials and functionalized GFs.
Acoustic and electromagnetic holograms with specified frequency and spatial characteristics are capable of providing spatial marking of the structure of the grown carbyne-enriched nanostructures on the functionalized GFs.

Acknowledgments
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INVITED LECTURE

Electrospun carbon nanofibers for advanced lithium sulfur batteries

Zheng-Long Xu
The Hong Kong Polytechnic University

Taken advantage of a high theoretical energy density of 2567 Wh kg-1, lithium sulfur batteries (LSBs) have been considered promising candidates for next-generation energy storage systems. Tremendous efforts have been devoted to improving the battery performance by preparing smart nanostructures. However, detailed reaction mechanisms and the principles of tailoring reaction paths at nanoscale remain unclear. In-situ transmission electron microscopy (TEM) is a powerful technique to probe the dynamic processes of electrochemical reactions at a high spatial resolution and in real-time. Through in-situ TEM study with a solid cell (using Li/Li2O as lithium source and electrolyte, respectively), we find that carbon nanofibers activated at 550 °C encapsulating sulfur particles (PCNF/A550/S) present a low volume expansion of ≈35% and integrated structure upon full lithiation. In contrast, PCNF/A750/S prepared from carbon fibers activated at 750 °C shows a larger volume expansion of 61 % and overflowing of Li2S, due to the weak mechanical property and large pores of the carbon host, providing a testament to their poor electrochemical performance. Although porous carbon fibers indicate great progress in anchoring LiPSs through physical/chemical immobilization approaches, but their effectiveness is degraded if the blocked intermediated are accumulated without re-utilization. Through theoretical and experimental studies, we demonstrated that black phosphorus quantum dots (BPQDs) are powerful electrocatalysts for LSBs due to the unique merits of the edge-preferential LiPS immobilization ability of BP and the maximum amount of catalytically active sites offered by QD structures. In the presence of a small amount of BPQDs (2 wt% of the cathode material), porous carbon nanofiber/sulfur (PCNF/S/BPQD) cathodes presented an extremely low capacity fading rate (0.027 % per cycle over 1000 cycles), a high rate capacity of 784 mAh g-1 at 4 C and remarkable capacity retentions of near 90 % at high sulfur loadings up to 8 mg cm-2, which are among the best thus far reported for LSB systems. We expect that these findings to open a new avenue towards the design of high energy rechargeable batteries through exploring functional carbon nanofibers and metal-free quantum dot structured catalyst materials.

INVITED LECTURE

Crystalline nanofiber supported single atom catalysts

Xiaopeng Li
Donghua University

Single atom catalysts (SACs) represent a new frontier in the catalysis field. Metal single atoms possess strikingly different physical and chemical properties as compared to the nanoparticle counterpart. Single atoms usually have been considered as isolated and lonely sites during catalysis. Recently, we developed a series of lattice confined metal single atoms supported by metal oxides. A unique cooperative catalysis between metal single atoms and their neighboring sites from supports was found, which greatly promote the activity of SACs. Such phenomenon can be found in the different applications such as oxygen electrocatalysis, catalytic conversion of biomass derived chemicals and carbon monoxide.

INVITED LECTURE

Graphene Reinforced Hybrid Functional Fibers

Yuanlong Shao
Soochow University

Based on the astonishing properties, such as superior mechanical strength and electronic conductivity, light-weight and efficient thermal conductivity, graphene is an attractive reinforcing phase to enhance functional hybrid fiber. In a result, graphene hybrid fiber exhibits broad prospects in the applications fields of ultralight cable for aerospace, wearable energy storage devices, biosensors and neuroelectronics.1-3 It could be a critical breakthrough to realize multi-functional fiber or even smart textile.4

In this presentation, we will introduce our recent research works on a series of graphene enhanced hybrid fiber, including vanadium oxide/graphene, keratin/graphene, tatraaniline/graphene hybrid systems and try to conclude a versatile reinforcement theory for graphene hybrid fibrillar materials. Specific functionalities, such as fibrillar Zn-ion battery and artificial muscle have been systematically analyzed in our present work. We will also discuss the fundamental relationship between the typical functionalities of graphene hybrid fibers and their hierarchical structures, such as the in-planar structure of graphene sheets, aggregation structure of graphene flakes. The graphene flake confined nanofluidic triggered orientation have been proposed for the graphene reinforcement mechanism. These research work will shed some lights on future research on other 2D materials based smart fiber and fabric preparation and functional applications.

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INVITED LECTURE

The Interfacial Properties and Catalytic applications of Carbon Nitrides

Jingsan Xu
Queensland University of Technology

Graphitic carbon nitrides (g-C3N4) have been extensively researched in the past decade as a metal-free semiconductor material in several fields, such as solar-to-fuel conversion, solar cells, LEDs and catalysis, etc. In this talk, I would like to share the below progress in regards to the application of carbon nitrides: 1) photocatalytic water-donating hydrogen transfer reaction using platnium/carbon nitride as the catalysts; 2) the interfacial properties of particulate carbon nitrides; 3) high-efficiency hydrogenation reactions in carbon nitrides stabilized emulsions.

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INVITED LECTURE

Super-foldable conductive materials and energy storage devices for carbon-based nanofiber networks

Tong Wu、Guangtao Zan、Shanshan Chai、Kangze Dong、Qingsheng Wu
Tongji University

With the rapid development of flexible electronics, a large number of nondestructive folding of conductive materials, namely, super-foldable, has become the "bottleneck" which restricts the further development of these directions. However, although people have carried out a lot of exploration, it is still far from the requirement of super-foldable, even if more than a thousand lossless true folding can not be achieved. The main reason is that the stress dispersion principle and the structure-activity relationship in the process of conductive material folding are not well-understood, and the unfoldable property of intrinsic conductive material is not well-understood. Therefore, based on "the principle of unfoldable intrinsic conductive Materials", our research team improved electrostatic spinning/gradient carbonization/surface modification technologies by utilizing the idea of meta-material design and bionic design, and achieved a series of original research results:

1. A kind of super-foldable conductive carbon materials (SFCMs) which can withstand 1 million or even infinite folds without any damage was prepared by biomimetic cocoon first time; The multistage stress dispersion mechanism in SFCMs folding process was revealed through the observation and study on self-built real-time SEM folding system and finite element method simulation analysis, which pointed out the direction for the design and preparation of other super-foldable materials and devices.
2. Under the guidance of these theories, through the imitation silk weaving process and the mode of water management, effectively solve the puzzles with that of the water-soluble precursor PVA, such as hard for electrospinning and in-situ carbonization, low production rate and flexible, and so on. It's the first time reported biomimetic preparation of the hydrophilic folding carbon fiber membrane, which not only has more than 100000 times lossless super-foldable performance, but also has a better biocompatibility.
3. With super-foldable conductive substrates, how to modify active substances or assemble electronic components on them without affecting their super-foldable properties becomes a key problem. Through the combination of bionic thinking and new nanotechnology, our research team successfully realized a series of super-foldable composite electrodes and their related supercapacitors, such as iron hydroxyl oxide, nickel sulfide, molybdenum cobalt oxide and nickel cobalt sulfide.
4. Although the success of super-foldable conductive materials, super-folded electrodes and super-foldable supercapacitors mentioned above has been achieved, it is still a challenging problem to design, assemble and prepare a Li-ion pouch cell. The research group succeeded in breaking through this difficulty through the preparation of precursors and the fine control of carbonization temperature, and realized the laboratory manufacture of super-foldable pouch cell.

In conclusion, we used our pioneer process-biomimetic-design which developed more than 20 years as well as rich preparation experience of nano-materials, successfully broke through the "bottleneck" of super-foldable conductive materials in the field of electronic materials, has realized preparation from the super-foldable material to the super-foldable device system, and establish the super-foldable principle of multilevel stress dispersion, which points out the direction for the development of super-foldable electronics field.

INVITED LECTURE

Separator Construction and Interfacial modification for High-performance Sodium-Ion Batteries

Weihua Chen
Zhengzhou University

Sodium-ion batteries (SIBs) are one of the most promising next generation energy storage systems due to their high sodium abundance and low electrode cost. The commercial polyolefin separators used in lithium-ion batteries suffer from incompatibility with high-viscosity electrolytes in SIBs and poor thermal stability. Meanwhile, the common glass fiber separators have poor mechanical strength, large pore size and high cost. We proposed a modified acetate cellulose separator prepared by electrospinning, which achieved chemical stability in series of electrolytes by regulating the partial conversion of hydrophobic acetyl group into hydroxyl group. In addition, utilizing the synergism of functional group tranfer, the in-situ growth of SiO_2 aerogel on the surface of polyacrylonitrile improves the thermal stability of the separator, and coating hydrophobic SiO_2 aerogel on polypropylene separator is well solved the poor wettability. Beyond that, an ultra-thin separator with honeycomb structure is designed via the electrostatic interaction between the functional groups of the two polymers which can significantly improve the energy density and safety of the battery. These separators design strategies provide new inspirations to construct high-performance SIBs.

INVITED LECTURE

Charge Carrier Mapping for Z-scheme Photocatalytic Water Splitting Sheet by Categorization of Microscopic Time-resolved Image Sequence

Kenji Katayama
Chuo University

Photocatalytic water splitting system using particulate semiconductor materials is a promising strategy for converting solar energy into hydrogen and oxygen. In particular, visible-light-driven 'Z-schematic' printable photocatalyst sheets are cost-effective and scalable systems. However, little is known about the fundamental photophysical processes, which are key to explain and promote photoactivity. Here, we applied the pattern-illumination time-resolved phase microscopy (PI-PM) for the printed photocatalyst sheet, composed of Mo-doped $BiVO_4$ (BVOM) and Rh-doped $SrTiO_3$ (STOR), indium tin oxide (ITO) as an electron mediator, to investigate photo-generated charge carrier dynamics. Using the PI-PM, we successfully observed for the first time the position- and structure-dependent charge carrier behavior, including visualization of the active/inactive sites in the sheet, under the visible-light irradiation via the time sequence images and the clustering analysis.

In the water splitting by photocatalysts, it is essential how efficiently photo-excited charge carriers are separated and utilized for water oxidation and reduction without losing them due to recombination. So far, charge carrier dynamics in various photocatalyst particles and films, including $SrTiO_3$ or $BiVO_4$, have been studied. Transient absorption and time-resolved photoluminescence have been frequently utilized to understand the processes. On the other hand, our approach for studying the charge carrier dynamics uses the special combination of the measurement of the refractive index change and its accompanying original analysis method called spectral clustering method, instead of the absorption change or photoluminescence. [1-3]

The charge carrier behavior depends on the local structure and is inhomogeneous in nature for the photocatalysts, typically composed of calcinated particles and aggregates. Many researches have been devoted for studying the spatio-temporal behavior of charge carrier dynamics by using TA and photoluminescence microscopy on micro-scales, and the photocurrent behavior by microscopic photo-electrochemical measurements. We also have extended our measurements of the refractive index change for a local mapping of the transient responses of photo-excited charge carriers, PI-PM method. By illuminating a pattern of light, the sequence of images due to the refractive index change was obtained, and the image quality was recovered by the image recovery calculation techniques.[1] The lifetime distribution of the charge carriers for a TiO_2 particulate film was obtained, and the research clarified a broad range of the lifetime of charge carriers.[2] Furthermore, the local responses of charge carriers were categorized by the spectral clustering method and found the hidden local responses of the non-radiative exciton relaxation for higher pump intensities. [3] These findings have motivated us to apply this combination of PI-PM and clustering analysis method for one of the most promising Z-scheme water splitting materials, $BiVO_4$:Mo/$SrTiO_3$:Rh with a conductive colloidal binder (ITO), as a printable photocatalyst sheet with a conductive colloidal binder (ITO) prepared by the printing method. We could visualize the spatially-resolved photocatalytic activity by the categorization of the charge carrier behaviors. This new methodology could detect the real active and inactive sites in the photocatalytic device and will support the optimization of the active structure of the photocatalyst.[4]

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INVITED LECTURE

Improving polymer solar cell performance using random coplymerization

Ming Wang、Shuojun Wang
Donghua University

Polymer solar cells (PSCs) have gained considerable attention as a promising renewable energy technology due to the advantage of flexibility, lightweight and low fabricating cost[1]. Profited by the tremendous progress in non-fullerene acceptors (NFAs), the power conversion efficiency (PCE) of non-fullerene-based single-junction PSCs (NF-PSCs) has surpassed 14% during the past few years, and a world record PCE of 18.22% has also been achieved very recently[2]. Despite the surge of a series of state-of the-art NFAs, the research of the polymer donor still lags behind and there is a large room to improve PCE by optimizing the donor structures.
In this work, four donor-acceptor (D-A) conjugated polymers using 4,7-bis(4-(2-butyloctyl)thiophen-2-yl)-5,6-difluorobenzo[c][1,2,5]thiadiazole (DTffBT) with two symmetrical alkyl-thienyl unit and ffBT as the two different acceptor units were synthesized by controlling the molar feed ratio of DTffBT and ffBT. The two thiophene units in the DTffBT would gift the backbone with a degree of flexibility, while the increased dihedral angle along the backbone could simultaneously harm the crystallinity of polymer. In contrast, ffBT, which has a much smaller dihedral angle with BDT could increase the planarity of the polymer. Thus, the two different effects of DTffBT and ffBT were combined together and investigated to understand the structure–property relationship. With the increase of ffBT percentage from 0% to 65%, the stacking property and crystallinity of the polymer were promoted accordingly. Meanwhile, the less loading of thiophene spacer leads to the down-shift of energy level. As a result, DTffBT75 in which the ratio of DTffBT is 75% achieved the best PCE of 11.12% in the solar cell device measurement. More intriguingly, all polymers display a very low energy loss (Eloss) around 0.45 eV resulting from the low non-radiative energy loss of 0.18 eV. To our best knowledge, it is among the best values for NF-PSCs up to date. Our findings demonstrate that the random copolymerization is a promising approach for designing advanced high-performance PSCs with low Eloss.

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INVITED LECTURE

Polymers for Energy Storage: Polymer Cathodes and Polymer Electrolytes

Patrick Theato
Karlsruhe Institute of Technology (KIT)

Energy storage plays a crucial role in the future. Ranging from electrical vehicles to mobile devices, the necessity for storing electrical energy is growing. In this regard, polymers do play a vital role in the development of current and future electrical energy storage systems.
Most state-of-the-art vehicles still employ lithium-ion batteries that feature organic liquid electrolytes, which represents a drawback in several perspectives. On the one hand, those organic liquids are prone to leakage, flammable and toxic, thus constituting a huge safety issue.2 On the other hand, the limited electrochemical stability and the unrestricted dendrite-growth does not allow for the use of metallic lithium electrodes, although metallic lithium electrodes would drastically increase the energy density.3 In this regard, polymer electrolytes (PEs) are expected to overcome most if not all of these drawbacks, hence, enabling a safer operation of next-generation lithium batteries. Herein, we present a new class of materials, namely vinyl ether- and styryl-based poly(ethylene oxide) side-chain polymer electrolytes, for solid-state lithium-ion batteries. Additionally, sulfur as a side product of natural gas and oil refining is an underused resource. Converting landfilled sulfur waste into materials merges the ecological imperative of resource efficiency with economic considerations. A strategy to convert sulfur into polymeric materials is the inverse vulcanization reaction of sulfur with alkenes. Therefore, we propose the utlization of sulfur polymers as cathode materials for lithium-sulfur batteries.

INVITED LECTURE

Electrospinning - Based Strategies for Battery Materials

Yuming Chen
Fujian Normal University

Electrospinning is a popular technique to prepare 1D tubular/fibrous nanomaterials that assemble into 2D/3D architectures. When combined with other material processing techniques such as chemical vapor deposition and hydrothermal treatment, electrospinning enables powerful synthesis strategies that can tailor structural and compositional features of energy storage materials [1]. Herein, a simple description is given of the basic electrospinning technique and its combination with other synthetic approaches. Then its employment in the preparation of frameworks and scaffolds with various functions is introduced, e.g., a graphitic tubular network to enhance the electronic conductivity and structural integrity of the electrodes [2]. Current developments in 3D scaffold structures as a host for Li metal anodes, sulfur cathodes, membrane separators, or as a 3D matrix for polymeric solid - state electrolytes for rechargeable batteries are presented. The use of 1D electrospun nanomaterials as a nanoreactor for in situ transmission electron microscopy (TEM) observations of the mechanisms of materials synthesis and electrochemical reactions is summarized [3], which has gained popularity due to easy mechanical manipulation, electron transparency, electronic conductivity, and the easy prepositioning of complex chemical ingredients by liquid - solution processing. Finally, an outlook on industrial production and future challenges for energy storage materials is given.

INVITED LECTURE

Rational design of electrospun nanofibers and their energy application

Shengjie Peng
Nanhang University

Energy conversion and storage materials are the key materials to realize the conversion and utilization of new energy and develop new energy technology. With the development of new energy material industry, the research and technology innovation of energy conversion and storage materials become more and more important. Nanomaterials, especially one-dimensional nanofibers, provide unique physical and chemical properties in energy devices and significantly improve their electrochemical properties. This report describes a simple and universal single-needle electrospinning technique for the preparation of a range of one-dimensional materials with complex structures, including carbon composites and spinel composite oxides. It was found that the type of precursors and heat treatment parameters could affect the structure of the product, especially the high strength flexible self-supporting electrodes were obtained by electrospinning method. Secondly, the application of electrocatalysis and energy storage of one-dimensional functional materials is reported, mainly introducing the electrochemical activity of various reaction sites in electrode materials with different structures, the influence factors of structure and defects on electrocatalysis and energy storage performance, as well as the synergistic effect of each component. Combined with theoretical calculation, the adsorption and desorption process of hydrogen/oxygen on the active site was studied in order to reveal the source and mechanism of its electrocatalytic activity, and provide feedback to guide the design of electrode materials. Finally, the device application of flexible electrode is introduced. The three-dimensional mesh of flexible electrodes can increase the hydrophobicity and facilitate the desorption of bubbles formed on the surface, thus speeding up the electrocatalytic reaction kinetics. Moreover, it is directly applied to Zn-air batteries, showing excellent charge-discharge performance and cycle stability.

INVITED LECTURE

Nanofibrous materials in energy harvesting and storage

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Electrospun nanofibrous materials have the advantages of simple fabrication, nano-sized fiber diameter, rich fibrous structure, high specific surface area and versatile functions. Therefore, they have been intensively investigated for a wide range of applications. This presentation will talk about the applications of electrospun nanofibers in energy harvesting and storage. Harvesting renewable mechanical energies into electric power through piezoelectric or triboelectric effects is an emerging technology attracting broad attention in materials and technology fields. Compared with traditional planar and rigid devices, power generating devices made from fibrous materials have attracted growing attention owing to their flexibility, breathability and good compatibility with textiles. These attributes offer them outstanding potential in the development of next-generation self-powered wearable electronics. In addition, polymeric electrospun nanofibers can be converted to carbon nanofiber membranes after carbonization, their self-supported structure, highly porous structure and adjustable electrochemical function make them ideal candidate as free-standing binder-free electrode material for energy storage devices.

INVITED LECTURE

A-DA'D-A Acceptor Photovoltaic Materials

Yingping Zou
Central South University, China

Over more than two decades of research, organic solar cells have achieved tremendous progresses in materials & device engineering and applications. For further advance, the power conversion efficiencies (PCEs) of organic solar cells need to be substantially improved. Inspired by the recent success in non-fullerene electron acceptors (NFAs), we have developed a design strategy defined as “A-DAD-A” to obtain a series of high-performing NFAs, called as Y series. D = electron donor unit while A = electron acceptor unit. The key to this molecular innovation is introducing an electron-deficient moiety (A) such as benzotriazole or benzothiadiazole into the central fused ring. Generally, these electron acceptors show extended absorption in the NIR region and provide considerably low energy losses in organic solar cells, hence having set new records for the certified power conversion efficiencies by National Renewable Energy Laboratory (NREL).

It is worth mentioned that our research on these newly designed electron acceptors has attracted extensive attention. For instance, the research paper on the Y6 acceptor (Joule, 2019, 3, 1140) was cited over 1000 times by the others within a very short time since its publication. More importantly, the certified power conversion efficiency of more than 18% has been reported by our fellow researchers based on the commercially available Y6. The underlying role of these acceptors has been actively investigated at home and abroad. While first achieving the 15% PCE in the single-junction solar cells, Y6 appears to be a universal electron acceptor and contributes to developing semi-transparent and flexible organic solar cells.

INVITED LECTURE

Electrospun fibers for textile electronics

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Emerging electromechanical systems, healthcare, internet of things (IoT), and communication systems recognize incredible opportunities in consumer clothing; fundamental to these textile electronics is to develop the fibers forming the cloths into electronic devices. These make the textile electronics as a fast-growing industry with a predicted global market of US$ 9.3 billion by 2024. An electronic fiber must undergo diverse scrutiny for its selection for a multi-functional textile, viz., from the material selection to the device architecture, from the wearability to the mechanical torment, and from the environmental compatibility to the end-use management. The smart textiles integrate the state-of-the-art electronic gadgets such as sensors, actuators, controllers, displays, and others in consumer clothing. One of the most viable approaches to power the smart textiles electronics is to develop energizers (solar cells, piezoelectric cells, batteries, and supercapacitors) into the fundamental constituent of the cloth, for example, fibers (or synonymously yarns) as energy conversion and storage system. This lecture aims to focus on the current state of flexible energy devices developed by electrospinning, both in the lecturer's laboratory and elsewhere. Given the importance of sustainable materials in shaping the emerging sustainability scenario, foreseeable initiatives required to leverage the laboratory developments to the commercial sector are highlighted.

Fibrous Thiazolothiazole-bridged Viologen Polymer for High-Performance Lithium-Ion Batteries

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Development of redox-active conjugated polymers with superior electrochemical performance and uniform hierarchical structure is a highly rewarding direction for improving the performance of organic hybrid batteries. As a strong electron acceptor, viologen-based compounds have desirable and tunable redox properties, making them suitable candidates for battery applications. In this paper, we disclose the preparation of a fibrous, conjugated porous polymer P1 from newly designed N,N'-diarylation of dipyridinium thiazolo[5,4-d]thiazoles (Py_2TTzs) building block with promising reversible one-step two-electron redox process. Notably, the fibrous P1 shows a high capacity and excellent cycling stability (nearly 100% capacity retention at high current density of 800 mA g^{-1} after 1000 cycles), which is far priority to the state-of-the-art viologen materials. This work opens a promising approach for the development of novel organic electrodes for sustainable and durable rechargeable batteries

Efficient construction of hierarchical nanostructure of polyaniline nanofibers for enhancing charge storage capacity through frozen interface polymerization

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It is well known that capacitance performances of polyaniline (PANI) strongly depend on its morphology and microstructure, and furthermore, porous and hierarchical structure of PANI nanofibers can provide a large number of surface active sites and a shorter ion diffusion path. Apparently, hierarchical nanostructured PANIs could be expected to be the most promising electrode materials for high performance supercapacitor. However, hierarchical nanostructured PANIs always are constructed through dilute polymerization or template method in strong acidic solution or chemically polymerization in weak acid and even alkaline condition. Low yield and weak conductivity seriously limit their practical application. In this work, a simple and efficient template–free frozen polymerization was developed for fabricating hierarchical nanostructured PANI nanofibers in strong acidic condition as cost-effective electrode materials for high performance supercapacitor. The morphology, chemical and crystal structures of as–prepared PANI were respectively investigated by field emission scanning electron microscope (FE–SEM), Fourier transform infrared spectrometer (FT–IR) and X-ray diffraction (XRD). The capacitance performance was evaluated in 1 M H_2SO_4 solution on a CHI 660E electrochemical workstation by cyclic voltammetry (CV), galvanostatic charge-discharge (GCD) and electrochemical impedance spectroscopy (EIS) techniques. It is found that the formation of hierarchical micro/nanostructured PANI nanofibers were significantly affected by the interfacial area between aniline and oxidant ice layers, and the morphology and structure of PANI nanofibers can be adjusted simply by changing the ice layer thickness. The differences on the morphology and microstructure could be ascribed to different number of the nanofibrous seeds formed at the early stage of polymerization and their ambient aniline concentration as well as the release rates of aniline and oxidant. Among all the hierarchical micro/nanostructured PANIs, PANI with sea urchin–like micro/nanostructure could exhibit the strongest charge storage ability. More clearly, the specific capacitance of 716.8 F g^{-1} at a current density of 1 A g^{-1}, rate retention of 96.9 % from 1 to 20 A g^{-1}, and cycling retention of 73.6 % after 2000 cycles could be achieved. Unique self–assembly of highly ordered nanofibers could make it possible to give full play to the advantages of polyaniline nanofibers including large electrode/electrolyte contact area, high charge transport along the nanofibers, accommodate volume changes extending in every direction during cycling, and fast electron transport and ion diffusion through porous structure. It is believed that such efficient construction and eco–friendly fabrication can offer a favorable strategy to promote the electroactive properties of the polyaniline, and further development in the sensor– and energy–related fields.

Synergistic Solvation and Interface Regulations of Eco-Friendly Silk Peptide Additive Enabling Stable Aqueous Zinc-Ion Batteries

Baojun Wang、Rong Zheng、Wei Yang、Kerui Li、Chengyi Hou、Qinghong Zhang、Yaogang Li、Hongzhi Wang
Donghua University

Aqueous Zn-ion batteries aroused much attention recently due to their low cost, high safety and ecological friendliness. Yet, their further development has been hindered by the serious side reactions (dendrite growth, hydrogen evolution, corrosion) occurring between Zn anode–electrolyte interfaces. Although great efforts have been made, there is still lack of low-cost, highly stable electrolytes to tackle this challenge. Herein, an ZnSO4-based low-cost aqueous electrolyte is demonstrated with very few silk peptide molecules as an efficient additive. In the aqueous electrolyte, compared with sericin and fibroin, stable conformation and abundant polar groups of silk peptide are crucial in modulating Zn anode–electrolyte interfaces, offering abundant binding sites, which guides uniform Zn deposition. Meanwhile, silk peptide additive tends to regulate the solvation structure of Zn2+ ions and adsorb on the anode surface, isolating active water adsorption. Consequently, the excellent cycle life of symmetric cells (3000 h) and superior Coulombic efficiency (99.7%) of Zn anodes are revealed in 2 M ZnSO4 electrolyte with only 5 mg mL-1 silk peptide (cost: 0.49 $ L-1). At last, good cycling stability (76% capacity retention after 1000 cycles) of Zn-MnO2 full cells is also achieved, offering an alternative approach to develop practical reversible Zn metal batteries.

Hierarchical photothermal fabrics for solar seawater evaporation

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Solar-enabled evaporation for seawater desalination has been considered to be an attractive, renewable and environmentally friendly way to alleviate the long-standing problem of freshwater scarcity. [1] The present evaporators are usually achieved on floating solar absorbers [2], but their performances are substantially limited by high evaporation enthalpy, solid salt crystallization and reduced evaporation due to inclined sunlight. To solve these problems, we fabricated hierarchical polyacrylonitrile@copper sulfide (PAN@CuS) fabrics and proposed a prototype of heliotropic evaporator. [3] Hierarchical PAN@CuS fabrics showed significantly decreased water-evaporation enthalpy (1956.32 kJ kg^{-1}) compared with that of pure water (2406.17 kJ kg^{-1}), due to the disorganization of the hydrogen bonds at the CuS interfaces. Based on this fabric, a heliotropic evaporation model was developed with seawater slowly flowing from high to low in the fabric, and no solid salt crystallization appeared even after 100 h evaporation. In particular, under inclined sunlight (angle range: from −90° to +90°), the heliotropic model retained an almost unchanged solar evaporation rate, whereas the floating model showed severe evaporation reduction (83.9%). Therefore, our study provides a strategy for reducing the evaporation enthalpy, maximally utilizing solar energy and continuous salt-free desalination.

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[3] Liu, Z.; Zhou, Z.; Wu, N.; Zhang, R.; Zhu, B.; Hong, J.; Zhang, Y.; Zhu, M.; Chen, Z., Hierarchical Photothermal Fabrics with Low Evaporation Enthalpy as Heliotropic Evaporators for Efficient, Continuous, Salt-Free Desalination. ACS Nano, 2021, DOI: 10.1021/acsnano.1c01900.

Uniform Li Regulation and Efficient Polysulfide Kinetics Triggered by Bifunctional Oxygen-Functionalized Porous Framework for Flexible Li-S Full Batteries

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Lithium-sulfur (Li-S) batteries have been considered as one of outstanding next-generation energy storage systems due to their high theoretical energy density. Nonetheless, it is still a great challenge to simultaneously realize dendrite-free lithium metal anode and stable sulfur cathode. Herein, an oxygen-functionalized mesoporous carbon nanofiber framework with well-distributed nickel nanoparticles (Ni@PCNF-O) has been prepared as a bifunctional electroactive host for both Li metal anode and S cathode. As expected, *COMSOL* simulations and experimental results reveal that the oxygenated functional groups and mesoporous structure can effectively tune the distribution of electric field, thus facilitating the continuous regulation of uniform nucleation and subsequent growth of dendrite-free Li deposition from the whole electrode to local nanofiber scales. Meanwhile, the strong immobilization of soluble lithium polysulfides facilitated by Ni@PCNF-O can greatly alleviate the shuttle effect and promise significantly improved electrochemical performance. As a result, the flexible Li-S full battery assembled with Ni@PCNF-O framework as bifunctional hosts with a low negative to positive electrode capacity ratio (N/P) of 2.0 demonstrates remarkable rate capability of 882 mAh g^{-1} at 2.0 C and long cycling life over 300 cycles with an extremely low capacity decay rate of 0.005% per cycle at 1.0 C. This work presents a perspective strategy for the design of bifunctional hosts to achieve high-performance flexible Li-S full batteries.

Zinc Salt Additives Strategy for Crystal Manipulation and Defect Passivation toward Highly Efficient and Stable $CH_3NH_3PbI_3$-Based Perovskite Solar Cells

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The spin-coating method is a facile yet effective approach for the fabrication of perovskite films in laboratories. However, the polycrystalline perovskite films fabricated by this method inevitably form small grains with a quick crystallization process. Also, large amounts of defect sites are distributed in grain boundaries and surfaces by using the spin-coating method, which acts as the non-radiative recombination centers and significantly limits the efficiency and stability of PSCs. To tackle these deficiencies, a series of zinc salt as functional additives were applied to the perovskite layer and further achieve the improvement of the PCE and stability of planar PSCs.

Multifunctional Ti3C2Tx MXene additive for two-step-processed highly efficient perovskite solar cells

Yu Zhao、Qinghong Zhang
Donghua University

As an emerging type of thin-film solar cell, organic-inorganic hybrid perovskite solar cells have developed rapidly in recent years. The two-step process without anti solvent has the advantages of simple operation and high repeatability. However, the process still faces the problem of PbI_2 residue in perovskite active layer. Excessive PbI_2 residue will not only reduce the power conversion efficiency (PCE) of the device, but also seriously reduce the long-term illumination stability. Therefore, in this work, the porous PbI_2-$Ti_3C_2T_x$ film with high reactivity was constructed by using monolayer $Ti_3C_2T_x$ MXene nanosheets with high conductivity and rich surface groups as the heterogeneous nucleation site of PbI_2 crystal. Compared with the dense PbI_2 film, the porous channel can promote the effective penetration of subsequent MAI, so as to significantly improve the conversion efficiency of perovskite and enhance the capture of sunlight. It is found that the pore size can be controlled by changing the amount of $Ti_3C_2T_x$. Finally, perovskite films containing ~ 2% PbI_2 are obtained, and the residue is equivalent to the reported optimum content. In addition, the study found that the porous PbI_2-$Ti_3C_2T_x$ film can also accommodate lattice expansion, which is conducive to obtain perovskite films with large grain size. Meanwhile, the work function of perovskite also increases due to the introduction of $Ti_3C_2T_x$, which realizes a more matched energy level structure and promote the transfer and extraction of carriers. The surface groups of $Ti_3C_2T_x$ can also interact with uncoordinated Pb^{2+} to passivate grain boundary defects. Finally, based on 0.03 wt% multifunctional additive, the planar perovskite solar cells achieve the highest PCE of 19.27%, which is up to 18% higher than that of the control device (16.45%), and the hysteresis phenomenon is weakened.

Setaria Viridis-Inspired Electrode with Polyaniline Decorated on Porous Heteroatom-Doped Carbon Nanofibers for Flexible Supercapacitors

Jianhua Zhu、Qian Zhang、Heping Chen、Ruiyun Zhang、Lifang Liu、Jianyong Yu
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Carbon nanofibers are promising as primary electrode material for supercapacitors on account of high specific surface area, lightweight, superior physicochemical stability, rich-resource, and renewability. However, constructing porous and flexible carbon electrode materials with high capacitance for practical application remains challenging. Here, heteroatom-decorated hierarchical porous carbon nanofibers composites containing phosphazene (N3P3(p-OC6H4-p-CHO)6, HAPCP), polymethyl methacrylate (PMMA), and graphene oxide (GO) are prepared through one-step electrospinning and subsequent thermal treatment. The alternant phosphorus-nitrogen structure links to the carbon backbones to improve flexibility and electrochemical performance. Inspired by a biomimetic Setaria viridis-like structure, the polyaniline (PANI) decorated porous hybrid electrodes are prepared. The PANI@GO/PMMA/HAPCP/PAN carbon nanofibers (400P@0.1GPHCNFs) covered by PANI nanofibers as a novel free-standing flexible electrode exhibits the excellent electrochemical performance of 680.8 F g-1 at 0.5 A g-1 with good capacitance retention of 93.5% after 3000 cycles. Moreover, the symmetric flexible all-solid-state supercapacitor assembled by the novel and delicate electrodes exhibits a high energy density of 27.70 Wh Kg-1 (at a power density of 231.08 W kg-1) and favorable cycling stability (84.50% retention of the capacitance after 1000 charge-discharge cycles), which indicates that the 400P@0.1GPHCNFs have great potential as a high-performance flexible supercapacitor electrode.

Highly stable RTILs-based electrochromic system

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Room temperature liquids (RTILs) have been extensively used in batteries, Electrochromism (EC) and supercapacitors because of their high ionic conductivity, wide potential windows, high chemical and thermal stability behavior. However, because of their large ion radius, RTILs are usually used as additional ions in electrolytes to improve the conductivity of electrolytes. Due to the influence of other components in the electrolyte, RTILs can not show its advantages. There are few reports on the electrochemical systems of pure ionic liquids. In most of these reports, the stability of the electrochemical systems are poor because of the poor diffusion kinetics which are caused by large ion radius during the process of intercalation /deintercalation. Here, through the design of organic linkers of EC metal-organic frameworks (MOFs), large ions can efficient transport through the channels. As a result, the well-designed RTILs-based MOFs system has excellent cycling stability. In additional, a smart electronic label is fabricated using a mask laser writing method for application in intelligent display.

Preparation of Ga-La5Ti2Cu0.9Ag0.1O7S5 oxysulfide photocatalyst with improved hydrogen evolution activity by post-treatment and co-catalyst loading

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Direct water splitting into H2 and O2 over particulate photocatalysts is one of the simplest models of artificial photosynthesis. Recently oxysulfide photocatalysts have shown promise for efficient solar energy harvesting due to their narrow bandgaps. As an oxysulfide photocatalyst, La5Ti2Cu0.9Ag0.1O7S5 (LTCA) has been applied as hydrogen evolution photocatalysts for Z-scheme water splitting, either as powder suspensions or in p/n PEC cells. However, LTCA powders synthesized by a conventional solid-state reaction always show large particle size (~10 μm), which may limit preparation of photocatalyst sheets for large scale application. Here we report a new method to prepare Ga doped LTCA (Ga-LTCA) photocatalyst using thermal sulfidation process with improved hydrogen evolution activity. The precursor was firstly prepared using precipitation method, subsequent thermal sulfidation to obtain the Ga-LTCA photocatalyst. The Ga-LTCA photocatalyst absorbs light with wavelength up to 650 nm, as shown by the diffuse reflectance spectrum. Compared with Ga-LTCA prepared using solid-state reaction method, the present method resulted in rod-like Ga-LTCA particles with much smaller size and uniform particle distribution (SEM). With Rh (1%) co-catalyst loading by direct photodeposition, the as prepared Ga-LTCA exhibited 73 μmol/h hydrogen evolution rate under visible light irradiation (λ > 420 nm). Importantly, we find that post-treatment of Ga-LTCA with additional sulfur powder in a sealed evacuated quartz tube further improved its activity. Optimized loading of the Rh co-catalyst onto the post-treated Ga-LTCA sample significantly improved the hydrogen evolution activity to 493 μmol/h, which is about ~6.7 fold of the activity of the original Ga-LTCA sample. This work shows the potential for large scale preparation of Ga-LTCA with smaller particle size, and provides insights toward the development of efficient photocatalysts.

Biomimetic crumple-like micro-texture for environmental and energy storage applications

Kerui Li
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Recent years have witnessed continuing advances in solar evaporation technologies to achieve strong synergy among sufficient water supply, efficient light absorption, and favorable heat localization. Still, challenges remain in the fabrication of solar evaporation devices with synergistic performance in a facile, scalable, and cost-effective fashion. Herein, we develop a scalable fabrication process involving multi-scale and multi-interface engineering to achieve high-performance and large-area solar evaporation devices. At nanoscale, different light-absorbing materials are developed to form the nanocomposite inks with tunable viscosity for doctor blading on ethanol-diffused polystyrene (PS) films. Through one-step thermal treatment, device shrinkage and substrate foaming are triggered at multi-interfaces to synchronously induce (1) the creation of biomimetic micro-crumpled textures with dual-improved water supply and light absorption and (2) the generation of mesoscale pores in PS substrates with dual-suppressed thermal conduction and radiation. Contributed by the synergistic designs, the solar evaporation device demonstrates a high evaporation rate of 1.41 kg m−2 h−1 and a conversion efficiency of 95.8% at an extremely low loading of photothermal materials (0.25 mg cm−2). A large-area solar evaporation panel is realized to highlight the practical consideration toward more impactful solar evaporation exploitation.

3D printed reduced graphene oxide/polyimide nanofibers composite aerogel for stable lithium metal anode

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Three-dimensional (3D) printing is an effective technique to construct key electrode materials with various customized architectures for rechargeable batteries. In this work, a reduced graphene oxide/polyimide nanofibers (rGO/PIfs) composite aerogel is designed using the 3D printing technology and further adopted as a free-standing lithium metal host. The 3D-printed rGO/PIfs composite aerogel has a special hierarchical porous structure as well as large specific surface area, which can provide abundant lithium nucleation sites and reduce local current density, resulting in homogeneous lithium deposition to overcome dendrite issues. Moreover, through introducing proper PIfs, the mechanical property of the composite aerogel is further enhanced with 3.5 times compressive stress of pure rGO aerogel, which can effectively prevent the structural damage caused by the large pressure during battery assembling process. Thus, when used in rGO/PIfs||Li half-cell, the rGO/PIfs composite aerogel displays a stable cycling performance with a high Coulombic efficiency of 98% after 260 cycles at 2 mA cm^{-2} and 1 mAh cm^{-2}.

Surface sulfonated polyaniline nanofibers for enhancing efficient charge storage capability through flowing polymerization method

Shuo Hu、Yueying Shen、Yeping Liu、Xueshi Shan、Huafeng Yan、Zongyi Qin
Donghua University

As we all know, oriented polyaniline (PANI) with good dispersibility has excellent capacitance performance because it provides fast ion diffusion path and larger specific surface area. In this work, the flowing polymerization method was used to limited reaction space and subsequently online adding meta-aminobenzene sulfonic acid (ASA) and aniline to obtain sulfonated polyaniline nanofibers (PANI-ASA). Through field emission scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FT-IR), X–ray diffraction analysis (XRD) as well as X-ray photoelectron spectroscopy (XPS), the morphology, microstructure of PANI products were studied. The capacitance performance containing cyclic voltammetry (CV), galvanostatic charge-discharge (GCD) and electrochemical impedance spectroscopy (EIS) was investigated on a CHI 660E electrochemical workstation. It was found that the flowing polymerization method induced the orientation of PANI molecules through reaction space limitation to improve conductivity. What's more, the introduction of ASA promoted the dispersion of PANI during fiber growth and enhanced the electrochemical performance. In addition, the PANI-ASA electrode reached its maximum specific capacitance 567.7 F g-1 with a current of 1 A g-1 and high rate retention of 96.7 % from 1 to 10 A g–1. It has been proved that the flowing method and the introduction of ASA could achieve a great improvement in capacitance performance due to its high orientation and good dispersion, which would promote the formation of PANI nanofibers. This method will provide new ideas for the continuous industrial production of PANI with high electrochemical performance.

Activated Carbon Nanotube Fiber Fabric as a High-Performance Flexible Electrode for Solid-State Supercapacitors

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Owing to their features of excellent mechanical flexibility, high conductivity, and light weight, carbon-based fiber fabrics (CBFFs) are highly attractive as flexible electrodes for flexible solid-state supercapacitors (SCs). However, the achieved areal capacitance of most CBFFs is still unsatisfactory. Carbon nanotube fiber fabric (CNTFF) is a new kind of CBFFs and could provide a potential alternative to high-performance flexible electrodes. Herein, we report the activation of CNTFF using a facile thermal oxidation and acid treatment process. The activated CNTFF shows an exceptional combination of large areal capacitance (1988 mF cm^{-2} at 2 mA cm^{-2}), excellent rate performance (45% capacitance reservation at 100 mA cm^{-2}), and outstanding cycle life (only 3% capacitance decay after 10000 cycles). The constructed solid-state SC reaches a maximum energy density of 143 μWh cm^{-2} at 1000 μW cm^{-2} and a maximum power density of 30600 μW cm^{-2} at 82 μWh cm^{-2}. Additionally, this device possesses good rate performance along with superb cycle stability and excellent mechanical flexibility under various bending conditions. Our present work therefore offers a new opportunity in developing high-performance flexible electrodes for flexible energy storage.

Study on Crosslinked of POE with UV irradiation

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Crosslinked can improve the insulation, tensile strength and temperature resistance of materials. It is a common method to improve the properties of polyethylene. Polyethylene elastomer (POE) is widely used in conveyor belt coating, wire and cable, but it also has the problems of poor temperature resistance and environmental stress cracking resistance. In this study, the polyolefin elastomer was irradiated and crosslinked by ultraviolet light with benzophenone (BP) as initiator and triallyl isocyanurate (TAIC) as crosslinking agent. The crosslinking characteristics and related properties of UV irradiated POE were investigated by gel content test, Fourier transform infra-red (FT-IR) spectroscopy, differential scanning calorimetry (DSC) and mechanical properties tests. The results showed that when UV irradiation was applied to 120s, the gel content reached 65.47%. After UV irradiation, the crystallinity of POE decreased and the melting point first decreased and then increased. The mechanical properties test showed that the tensile strength of crosslinked POE decreased at room temperature, but the tensile strength of crosslinked POE at 60 ℃ increased from 11.64 MPa to 12.96 MPa compared with that of pure POE.

Study on Preparation and Performance of Carbon Paper for Fuel Cell

Yipeng Mao、Guang Li、Shenglin Yang、Junhong Jin
Donghua University

Proton Exchange Membrane Fuel Cell (PEMFC) is considered to be one of the most promising energy conversion equipment due to its advantages of low operating temperature, high power density, low noise and zero emission. Membrane Electrode Assembly (MEA), as the core component of fuel cell, is mainly composed of gas diffusion layer, catalyst layer and proton exchange membrane. Carbon papers (CPs), as the core material of gas diffusion layer, play an important role in transporting electrons, supporting catalyst layer, distributing reactant gases and draining water. Its performance will directly affect the overall performance of the PEMFC. In this paper, high-performance CPs are fabricated via wet paper-making process through mixing carbon fibers with different lengths, resin impregnation, compression molding, carbonization, and graphitization. The effect of fiber mixing ratio, resin impregnation time, and molding pressure on the performance of CPs are studied. The results show that the performance of CPs can be adjusted by changing the blending ratio. At the same time, as the immersion time increases, its performance rises firstly and then declines. In addition, the appropriate molding pressure also has a greater impact on its performance. When the content of 10mm length carbon fibers reaches 30wt% among 6mm carbon fibers, the overall performance of CPs are the best and close to commercial CPs. When the immersion time is 30 min, the resin residual carbon rate is higher than others, and the overall performance of CPs are excellent. When using pressure molding at 10 Mpa, CPs show excellent performance. At the optimized processing conditions, high-performance CPs with tensile strength of 6.78 MPa, thickness of 0.33 mm, resistivity of 8.44 mΩ·cm, and porosity of 62% are fabricated. The results of this CPs could be a beneficial reference for the production of CPs using in the fields of PEMFC.

High performance polyaniline nanofibers enable efficient energy storage via sustainable and scalable flowing polymerization for flexible supercapacitors

Yueying Shen、Yeping Liu、Huafeng Yan、Xueshi Shan、Shuo Hu、Xian Xu、Zongyi Qin
Donghua University

Polyaniline (PANi) is a promising conducting polymer for many essential applications because of its fast reversible doping and de-doping process, facile synthesis, low cost, high environmental stability and ultrahigh theoretical specific capacitance. However, PANi has not achieved the expected application potential in practice due to the lack of sustainable and effective method for scalable preparation of PANi nanofibers with high aspect ratio. Recently, microreactor technology has been proposed for the preparation of PANi nanofibers, nonetheless, the usage of organic solvents and much lower yield due to the extremely dilute monomer concentration greatly restrict the large–scale production and wide–spread application of nanofibers. Here we introduce an efficient strategy for large–scale preparation of PANi nanofibers via flowing polymerization in fully aqueous system. The growth of oligomer seed and the nanofiber would be controlled in stages so that the overgrowth of PANi can be avoided after the initial nanofibrillar formation step and finally the pure PANi nanofibers with a higher aspect ratio could be obtained. The influences of flowing rate on the growth of PANi nanofibers and capacitive behaviors are discussed. It is found that the products show remarkable energy storage ability, especially the PANi nanofibers prepared at the flowing rate of 80 mL h–1 have the highest specific capacitance of 529.4 F g–1 at a current density of 1 A g–1 with the capacitance retention of 80.3 % after 2000 cycles. Moreover, a flexible supercapacitor assembled with the PANi electrodes also exhibits the energy density of 8.2 W h kg–1 under a power density of 258.9 W kg–1. These results prove that this fundamental study could provide a much easier route in achieving high performance PANi nanofibers in large-scale preparation and opens new opportunities for facilitating flexible PANi–based electrodes as promising candidates for wearable electronics.

Thermoelectric fibers for wearable devices

Bo Wu、Yang Guo、Kerui Li、Chengyi Hou、Qinghong Zhang、Yaogang Li、Hongzhi Wang
Donghua University

The human body is a huge source of energy, but 70-85% of the energy produced every day is dissipated in the surrounding environment as heat radiation. How to effectively utilize the low-grade thermal energy such as human body waste heat has aroused widespread concern. Thermoelectric materials can directly convert thermal energy into electrical energy, and it can solve the problem of continuous energy supply if the generated electrical energy is used as the energy source of wearable electronic devices. However, the application of thermoelectric materials in the wearable field still has two major problems: low flexibility and low output.

To address these problems, our believe that the low-dimensionalization of traditional thermoelectric materials will greatly improve their thermoelectric properties, and the team has also been engaged in the preparation and structural design of low-dimensional materials for a long time. As a representative of low-dimensional materials, graphene has a wide range of applications in the field of thermoelectricity. In the team's previous work, our prepared self-supporting, super-elastic reduced graphene oxide foams using freeze-drawing techniques, which were assembled into electronic skins that can recognize human touch based on thermoelectric principles (Hou C, Wang H, Zhang Q, et al. Advanced Materials, 2014, 26, 5018-5024.). To further improve the thermoelectric conversion efficiency of the materials, two-dimensional Bi_2Te_3 and Sb_2Te_3 nanosheets with topological insulator properties were introduced into the active carbon materials, and the assembled photovoltaic thermoelectric integrated devices could directly convert solar heat into electricity and enhance the solar cell efficiency (Wu. B, Hou C, Wang H, et al. Advanced Functional Materials, 2019, 29, 1900304)

In this work, to further convert human waste heat, we used wet spinning and twisting techniques to prepare high-performance organic/inorganic hybrid thermoelectric fibers and construct wearable flexible thermoelectric fabrics, respectively. The fibers prepared by the two one-step methods exhibit only p-type conductive properties, and the carrier compounding phenomenon generated when woven in ordinary fabrics is not conducive to thermoelectric output. To solve this problem, we modified the thermoelectric fibers in segments to obtain thermoelectric fibers with continuous p-n junctions, and embedded them in fabrics or wristbands in a wave configuration. The resulting wearable thermoelectric devices with all-weather thermal conversion capability provide an efficient solution for human thermal energy capture.

Emission and functionalization of MXene-based coating materials

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Since its discovery in 2011, the new family of two-dimensional (2D) transition metal carbides and nitrides, known as MXenes, have quickly triggered broad research attention, especially in the field of supercapacitors (SCs). Due to the high electronic conductivity (~ 10,000 S cm-1), high packing density (~ 4 g cm-3), and fertile surface chemistry, MXenes can deliver volumetric capacitance up to 1,500 F cm-3, which approaches the previously unmatched volumetric capacitance of RuO2. The metallic conductivity also induced an excellent rate capability of MXene-based electrode materials. Researches have proved that the high capacitance of MXene is mainly benefited from the high reversible redox reactions followed by the electrochemical intercalation of electrolyte ions. Generally, intercalation is the reversible insertion of guest molecules (or ions) into materials with layered structures, without changing the structure features of the host, which may induce drastically enhanced or changed performance for a wide range of applications. Thus, other phenomena, such as electrochromism and electrochemical actuation, have also been reported accompanying the energy storage process of MXenes. In this talk, the intercalation of different foreign species (ions and solvents) in MXene layers were discussed toward SCs and electrochromic devices.

Enhancing the Electrochemical Performance of Sodium-ion Batteries by Building Optimized NiS2/NiSe2 Heterostructures

Shuang He
Donghua University

NiS1.23Se0.77 nanosheets closely attached to the internal surface of hollow mesoporous carbon sphere (HMCS) to form a NiS1.23Se0.77 nanosheets embedded in HMCS (NSSNs@HMCS) composite as the anode of sodium ion batteries (SIBs) is reported by a facile synthesis route. The anode exhibited a superior reversible capacity (520 mAh·g-1 at 0.1 A·g-1), impressive coulombic efficiency (CE) of up to 95.3%, a high rate capacity (353 mAh·g-1 at 5.0 A·g-1), excellent capacity retention at high current density (95.6%), and high initial coulombic efficiency (ICE) (95.1%). Firstly, the highest ICE for NiS2/NiSe2-based anode can be ascribed to ultrathin layered structure of NiS1.23Se0.77 nanosheet and highly efficient electron transfer between the active material and HMCS. Secondly, the optimized NiS2/NiSe2 heterostructure at the nanoscale of the inside HMCS was formed after the first discharge/charge cycles, which can provide rich heterojunction interfaces/boundaries of sulfide/selenides to offer faster Na+ pathways, decrease the Na+ diffusion barriers, increase electronic conductivity, and limit the dissolution of polysulfides or polyselenides in the electrolyte. Finally, the hollow structure of the HMCS accommodates the volume expansion, prevents the pulverization and aggregation issues of composite materials, which can also promote outstanding electrochemical performance.

KEYNOTE SPEECH

High performance semiconducting polymers and their optoelectronic properties

Yunqi Liu
Institute of Chemistry, Chinese Academy of Sciences

Semiconducting polymeric materials have attracted great attention owing to their significantly improved performance and the recently emerged prospects for broad applications. Research activities on their optoelectronic devices, such as field-effect transistors (OFETs), near-infrared sensors, artificial synaptic perceptors, intrinsic flexible driver and display, etc., on the one hand of basic research are moving on deep exloration, on the other hand of pertential applications are full of promise.
In this presentation, I will introduce a few design strategies and fabrication processing methods for the realization of high-performance semiconducting molecular materials. Moreover, special fabrication processes of OFET devices can further enhance the charge transport by optimizing the hierarchical structures of semiconducting polymers, thereby enhancing the carrier mobility and stability of the polymer-based OFETs. Various applications range from small-scale logic signal processing and periodic signal generation to complex visual perception systems are also involved.

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KEYNOTE SPEECH

Stretchable semiconducting polymers and their application in organic transistors

Yan Zhao
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stretchable semiconducting polymers capable of performing electrical functionalities under mechanical deformations have shown great potential applications in next-generation robotics, prosthetics, health monitoring, and medical implants. Owning to their extraordinary chemical tunability, designing rational molecular structures enables the improvement in polymer inherent characteristics. Thus, in-depth understanding of the structure-property relationships is of great significance to develop effective design strategies for intrinsically stretchable organic semiconductors.

In this paper, a series of diketopyrrolopyrrole (DPP)-based semiconducting polymers with featured side-chain and backbone structure are designed to investigate the relationship between molecular structure and macroscopic property. Through combining flexible conductive components and elastic substrates, the intrinsically stretchable transistors are established to characterize the electrical performances of the as-designed polymers under varied tensile strains. The change trends of the micromorphology and electrical properties of the polymer thin films reveals the impact of molecular structure on charge transport behavior and deformation ability. In-depth exploration of the thermal relaxation process and polymer chain kinetics facilitates the clarification of the influence of polymer side-chain and backbone structures on the thermomechanical properties and electrical performance of semiconducting polymers. These results and analysis provide general guidelines for performance optimization and tailoring properties of semiconducting polymers from molecular level, contributing to their applications in next-generation flexible and wearable photoelectronic devices.

INVITED LECTURE

Sequentially Differential Microcracking for Ultrasensitive Stretchable Fiber Strain Sensors

Conghua Lu[1,2]、Lele Li[1]、enping liu[1]、juanjuan wang [2]、xue han [2]
1. Tianjin University
2. Tianjin Chengjian University

Stretchable fiber strain sensors typically suffer from an irreconcilable trade-off between sensitivity and stretchability, which can severely limit their capability to detect both subtle and large deformations at the same time. Here, a class of stretchable and ultrasensitive fiber strain sensors is proposed based on a hitherto unexploited sequentially differential microcracking in strain-sensing multilayer consisting of a pre-wrinkled interlayer and a conformally deposited surface-layer. During straining, the surface-layer preferentially microcracks at the wavy troughs, followed by the microcracking of the interlayer. The resulting strain sensor shows excellent stretchability, unprecedented gauge factor in both small and large strain ranges, ultralow strain detection limit and ultrafast response. Demonstrated applications of the strain sensor include human health monitoring and motion detection, acoustic vibration identification, and voice recognition. It is expected that the proposed sequentially differential microcracking can be extended to a new generation of stretchable sensing devices.

INVITED LECTURE

Skin - like wearable optical sensors based on micro/nanofibers

Lei Zhang
Zhejiang University

Electronic skin, a class of wearable electronic sensors that mimic the functionalities of human skin, has made remarkable success in applications including health monitoring, human-machine interaction and electronic-biological interfaces. Herein, I will demonstrate highly sensitive skin-like wearable optical sensors based on polydimethylsiloxane (PDMS) embedded optical micro/nanofibers (MNFs). Enabled by the transition from guided modes into radiation modes of the waveguiding MNFs upon external stimuli, the skin-like optical sensors show ultrahigh sensitivity, low detection limit and fast response for pressure, strain, and temperature sensing. Electromagnetic interference (EMI)-free detection of high-frequency vibrations, wrist pulse and human voice are realized. Moreover, a five-sensor optical data glove and a 2×2-MNF tactile sensor are demonstrated. These initial results pave the way toward a new category of optical devices ranging from ultrasensitive wearable sensors to optical skins.

INVITED LECTURE

Multifunctional Fibers for Wearable and Implantable Applications

Xiaoting Jia
Virginia Tech

Smart textiles, wearable electronics, and biomedical implants can gain significant breakthrough through the invention of novel flexible devices that are capable of sensing, communicating, and interacting with humans and the environment. Among different types of flexible devices, multimaterial fibers offer unique advantages for interfacing with humans, because of their minimal footprint, scalability, high flexibility, multifunctionality, and biocompatibility. Despite the significant progress made in the fabrication of multimaterial fibers in recent years, significant challenges remain to enable wide applications in wearable and biomedical fields.

Here we present our research on developing multimaterial fibers for wearable and implantable applications. Firstly, we developed three dimensional (3D) and multifunctional deep brain interfaces based on multimaterial fibers. Human brain is a complex organ consisting of tens of billions of interconnected neurons. It is critical to understand the brain circuitry across multiple regions in the brain in order to effectively treat neurological diseases. However, mapping the brain circuitry over a large volume in the deep brain has been a major challenge. To address this challenge, we have developed a first 3D fiber-based neural probes using multifunctional fiber arrays guided through a helical multi-channel scaffold. These fiber probes enable simultaneous electrical recording, optical stimulation, and chemical delivery over a large volume in the deep brain using a small surgical burr hole for the first time.

Next, we present various wearable sensors based on multimaterial fibers. Examples include fully distributed pressure and temperature sensing fiber and fabric which can sense multi-point pressure distribution along the fiber, pressure variation, as well as continuous pressure shifting along the fabric with simple one-end connection, strain sensing fibers for multimodal extreme deformation sensing, and nano-integrated multifunctional fibers for bio-/chemical sensing. We have also developed fiber-based triboelectric nanogenerators for energy harvesting, motion and touch sensing. These fiber sensors can be woven into fabrics, and undergo multiple washing and drying cycles without degrading their performances.

In conclusion, multimaterial fibers provide a powerful platform for wearable and implantable applications. Some of the future directions include more complex and integrated functions, reduced feature sizes, increased flexibility, and facile integration with silicon electronics for signal acquisition and processing.

INVITED LECTURE

Polymer Complex Fiber: Adaptive Behaviors and Actuation

Shuguang Yang
Donghua University

Polymer complex refers to the system where different polymers associate together based on non-covalent bonds to form homogenous phase. The fibers prepared through polymer complexation process or by directly spinning polymer complex are defined as polymer complex fibers. Different polymers are miscible on the molecular level in polymer complex fiber system, providing a platform to design multifunctional fibers with good compatibility. We develop the method to prepare polymer complex into fibers. First, a spinnable fluid is obtained by restricting complexation, and then it is extruded through a spinneret into a coagulation bath where polymer complexation happens and hence fibers are formed. We will introduce our recently work about polyelectrolyte fibers and hydrogen-bonded polymer complex fibers, which shows environmental adaptivity and can be used for actuation.

INVITED LECTURE

Polysaccharide Polyelectrolyte Intelligent hydrogels

Kunyan Sui
Qingdao University

Polysaccharide polyelectrolytes have a wide range of applications due to its promising properties, including high biocompatibility, excellent biodegradability, low toxicity, as well as abundant availability and low production cost. In this work, by using of the polyelectrolyte complexation and polyelectrolyte electrostatic shielding effect of the polysaccharides, various intelligent hydrogels have been fabricated, including ionic hydrogels, gradient hydrogels and hollow multilayer hydrogel capsules. The present report focuses on alginate, chitosan, carrageenan, and xanthan gum, etc. The fabrication techniques and applications are discussed in detail.

INVITED LECTURE

Wet spinning of polyetherketoneketone fibers with superior mechanical and thermal properties

Xiaohua Zhang、Yanbo Li、Bolan Li、Feng Zhang、Xin Wang
Donghua University

As a semi-crystalline thermoplastic, polyetherketoneketone (PEKK) has shown advantages of low density, high mechanical properties, high temperature thermal stability, electrical insulation and excellent chemical resistance, and thus can be applied in advanced fiber fabrics and devices. However, due to the high fraction of ketone groups, its melting temperature is as high as above 340 °C, and the melt viscosity is extremely high, making it very difficult to prepare PEKK fibers via melt spinning. Furthermore, it is also difficult to dissolve in common polar solvents, and thus it is lack of an appropriate wet spinning.

In this study, high performance PEKK fibers with high temperature resistance, high strength and toughness, and controllable interior microstructures were prepared by realizing the wet spinning. By controlling the concentrations and solvent types of the spinning and coagulation solutions, a spinning phase diagram is established, which involves both the aggregation of PEKK molecules and the diffusion process of solvent molecules. The as-spun PEKK fibers can be remarkably strengthened by a series of hot stretching, during which the orientation and crystallinity of PEKK molecular chains are optimized. The PEKK fibers have exhibited a tensile strength above 800 MPa, and showed exciting stability at both high and low temperatures. This study provides a new means for developing advanced fibers with superior mechanical properties, and high- and low-temperature resistances.

INVITED LECTURE

Flexible supercapacitors based on carbon nanotube fabrics

Xiaogang Luo[1,2]、Yunxia Liang[2]、Meifang Zhu[2]
1. Soochow University
2. Donghua University

Owing to their features of excellent mechanical flexibility, high conductivity, and light weight, carbon-based fiber fabrics (CBFFs) are highly attractive as flexible electrodes for flexible solid-state supercapacitors (SCs). However, the achieved areal capacitance of most CBFFs is still unsatisfactory. Carbon nanotube fiber fabric (CNTFF) is a new kind of CBFFs and could provide a potential alternative to high-performance flexible electrodes. Herein, we report the activation of CNTFF using a facile thermal oxidation and acid treatment process. The activated CNTFF shows an exceptional combination of large areal capacitance (1988 mF cm-2 at 2 mA cm-2), excellent rate performance (45% capacitance reservation at 100 mA cm-2), and outstanding cycle life (only 3% capacitance decay after 10000 cycles). The constructed solid-state SC reaches a maximum energy density of 143 μWh cm-2 at 1000 μW cm-2 and a maximum power density of 30600 μW cm-2 at 82 μWh cm-2. Additionally, this device possesses good rate performance along with superb cycle stability and excellent mechanical flexibility under various bending conditions. Our present work therefore offers a new opportunity in developing high-performance flexible electrodes for flexible energy storage.

INVITED LECTURE

Ice-templating technique and its application in bioinspired functional materials

Hao Bai
Zhejiang University

Development of human society is, to some extent, relying on the invention of new materials. In this context, biological materials, such as bone, shell and bamboo, constantly serve as a source of inspiration to design strong, tough, lightweight, self-healing and smart synthetic materials for future engineering applications. While biological materials achieve multifunctionality by building sophisticated multiscale architecture, synthetic materials are always relying on the diversity of constituents. Combining these two strategies would stimulate green fabrication approaches and result in multifunctional materials with unprecedented properties. Specifically, we take an ice-templating technique to mimic the sophisticated architecture of biological materials in our synthetic counterparts. The ice-templating technology takes advantage of the "solute precipitation" effect during the ice crystal growth process to effectively assemble the monomer, prepolymer, polymer, inorganic nanomaterials and other systems dissolved or dispersed in water. By regulating the nucleation and growth process of ice crystals, the structure and properties of the materials can be effectively controlled. Although ice-templating technology is an atypical material processing method, it has attracted the attention of many research groups at home and abroad due to its advantages of simple operation, green environmental protection, wide range of applicable material systems and its advantages in constructing orderly structures. We systematically studied the material assembly process and the heat and mass transfer mechanism of the ice-templating technology from the aspects of cold surface, temperature field design and properties of the assembly building blocks. High efficiency heat insulation, infrared stealth fibers and fabrics with porous structure imitating polar bear hair have been developed by using freeze spinning technology. A new macroscopic technique for the preparation of nacre-like laminated materials has been developed by means of bidirectional freezing. Porous polymer materials with low density, high strength and negative Poisson's ratio were developed by using emulsion ice-templating technology. These polymers and their composites with multiscale structures have great potential applications in aerospace, thermal insulation, electronic materials and other fields, demonstrating the potential of the ice-templating technology in material fabrication.

INVITED LECTURE

Knitting for wearables: sensing and energy

Pibo Ma[2]、Li Niu[1]、Yuankun Liu[3]
1. Jiangnan University
2. Jiangnan University
3. Beijing Institute of Aerospace Testing Technology

Apparel is the second skin that can fully cover the human body. This is a perfect vehicle for electronics for collecting and transferring signals. The development of wearables, integrated electronics with apparel for collecting body signals is a tough and tremendous challenge. Knitting, as one of the traditional textile processes, can provide fitting clothing with high stretchability, great recovery, softness, comfort and breathability. And the knitted textile offers a potential solution to the poor compatibility through varied knitting techniques. It presents that a huge innovation and wide application in the process of realizing really comfortable wearable. In this talk, an overview of knitting characteristics and classification. Then the work at Jiangnan University towards breathing signals detection and sensing, human motions monitor and knitted-based triboelectric nanogenerator are been introduced. The knitted-based electrical textile will be a prominent candidate of the flexible wearable substrate.

INVITED LECTURE

Polymeric material systems for active cooling and thermal management

Xiaoshi Qian
Shanghai Jiaotong University

Active thermal management is the key component in numerous departments in the industry, i.e., the household air-conditioning (AC) and refrigeration, the building thermal management, the thermal management for electric vehicles, the battery management systems, aviation and space operations, etc. The conventional technology utilizes the phase transition of gaseous refrigerants to provide the active heating/cooling, and the electromechanical system to sense ambient and control the operation accordingly. However, the currently dominant technologies are energy inefficient and environmentally detrimental. In addition, the electromechanical control systems are bulky and pre-programmed by men, thus cannot adapt to a complicated ambient condition that keeps varying. Here, we will show the recent development in functional dielectrics, including the electroactive polymers, composites, and stimuli-responsive composites, which provide the long-overdue solutions for the energy-efficient, zero-carbon-emission thermal management. Such dielectric systems are capable to provide active cooling/heating, and self-adaptive thermal management without human intervention.

INVITED LECTURE

Silk Ionotronics

Shengjie Ling
ShanghaiTech University

Ionotronic skin has drawn considerable attention because it can interface with different systems to sense and respond to external stimuli, such as force and temperature. To meet the challenges in tensile performance, self-repairing ability, degradability, and safety performance, we introduced silk protein into ordinary polymer ionotropic skin, which obviously improved the mechanical properties and self-healing property of the ionotropic skin. Subsequently, we further extended the application scope of the ionotropic skin to the range of -30~80℃ through introducing calcium ions into the silk protein hydrogels. Such a process is significant in broadening the stable usage of the ionotronic skin. We investigated the conduction mechanism of the silk fibroin hydrogel-based ionotronic skin by combining the experimental characterization with the theoretical analysis. The results confirmed that the hydrated protons significantly affected the temperature and humidity responses of the skin. More precisely, the temperature response followed the rate of proton rearrangement reaction, while the humidity response obeyed the percolation theory. With these findings, our group developed a combined theoretical model to decouple the experimental temperature and humidity responses of silk ionotronic silk during synchronic variation. In addition, a flame-retardant and biosafe ionotronic skin was developed by using silk fibroin and Ca^{2+} ions as starting materials. In this study, the structures, performance, and safety issues of the ionotronic skins were well-balanced. The resultant ionotronic skins not only maintained the advantages of conventional ionotronic skins, such as conductivity, transparency, high stretchability, and self-healing ability, but also featured outstanding flame retardancy and temperature sensibility. With these features, an automated fire alarm system was designed to detect possible fire conditions. These ionotronic skins are expected to be employed in a range of emerging fields, such as flame-retardant materials, fire alarms, temperature sensors, and human/machine interfaces

INVITED LECTURE

Intelligent Health Monitoring based on Advanced Soft Materials

Wei Chen
Fudan University

Many challenges exist in health monitoring and management, such as continuous, accurate, and comfortable monitoring of multi-parameters, early detection and warning of diseases, as well as the interaction with environments. The challenges in healthcare raise health risks and imposes significant economic and social burden. Thus, seeking for the innovative solutions and new technologies to address these issues is very important. The development of modern sensors, Internet of Things, advanced materials, machine learning and AI technology has inspired the innovation on intelligent designs for healthcare.

The novel intelligent wellness sensing platforms seamlessly integrate smart sensing technologies, data fusion techniques, advanced materials, and clinical practice. Physiological signs, behaviors and environmental information can be obtained effectively. By jointly analyzing physiological behavior parameters with environmental interaction information and using data fusion technology, the health-related activities can be identified. With intelligent wellness sensing platform, personal health monitoring and forecasting will be provided assisting to develop personal healthcare plan, and guide people towards a healthier lifestyle. The multi-disciplinary research on intelligent wellness sensing, machine learning, and biomedical signal processing will bring new development for improving the quality of life for people ranging from babies to aging population during their everyday life, and have long term social impact.

INVITED LECTURE

Skin-contact actuated touch-sensing fabric with strain and pressure insensitive for human-computer interaction

Mingwei Tian、Ruidong Xu、Ganghua Li、Xiangmin Fang、Shikang Zhao、Jiaxu Liu、Yuanyuan Liu、Yalin Tang、Lijun Qu
青岛大学纺织服装学院智能可穿戴技术研究中心

Touch-sensing devices have become familiar to people and it can effectively build a bridge of “communication” between human and computers. Though current touch-sensing devices have outstanding precision and sensitivity, it suffers from the lack stretchability and flexibility. More important, the substrate materials of above devices are not ideal wearable materials. Consequently, these drawbacks greatly limit the application range of touch devices. Herein, we show that a novel and simple strategy is reported to design a conductive hydrogel filled touch-sensing fabric. The touch-sensing fabric exhibits a warp and weft stretch rates of the touch-sensing fabric can reach 52.3% and 21.4%, respectively due to knitted fabric illustrating that the touch-sensing fabric has obvious stretchability and flexibility. In addition, theoretically, the resolution of the touch-sensing fabric we designed is infinite compared with the traditional resistance type, showing extremely high accuracy. Meanwhile, the fabric not only shows the characteristics of being insensitive to strain (> 105°) and stress (> 1000 kPa), but also has a very low monitoring touch-sensing threshold (50 Pa). Besides, the touch-sensing fabric is only 1mm thick, which is very suitable for wearing. Based on this, a touch-sensing sleeve is designed to achieve human-computer interaction such as writhing, drawing and typing exhibiting a good potential for future wearable interaction devices.

INVITED LECTURE

Engineering Atomic Structures of Two-Dimensional Heterostructures for Thermal Management

Xiangjun Liu
Donghua University

Combing two-dimentional (2D) materials with distinct properties into heterostructures provides a dramatic scientific and technological platform to explore new physics and create novel functionalities. Low thermal conductance across the heterostructure interface is often the limiting factor in managing heat in many advanced device applications of 2D heterostructures, including nanoelectronics, solid-state lighting, energy generation and nanocomposites. Thus, tailoring interfacial thermal transport in 2D heterostructures is of great importance for the reliability of these devices.
We demonstrate that interfacial thermal conductance G in 2D heterostructures can be significantly enhanced by introducing covalent bonds at the interfaces using molecular dynamics simulations. The simulations captured the trend of thermal transport enhancement with the increment of interfacial covalent bond density. The results confirm that the observed G enhancements at the interfaces are due to strong interfacial covalent bonds and resultant coupling in the atomic vibrational spectra near the interface. Using a graphene/h-BN 2D heterostructures, we show surprisingly that topological defects at the interface are able to enhance the thermal conductance across the interface, which is due to the localization of the stress fields arising from misfit dislocations and their out-of-plane deformations at the defective interface. In graphene/MoS2 2D heterostructures, we found high interface thermal conductance exists at the interface, which is comparable to that of graphene-metal covalent-bonded interfaces. Importantly, each interfacial Mo-C bond serves as an independent thermal channel, enabling the modulation of interfacial thermal conductance by controlling Mo vacancy concentration at the interface.

INVITED LECTURE

Mimicking eyes with nanowire arrays

Leilei Gu
Shanghai Jiao Tong University

Nature has provided endless sources and inspiration for engineering. The diverse environment has promoted various functional systems and the long-term natural selection has continued to choose the best. Every surviving creature is, therefore, the accumulatioin of time, the crystallization of wisdom, and a rich treasure house of technologies. Imitating nature is a shortcut to improve our existing systems. One-dimensional nanostructures, which have unique properties and comparable size to many biological cells, are excellent building blocks for high-performance biomimetic systems, particularly biomimetic smart sensor systems. This report focuses on nanowire array based integrated photodetector arrays. Special attention will be given to the spherical, biomimetic eyes with perovskite nanowire array retina, including its design, assembly, characterization and prospective.

INVITED LECTURE

Advanced Multi-material Optoelectronic and Electronic Fiber Devices

Wei Yan
Massachusetts Institute of Technology

Fibers, ancient yet largely underdeveloped forms, are the common building blocks of a broad spectrum of product forms from textiles to aircraft constructs. While ubiquitous, these fibers are produced at scale from essentially single materials. The integration of a variety of electronic and optoelectronic materials within thermally-drawn fibers has emerged as an unprecedentedly compelling platform for enabling fibers to evolve into functional devices and smart systems. This approach exploits the thermal drawing of a macroscopic preform, where functional materials or prefabricated devices are arranged at a prescribed position, yielding kilometers of functional fibers with a sophisticated architecture and complex functionalities in a very simple and scalable manner. A single strand of fiber that incorporates materials with disparate electronic, optoelectronics, thermomechanical, rheological and acoustic properties can see objects, hear sound, sense stimuli, communicate, store and convert energy, modulate temperature, monitor health and dissect brains. Integrating these fibers into fabrics, ancient yet largely underdeveloped forms, is setting a stage for fabrics to be the next frontier in computation and Artificial Intelligence. In this presentation, I will show the fabrication of smart optoelectronic and electronic fiber devices, and elaborate their unique applications in the fields of sensing, healthcare, robotics, textiles and neuron science as well as their fundamental research in materials science and physics.

Stimulus-driven liquid metal and liquid crystal network actuators for programmable soft robotics

Shukuan Shi、Xiang Li、Pengfei Lv、Ling Wang
Tianjin University

Sophisticated soft matter engineering has been endorsed as an emerging paradigm for developing untethered soft robots with built-in electronic functions and biomimetic adaptation capacities. However, the integration of flexible electronic components into soft robotic actuators is challenging due to strain mismatch and material incompatibilities. Herein, we report a general strategy to integrate electrically conductive liquid metals (LMs) and shape-morphing liquid crystal networks (LCNs) towards multifunctional and programmable soft robotics. A unique colloidal LM ink with superior adhesion and photothermal conversion efficiency was judiciously designed and fabricated by ultrasonicating LMs and miniature carboxylated gold nanorods (MiniGNR-COOH) in an aqueous suspension of biological bacterial cellulose. The designed nanocellulose-based colloidal LM ink is used for shape-deformable and electrically conductive LM–LCN soft robots that can be electro- and photo-thermally actuated. As proof-of-concept demonstrations, we present a light-fueled soft oscillator, an inchworm-inspired soft crawler and programmable robotic Shadow Play exhibiting multifunctional controllability. The strategy disclosed here could open up a new technological arena for advanced multifunctional soft materials with potential utility in bioinspired soft machines, integrated soft electronics, human–computer interaction and beyond.

Hydrogen-bond Associated Elastomer with High Toughness, Humidity Adaptivity and pH Actuation Ability

Weijie Wang、Shuguang Yang
Donghua University

Elastomers with good flexibility and cross-function ability are high desired in the field of soft Robert and electric devices. Here, a new-type of elastomer with multi-hierarchical structure was fabricated apply tri-block copolymer of polystyrene -b- poly (ethylene oxide) -b- polystyrene (SES) and polystyrene -b- poly (acrylic acid) -b- polystyrene (SAS). Different from the traditional elastomer, the flexible domain of this new-type of elastomer is use poly (ethylene oxide) (E) and poly (acrylic acid) (A) hydrogen-bond complex chains (E/A) rather than single chains. While the polystyrene (S) is microphase separation and hydrophobic associated together to crosslink the flexible complex chains (A/E) and enhanced the strength of the elastomer. This elastomer is highly sensitive to changes in humidity, pH, salt concentration and temperature which is integrated multifunctional material. The humidity adaptivity, pH actuation ability, and elasticity of the elastomer were analyzed in detail. This research can provide new methods and ideas for constructing new types of multifuctional integrated materials.

Touch-sensing fabric encapsulated with hydrogel for human-computer interaction

Ruidong Xu、Mingwei Tian、Lijun Qu
Qingdao Uiversity

Flexible touch-sensing devices have raised extensive attention for wearable electronics and human-machine interaction. The ionic touch-sensing hydrogels are ideal candidates for these scenarios, but the absorbed water is evaporated easily from the hydrogel reducing their working time and stability. Herein, we propose the touch-sensing fabric system with non-woven cellulose fabrics as sheath layer encapsulated with hydrogel filling layer. The resultant touch-sensing fabric with superthin structure (1 mm) exhibits low detecting threshold (50 Pa), high durability (100k times), strain/pressure insensitivity and extremely touch positioning accuracy. On the proof of concept, a smart touch-sensing glove is equipped with our fabric which can execute human-computer interaction as flexible touch-sensing devices.

A New Strategy of Discretionarily Reconfigurable Actuators Based on Self-Healing Elastomers for Diverse Soft Robots

Wenfan Zhu、Jiaming Lou、Zenghe Liu、Zhengwei You
Donghua University

Actuators have shown great promise in many fields including soft robotics. Since reconfiguration allows actuators to change their actuation mode, it is considered a key characteristic for new-generation adaptive actuators. However, it remains a challenge to design simple and universal methods to fabricate actuators that can be reconfigured to allow diverse actuation modes. Here, a macroscopically discretionary healing-assembly strategy to fabricate reconfigurable soft actuators based on intrinsic self-healing poly(dimethylglyoxime-urethane) (PDOU) elastomers is developed. The PDOU elastomers with different degrees of crosslinking show different responsiveness to solvents, and are seamlessly healed. Crosslinked and non-crosslinked PDOU elastomers as building units are healing-assembled into actuators/robots with diverse actuation behaviors. Notably, the assembled actuators/robots are readily reprogrammed to exhibit multiple actuation modes by simply tailoring and reassembling without any external stimuli. This work paves a new, simple, powerful, and universal method to construct sophisticated soft robots.

Vanadium-doped cobalt phosphide/carbon nanofiber cloth catalysts for efficient and stable overall water splitting

Xiangheng Du[1,2]、Ming Zhang[2]、Shaowu Pan[1]
1. State Key Laboratory for Modification of Chemical Fibers and Polymer Materials, College of Materials Science and Engineering, Donghua University
2. School of Materials Science and Engineering, Zhejiang Sci-Tech University

With the development of society, the problem of energy crisis and global warming need to be solved urgently. Hydrogen energy has received extensive attention due to its clean and pollution-free characteristics. Carbon nanofiber cloth has a three-dimensional network structure, which is suitable as a substrate for hydrogen production by electrolysis of water. Transition metal phosphides are common electrolytic water catalytic materials. However, there is a big gap between phosphides and commercial precious metals. Herein, we proposed vanadium-doped cobalt phosphide nanorod arrays grown on carbon nanofiber cloth (V-CoP NRs/CC) as bifunctional catalysts. When V-CoP NRs/CC are employed as both anode and cathode materials, it only demands low cell voltages of 1.491 V and 1.606 V to drive current density of 10 mA cm^{-2} (j_{10}) and 50 mA cm^{-2} (j_{50}) in 1 M KOH alkaline electrolyte. Especially, V-CoP NRs/CC can maintain their outstanding electrocatalytic performance for more than 40 h at j_{50} in overall water splitting.

Preparation and Properties of EVOH Nanofiber Aerogel-Based Adsorption Materials

Wei Song
Donghua University

Organic solvent wastewater is produced from oil spills, industrial production and daily life. The ecological environment, the health and safety of life-form will be under threat. The adsorption method has the advantages of simple operation, high removal efficiency and low cost. Therefore, it is widely used to treat organic solvent wastewater. Nanofiber aerogel possesses excellent characteristics of adsorbents, including high specific surface area, large porosity, good flexibility, high compressive strength and so on. Thermoplastic polymer nanofibers can be prepared by melt-extrusion phase separation method which enriches and broadens the construction materials and applications of aerogels. In this study, the thermoplastic polymer poly(vinyl alcohol-co-ethylene) (EVOH) nanofibers were used as the elementary units, and the EVOH/sodium alginate composite nanofiber aerogels (EVOH/SA CNFAs) were designed by self-crosslinking method. The influence of sodium alginate (SA) content on morphology and mechanical properties was studied by changing the component ratio between EVOH and SA. And the adsorption performance was explored among different pollutants after silanization. The research results show that the mechanical strength of EVOH/SA CNFAs reach the highest when the SA content is 40%, which is the optimal formula within the experimental range. EVOH/SA CNFAs exhibit high porosity (98%) and efficiently adsorption capacity for organic solvents(including oils), the result confirms that the maximum adsorption capacity can reach up to 44 times their own weight. In the adsorption-desorption test, EVOH/SA CNFAs maintain 98.2% adsorption rate after 10 cycles, which show excellent cyclic adsorption property. After Silanization, EVOH/SA CNFAs can effectively remove pollutants in water including dyes and Cu^{2+} due to its hydrophobic.

Compression Strain-dependent Tubular Carbon Nanofibers/Graphene Aerogel Absorber with Ultrabroad Absorption Band

Shuai Kang[1]、Shiya Qiao[1]、Yutong Cao[2]、Zuming Hu[1]、Junrong Yu[1]、Yan Wang[1]
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The compressive strain-dependent microwave dissipation behavior gives aerogel a great superiority of achieving the broad-band absorption. Whereas, little is investigated about the close association between the compression strain and microwave attenuation performance, and it still remains a vast challenge for constructing the superb microwave absorbers with the remarkable elasticity. Herien, lightweight tubular carbon nanofibers (TCNFs)/graphene aerogel (TGA) with the anisotropic architecture was assembled through chemical cross-linking, freeze-drying and subsequent reduction, in which the intertwined TCNFs were encapsulated within graphene skeleton. The satisfactory impedance matching and multiple loss mechanisms derived from the directional cellular configuration and heterointerfaces, promote the pleased microwave consumption. When the compression strain is 60%, it harvests the most prominent microwave absorbency of a minimum reflection loss (RLmin) value of -46.1 dB and an effective absorption bandwidth (EAB) value of 7.1 GHz along the vertical direction. By tuning the compressive strain, an ultrabroad EAB of 11.5 GHz is realized. Besides, the favorable fatigue resistance and heat insulating performance benefitting from the stable network and anisotropic architecture, make the hybrid aerogel stand out among numerous absorbers. This study is instructive to develop multifunctional microwave absorbing materials for matching well with the practical environment.

INVITED LECTURE

Using Graphene to Fabricate Form-stable Phase Change Materials and Thermo-regulated Fiber

Xingxiang Zhang
Tiangong University

Solid-liquid phase change materials (SLPCM) as green and renewable energy storage materials are widely used in many fields. They are easy to leakage during the phase change process, however. Graphene is one-atom thick two dimensions nano sheet. It is very hopeful in preventing SLPCM from leakage with a very low content. Graphene oxide and graphene were used to polymerize with poly(hexadecyl acrylate) to fabricate form-stable phase change materials(FSPCM) through free-radical polymerization, atom transfer radical polymerization and Diels-Alder reaction. In addition, Thermo-regulated fiber was melt-spun using poly(hexadecyl acrylate)-co-graphene as core and modified polyester as sheath. The structure and properties of the resultant and fibers were investigated. FSPCM and thermo-regulated fibers with high performance properties were fabricated. They are very promise in energy storage materials and smart textiles.

INVITED LECTURE

Investigation on Thermal Comfort Property of Medical Protective Clothing

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1. Soochow University
2. Honeywell Security (China) Ltd.

Medical protective clothing is widely used in public health rescue. The protective properties are given in related standards, however thermal comfort property is not well considered. In this study, thermal comfort properties of medical protective clothing were systematically investigated in three levels, i.e., bench scale material test, garment test and human trial test. The water vapor transmission rate (WVTR), thermal insulation (Rct) and evaporative resistance (Ret) of medical protective material were measured. The thermal insulation and evaporative resistance of medical protective clothing were tested using sweating thermal manikin. The core temperature, skin temperature, skin wettness, heart rate, subjective thermal sensation were recorded during human trial tests in 26°C, 50%RH condition. The results showed that WVTR and Ret showed good agreement and the material property was in consistent with that of garment. Moreover, the Ret contributed to the differences in physiological responses. The research findings indicated that Ret of medical protective material and clothing can be used to assess thermal comfort property.

INVITED LECTURE

Developmental methods to evaluate the antimicrobial efficacy of surfaces and textiles

Guoyi Wu
Shanghai Public Health Clinical Center

The COVID-19 pandemic has created awareness toward ensuring best practices to avoid the spread of microorganisms. Antimicrobial surfaces and textiles are already available and offer a broad spectrum antimicrobial activities targeting different type of pathogens through multiple pathways. Currently, there are ranges of standardised methods available for antibacterial surfaces and textiles efficacy testing, but these methods may be inappropriate to test antimicrobial surfaces due to artificial experimental conditions including temperatures, humidity, the formation of microbe containing liquids, and the presentation of microorganisms to surfaces and textiles. By reviewing the current standards and literature reports, we found that there is a huge gap between the testing needs and available testing services. Thus, it is worthwhile proceeding to further develop testing methods to fully explore the potential activity of the antimicrobial materials. This could be done either by modifying the standard testing methods or by designing in-use evaluation (field studies). We suggest that assessment techniques of antimicrobial materials must be adapted to the issues arising in real life situations and important application in clinical settings.

INVITED LECTURE

Bioactive performance of lignin and its potential applications

Piming Ma、Weijun Yang
Jiangnan University

In this work, a variety of factors have been found to affect the antioxidant and antimicrobial properties of lignin: origin of the extracted lignin, particle size, shape, surface chemistry, charge, type of tested microorganisms. Due to this specific activity, lignin can be applied to stabilize food and feedstuff, commodity products with antioxidant or antimicrobial properties (sunscreen lotions, biocomposites and textiles etc.) The aim of this work is to present the most relevant and current research concerning the bioactive performance of lignin, as well as lignin based materials as a function of lignin key main parameters. The most relevant applications of the bioactive performance of lignin both at nano-scale will be highlighted, by considering their response when included in different polymeric matrices: their role in the antioxidant, antimicrobial, antiviral overall performance of produced materials will be extensively elucidated, underlining their determinant influence in different application sectors such as bio-medical, food packaging and cosmetics.

INVITED LECTURE

Fiber-based materials and its application in biosensing

Dong Wang
Wuhan Textile University

The portable, fast and accurate fiber-based biosensors show great prospects in disease prevention, environmental monitoring and food safety. At present, the detection methods of biomarkers can be divided into four types, including the capillary electrophoresis, chromatographic analysis, optical analysis and electrochemical analysis. Among them, the optical colorimetric methods, such as fiber-based colorimetric cards, were attractive due to their short detection time, small sample usage, high selectivity, and portability. While, the electrochemical analysis methods, especially the fiber-based organic electrochemical transistors (FOECTs), also showed great application potential for their intrinsic signal amplification capacity, excellent the sensitivity, and feasibility in integration and miniaturization. This report systematically studied the influence of the electrode geometry, conductive polymer morphology and thickness on the device limit of detection (LOD), sensitivity, anti-interference and response time. Meanwhile, the weaving integration process and practice applications of FOECT-based biosensors (FOECTS) were also explored. The results indicated that the FOECTS can be applied in biomonitoring of glucose, dopamine (DA), C-reactive protein etc.. The device LOD was lower to 1 nM with a response time of ~0.5 s. Further study showed that the results of laboratory sample were consistent with actual biochemical sample. In addition, this report introduced the preparation method of a surface functionalized bacteria detection nanofiber membrane and its rapid and visual detection of Escherichia coli and Staphylococcus aureus. The results manifested that the multifunctional nanofiber-based colorimetric card showed high detection efficiency and low threshold. The visual observation to the concentration of Staphylococcus aureus could reach up to $10^{2} \sim 10^{6}$ CFU/mL.

INVITED LECTURE

Study on enhancing drug loading and antibacterial per formance of algal based medical film by the united dou ble network structure

Hong Zhang、Ming Yan、Junfeng Shi
Dalian Polytechnic University

Sodium alginate (SA) and carboxymethyl chitosan (CMCS) have been widely used in the field of biomedicine because of their good biocompatibility, easy degradation and rich sources. However, the poor mechanical properties and functional deficiencies limit their application. In order to integrate the excellent performance of SA and CMCS and further improve the mechanical properties, the united double network film with dynamically united double network structure were prepared from SA, CMCS, Starch and dopamine (DA) using Michael addition and Schiff base reaction. The film had the best comprehensive performance when the content of CMCS, SA-polydopamine (PDA), Oxidized starch (OXS) and DA were 1.6%, 2%, 0.08% and 0.75%, respectively. At the same time, the water absorption rate of the film was 726%, the contact angle was 43.8°, the maximum swelling rate was 1452%, the water vapor transmittance was 953.05 g·m-2·d-1, the tensile strength was 91.92Mpa, the elongation at break was 2.55%, and the degradation rate was 11.05%. The drug-loaded hydrogel film was prepared with ciprofloxacin as the simulated drug and the hydrogel dressing loaded with silver was prepared by using the reducibility and metal chelation of PDA. The feasibility of the united double network film for drug carrier and medical dressing was preliminarily discussed. The film had excellent sustained release performance and pH sensitivity, and had obvious inhibitory effect on the growth of Escherichia coli and Staphylococcus aureus.

INVITED LECTURE

Organic Dye-based Assemblies for Enhanced Cancer Therapy

Meizhen Yin
Beijing University of Chemical Technology

Phototheranostics exhibits great potential for fighting with cancer,[1] but still suffers from insufficient stability, nonspecific photosensitivity, and poor penetration of organic photosensitizer. With the development of dye aggregate science, the construction of dye self-assembly provides new ideas for these problems.
The core-expanded water-soluble quaterrylenediimide (QDI) can self-assemble into nanoparticles (QDI-NPs) in aqueous solution by π-π interaction and hydrophobicity. The assembled QDI-NPs exhibit excellent stability and high photothermal conversion efficiency (up to 64.7%), realizing photothermal ablation of tumor. Besides, the ultra-small size (ca. 10 nm) of QDI-NPs enables sustained retention in deep tumor sites and proper clearance from the body.
Organic dye-based aggregates provide controllable size and photophysical properties. Self-assembly of a multi-functional indocyanine (ICy5) dye showed “aggregate enhanced photodynamic effect” with 10-folds enhancement of singlet oxygen yield. Upon stimuli, the sizes of ICy5 assemblies reduced, which facilitates deep tumor penetration of the agents,exhibiting enhanced cancer therapy.
Our work confirm facile and effective self-assembly strategies to construct organic nanoagents with enhanced cancer phototheranostic effects.

ORAL PRESENTATION

Synthetic Fibers for Medical Protection

Lifei Wei、Dan Hao、Chenying Sun
Shanghai Different Chemical Fiber Co., Ltd

Medical protective fiber is a kind of functional fiber used for diagnosis, medical treatment, repair or replacement of diseased tissues and organs of organisms or the enhancement of their functions. It can be divided into natural medical protective fiber (Cellulose, chitin, collagen and silk) and synthetic medical protective fiber (Polyester, polyamide, polyolefin and polyacrylonitrile). With the rapid development of the global medical protective materials, the market share of medical protective fiber and its products increase continuously, while the research and development of medical protective fibers is also facing higher requirements. This presentation will introduce in detail the relevant medical protective fibers and products produced by Shanghai Different Chemical Fiber Co., Ltd, including antibacterial fiber, minus ion fiber, Lyocell Bamboo fiber and polylactic acid fiber. What is more, the challenges and suggestions of the current synthetic medical protective fiber are also proposed.

n and properties of polyester/silica/tea active ingredient fiber

Shan Chi、Xiaohua Huang、Yanming Liu
Bestee Material (Qingdao) Co., Ltd.

In recent years, the concept of green health and environmental protection and the requirements of safe and comfortable textiles are rising. In order to solve the problem of carbonization and deactivation of natural active ingredients due to high temperature in the production process of polyester fiber, the Molecular Nest technology is adopted to protect the active ingredients of tea. The polyester fiber modified by tea active ingredient was prepared and named as polyester/silica/tea active ingredient fiber (PET/SiO2/T) with good antibacterial, antiviral and antioxidant function. The properties of fibers were studied by SEM, TEM, BET, HPLC, mechanical property, antibacterial and antiviral detection. The results showed that Laoshan green tea (picked in summer) contained high quality catechin. The loading capacity of mesoporous SiO2 particles to active substances reached 60.7%. Molecular Nests are distributed in PET/SiO2/T fibers, and the particle size is about 100 nm. The breaking strength of PET/SiO2/T fiber was 3.36 cN/dtex, the total content of catechin was 5.17 mg/kg, the antibacterial rate was more than 91%, the antiviral rate was 99.51%, and the antioxidant free radical scavenging rate was 80.79%, which were significantly better than other control polyester fibers ($P<0.01$).

ORAL PRESENTATION

Solution Blow Spun Fibers for Personal and Environmental Protection Applications

Chao Jia
Donghua University

Since the development in 2009, solution blow spinning has received widespread attention and has become an efficient and versatile tool for fabricating various ultrafine fiber materials with controlled microstructures and morphologies. Compared with other spinning methods, solution blow spinning has many advantages, including simple and safe process, high efficiency, suitability for a wider range of solution systems, controllability of fiber structure and diameter, etc. We developed a variety of polymer fibers and flexible ceramic fibers using solution blow spinning method, and explored the applications of these fiber materials in the fields of personal and environmental protection, including air filtration, water treatment, sound absorption and thermal protection.

Benign Synthesis of MOFs/Fiber for Ammonia Capture and Catalytic Hydrolysis of an Organophosphorus Chemical

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The efficient uptake and/or catalytic degradation of toxic chemicals is needed to provide efficient protection for both individuals and the environment. Metal–organic frameworks (MOFs), with permanent porosities, ultra-high surfaces areas, and programmable chemical properties, are highly attractive porous materials for the capture and detoxification of toxic chemicals. Here we report Zn-Azolate MOFs, MFU-4, MFU-4l, and their fiber composites for ammonia capture and organophosphorus chemical hydrolysis. Firstly, MFU-4 shows outstanding performance in capturing NH_3 at low concentration (10.8 mmol/g at 0.05 bar) beyond large NH_3 uptake capacity at 1 bar (17.7 mmol/g). After integration MFU-4 onto textile fiber, the MFU-4/fiber composite demonstrates an even higher ability to capture NH3 due to the well-exposed MFU-4 particles. At the same time, after base treatment, MFU-4l yields MFU-4l-(OH), which exhibited high affinity for NH3 with a steep uptake at a lower pressure (0.1 bar) as compared to the parent material (0.22 bar). Besides, MFU-4l can hydrolyze an organophosphorus chemical with a half-life of 0.5 h using only 6 mol% catalyst in solid-state. Better catalytic performance is expected when MFU-4l is integrated onto fiber. More importantly, subsequent fiber composite of MFU-4 and MFU-4l are promising materials for use as protective layers in personal protective equipment (PPE). We anticipate that the integration of MOFs onto fiber will stimulate the further development of MOFs and facilitate their real-world application.

ORAL PRESENTATION

Peptide-Mimicking Poly(2-oxazoline)s Displaying Potent Antimicrobial Properties and Alleviating Antimicrobial Resistance

Min Zhou、Runhui Liu
East China University of Science and Technology

Peptides exert important biological functions but their application is hindered by their susceptibility to proteolysis and poor stability in *vivo*. We demonstrated here for the first time that poly(2-oxazoline) (POX) with biocompatibility and protease-resistance can work as a functional mimic of peptides. Taking host defense peptide (HDP) as the model peptide, we designed and synthesized the glycine-pendent POX (Gly-POX) that had potent activities against methicillin-resistant *S. aureus* (MRSA) *in vitro* and *in vivo*. *S. aureus* did not develop resistance to Gly-POX and Gly-POX-treated *S. aureus* is sensitive to common antibiotics, demonstrating no observable antimicrobial pressure or cross-resistance in using antimicrobial POX. Further, we studied the connection between side chain structure and antibacterial mechanism of peptide-mimicking poly(2-oxazoline), and found the antibacterial mechanism switching from DNA-targeting to membrane-targeting when we changed the glycine-pendent POX to the γ-aminobutyric acid (GABA)-pendent POX (GABA-POX). Our study highlights POX as a new type of functional mimic of peptides and opens new avenues in designing and exploring peptide mimetic for biological functions and applications.

POSTER PRESENTATION

Antibacterial plant essential oil regenerated cellulose fibers constructed by ionic liquid

Le Zhou[1,2]、Hongshuai Gao[1,2]、Xinxin Li[2]、Zhimin Zhao[1,2]、Yi Nie[1,2]、Suojiang Zhang[1,2]
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The antibacterial and deodorizing textiles are welcomed and needed with the gradual increase of the attention to the impact of microbes on health and the awareness of health care.[1] Ionic liquid, as a new green solvent, has unique advantages in cellulose dissolution and regenerated cellulose fiber (RCF) manufacture. Besides, it has great potential in dissolving natural plant antibacterial agents due to its varieties of types and strong designability,[2] especially for plant essential oil (PEO). Thus, it provides a promising method for the preparation of antibacterial PEO RCF.

The aim of the present study was firstly to combine the PEO with RCF prepared in ionic liquid for fabricating various PEO composite RCF and to characterize their morphology, structure, mechanical properties, antibacterial activity, and stability. Five common kinds of PEO with good antibacterial effects were selected as antibacterial agents: thyme essential oil, melaleuca essential, oregano essential oil, cinnamon essential oil, and artemisia annua essential oil. Phosphate-based IL, an excellent solvent for cellulose dissolving and spinning process in our previous studies, [3-4] was chosen to dissolve cellulose and PEO simultaneously, and a series of PEO composite RCF with antibacterial rates over 95% were obtained.

To further improve the washing fastness and lasting antibacterial effect of antibacterial fiber, artemisia annua essential oil (A) was coated with microcapsules and spun with cellulose. The oil-water ratio and core-wall ratio in the preparation of microcapsules were optimized by suspension polymerization, the sphericity, symmetry, particle size is taken into consideration. The new process not only improved the stability of A but also improved the antibacterial activity of the fiber prepared with microencapsulation a lot after 30 standard washing, the antibacterial rates remained more than 90%.

Ultra-fast bacterial inactivation of Cu2O@HNTs nanohybrids with charge adsorption and physical piercing ability for medical protective fabrics

Yaping Wang、Hengxue Xiang、Jialiang Zhou、Meifang Zhu
Donghua University

Metals have been used for wound treatment and toxicity testing since ancient times. With the development of nanotechnology, metal oxides have been proven to have excellent sterilization and disinfection functions. However, The rapid bacterial inactivation efficiency and trapping physicochemical killing ability are not simultaneously demonstrated in the antibacterial nanohybrid. Here, we have developed a method for in-situ reduction of small-sized Cu2O particles on one-dimensional inorganic HNTs nanotubes. This resultant Cu2O@HNTs hybrids not only gives Cu2O excellent dispersibility, but also exerts the synergistic effect of the charge adsorption of metal oxides and the physical piercing effect of the small size of nanotubes. Furthermore, the release of Cu2+ from hybrids can damage cell membranes and denature proteins and DNA. Through this sterilization mechanism, Cu2O@HNTs can make the inactivation rate of Escherichia coli reach 94.5% within 2 minutes and complete inactivation within 10 minutes. This excellent sterilization mode makes Cu2O@HNTs exhibit excellent broad-spectrum antibacterial activity and inactivation efficiency, while shows weak cytotoxicity. Therefore, this hybrids has been applied to antibacterial fibers and fabrics. We believe that this excellent antibacterial hybrid can have exciting results at the critical time of the COVID-19 pandemic.

POSTER PRESENTATION

Antimicrobial Fibers and Textile based on Stereochemical Strategy

Xing Wang[1]、Jiangqi Xu[2]
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2. Beijing Technology and Business University

Cellulose textiles (CT) modified with antimicrobial activity have attracted much attention due to their versatile applications although there are still some problems associated with the conventional protocols, including the toxicity to organisms, unwanted resistance, and gradually increasing environmental pressure. Some commercial antibacterial textiles have been confirmed that they have a short-term impact on the microflora after the application. New type of antimicrobial cellulose designed with natural and safe strategy is desired. Herein, we report a borneol-grafted CT (BGCT) utilizing an advanced antimicrobial strategy of surface stereochemistry that mainly resist microbes' adhesion and growth. BGCT has strong and broad-spectrum antimicrobial adhesion activities against gram-positive bacteria (Staphylococcus aureus and Staphylococcus epidermidis), gram-negative bacteria (Escherichia coli and Pseudomonas aeruginosa) and fungi (Aspergillus niger and Mucor racemosus). Because of its unique antimicrobial mechanism, BGCT is harmless to normal skin flora. In addition, BGCT exhibits prominent durability of antimicrobial capability by bearing 50 times of accelerated laundering due to its high structural stability in pH 5-10. And, it causes no skin irritation. Therefore, this BGCT shows great potential for applications in the new generation of textiles and medical protection.

Study on the Synthesis of Isotope-labeled Deltamethrin-D5

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2. Shanghai Research Institute of Chemical Industry CO., LTD

A convenient synthetic route of deuterium-labeled deltamethrin-D_5 is described with high isotopic enrichment and excellent chemical purities using phenol-D_6 as labeled starting material. Phenol-D_6 reacted with sodium deuterium oxide using toluene as the solvent to obtain sodium phenolate-D_5. The 3-Phenoxy-benzaldehyde-D_5 was obtained by sodium phenolate-D_5 and 3-bromobenzaldehyde with CuCl as the catalytic through Ullmann Reaction. The phase transfer esterification reaction, which inorganic phase is sodium cyanide and deuterium oxide aqueous solution, taked 3-phenoxy-benzaldehyde-D_5 and 3-(2,2-dibromoethenyl)-2,2-dimethylcyclopropanecarbonyl chloride as raw material to get deltamethrin-D_5. The yield according to the phenol-D_6 was 25.54%. The structure and isotope-abundance were confirmed via 1H NMR and mass spectrometry. The prepared deltamethrin-D_5 can be used as internal standard reagent for the determination of residual pyrethroids of food.

INVITED LECTURE

Materials design accelerated by machine learning and first-principles computations

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Shanghai University

The materials design normally requires the exploration of large materials parameter spaces. It is, however, a formidable task for first-principles (FP) calculations and experiments to investigate extensively the enormous potential multi-component materials due to the limited cost and time. The data-driven approach provides an efficient and predictable tool to accelerate both computational and experimental materials search based on the machine learning (ML) of the complex composition/structure-property relationships. Perovskite-type oxide ABO_3 catalysts can be applied to prepare inexpensive, efficient, durable, and environmentally friendly electrochemical energy conversion devices. The numerous combinatorial site substitutions of perovskite oxides provide rich choices of candidates but pose a great challenge to examine all the possibilities both experimentally and computationally. Inspired by the data-driven materials design approach, we proposed a surface center-environment (SCE) feature model and developed FP based ML methods to predict the adsorption free energies of intermediate species (HO*, O*, and HOO*) on the surfaces of perovskite oxides and their overpotentials, critical to evaluating the catalytic performance of oxygen evolution reaction (OER). The SCE feature models contain the elementary properties of substitution elements and the structure information of the perovskite surfaces, demonstrated as an effective description of catalytic reactions on surface in ML models. The ML models predicted that the perovskite oxides adsorb the intermediate species most easily when B = Nb, Mo, Ta, W, and Os, and their overpotentials are low when B = Mn, Fe, Co, Ru, Rh, and Ir. This work demonstrated that the ML methods based on SCE features can be applied to describe surface chemical reactions and accelerate the screening for potential catalysts with target properties.

INVITED LECTURE

Ultraflexible Optoelectronics: From Microstructure Engineering to Wearable Applications

Xiaomin Xu
Tsinghua Shenzhen International Graduate School

Optical and electrical properties of organic and inorganic semiconducting materials are strongly determined by their microstructure. Consequently, the control and visualization of spatial structural variations are of paramount importance for applications in (opto)electronics. The realization of advanced optoelectronic functions, especially with a flexible device configuration, will ultimately benefit the Internet of Things (IoT) applications, which then requires an optimal combination of materials and devices at both microscopic and macroscopic levels.
Based on organic conjugated molecules, we firstly address fundamentals in mastering the assembly of molecules and discuss distinct charge transport regimes in relation to the different microstructure of organic thin films [1]. We will then highlight the combined lateral force microscopy (LFM) and transverse shear microscopy (TSM) techniques that allow microstructure visualization of synthesized two-dimensional materials, identifying grain boundaries, crystal orientation, and strain fields unambiguously in a high-throughput and nondestructive manner [2]. One-step closer to the application, we will demonstrate a design of ultraflexible optoelectronics featuring extreme mechanical compliance, high performance, and operational stability, allowed by the combined strategies of microstructure and device engineering [3,4].

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INVITED LECTURE

Fabrication of Flexible Bioderived Carbon Composite Films Based on the Hydrolysate of Waste Leather Scrap for Electromagnetic Shielding

Dangge Gao、Shihao Guo、Yingying Zhou、Bin Lyu、Ping Zhao、Jianzhong Ma
Shaanxi University of Science & Technology

Bioderived carbon composite films with electromagnetic shielding were prepared from hydrolysate of waste leather scrap, polyacrylonitrile and metal organic frame by electrospinning and high temperature carbonization method. The Transmission Electron Microscope and Energy Dispersive Spectroscopy results showed that cobalt nanoparticles was coated in carbon fiber to form the nuclear shell, when the thickness of the composite film was 50 μm, the electromagnetic shielding efficiency could reach 19 dB in the X-band. With the increased of the stack layer, the electromagnetic shielding efficiency gradually improved. When the five pieces of films were stacked, the electromagnetic shielding efficiency could reach 49 dB and the absorption loss was 41 dB, which proved that the loss mechanism of electromagnetic wave was mainly absorbed and able to avoid secondary pollution. The incident radiation arrived at 99.999%. High-performance and lightweight flexible electromagnetic shielding films not only show a prospect of protecting human health from electromagnetic radiation, but also provide new ways for utilizing leather solid waste.

INVITED LECTURE

Topological Hybrid Fibrous Membrane Mediates Tissue Regeneration

Jidong Li、Shue Jin、Renli Yang、Chen Hu、Yi Man、Yi Zuo、Yubao Li
Sichuan University

The strategies involving biological factors such as cells, growth and differentiation factors, and adhesion molecules have been widely studied and applied. Recently, however, some researchers suggest that physical stimulation therapy without delivering cells or biological factors is also considered possible to promote endogenous healing[1]. Physical stimuli are even considered the “fourth element”of tissue engineering, arousing more attention. In this study, we constructed fibrous membranes with different surface topologies (Random, Aligned, Latticed) through electrospinning. The bone formation performance was evaluated by critical-sized defect models, and the material structure-biological signal transduction mechanism of the topological structured fibrous membrane-mediated bone regeneration was analyzed and verified[2]. Finally, we expanded the study of the mechanism of topological structure cues of fibrous membranes in regulating the behavior of immune cells in soft tissue repair. Transcriptome sequencing results showed that the Latticed membrane mainly regulated bone regeneration through vascularization and HIF-1α signaling pathway-related genes. The results of the skin repair model suggested that the immune microenvironment around the Aligned membrane was more conducive to soft tissue repair. Our research showed that by manipulating the surface micro-nano structure of the implanted material, the material-cell interaction could be adjusted to mediate hard-soft tissue regeneration, especially monocyte/macrophage-mediated vascularization and immune response, which provied a basis for the design of surface topological structure for hard-soft tissue regeneration biomaterials.

Figure 1. a) Schematic diagram of the topological structured fibrous membranes mediating bone regeneration; b) the immune microenvironment around the Aligned topological structured fibrous membrane.

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INVITED LECTURE

Modeling Electrostatic Interactions in Ionic Polymeric Soft-condensed Systems

Xiaozheng Duan
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Ionic polymeric systems are ubiquitous in natural and man-made materials; however, modeling the complex feature of electrostatic interactions in such systems remains significantly challenging. In our work, we develop novel, low-scaling Monte Carlo (MC) and Molecular Dynamics (MD) simulation algorithms that can account for the multi-body correlations between ion-ion, ion-dipole, and dipole-dipole interactions [1-3]. Using these methods, we focus on some typical ionic polymeric soft-condensed systems and perform in-depth and systematic simulation studies. We clarify the microscopic mechanism and regulation principle for several representative physicochemical phenomena of ionic polymers, such as the noise of ionic current in nanopore technology for detecting ionic polymers, the assembly of ionomer proton exchange membrane, the complexation between polyelectrolytes and ionomers in aqueous solution, and the phase transition of polymer/ionic liquid mixtures, etc [3-7]. Our work can shed light on the fundamental understanding of ion-containing polymers, and provide insights into the design and fabrication of functional materials.

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INVITED LECTURE

Filexible and High-Sensible Perovskite@Wool Keratin Piezoelectric Film for Human Monitoring

Bin Lv、Yingying Zhou 、Dangge Gao、Chi Zheng、Shihao Guo、Jianzhong Ma
Shaanxi University of Science & Technology

Halide perovskite with excellent piezoelectric properties and low-temperature processing may be suitable for portable medical devices, but its stability is the important factor restricting its development. Herein, the high-stable wool keratin-cesium lead bromide perovskite was prepared using wool keratin by interfacial passivation. Then nanofiber films with piezoelectric were fabricated with wool keratin-cesium lead bromide perovskit and polyacrylonitrile by electrospinning. The Scanning Electron Microscope and Energy Dispersive Spectroscopy results showed that wool keratin-cesium lead bromide perovskite was uniformly distributed in polyacrylonitrile. The nanofiber film could produce ~2.5 V open circuit voltage and ~16 nA short circuit current per square centimeter, and the output characteristics was not discernible diminishment even after 1000 cycles. Remarkably, the nanofiber film exhibited a rapid response time of 93 ms. The piezoelectric nanofiber films could be used for the detection of human physiological signals.

INVITED LECTURE

Cellular Respiration Inspired Multifunctional Seawater Battery Based on Prussian Blue

Ming Hu
East China Normal University

Intelligent supply of power via cellular respiration is an ability of organism to adapt to environment by providing various modes with different power output. It is quite interesting to mimic this intelligent system to make our energy supply system to adapt to various environments and dynamic requests. We demonstrated that using Prussian blue could mimic this process by simultaneous reacting with dissolved-oxygen and alkali ions in seawater. The electrochemical device assembled with these coordination frameworks delivered power by using the dissolved-oxygen or through accommodation of the abundant alkali ions in the seawater. The reaction pathways were automatically switched between a low-power output mode (dissolved-oxygen route) and a high-power output mode (alkali-metal ions way). We showed that this device simultaneously had theoretical large energy density (3960 Wh/kg) and high-ower density (103 mW/cm2) with exceptional stability. The device could be more adapt to the dynamic ocean environment by generating porous seawater or growing Prussian blue on carbon felt.

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INVITED LECTURE

Swelling Dynamics of a Disk-Shaped Gel

Xingkun Man
Beihang University

In this talk, I will mainly introduce our recent work about gel dynamics by using Onsager variational principle theory. When a gel absorbs solvent from surrounding, stress field is created in the gel, and this causes complex dynamics of the swelling behavior. We study this effect for disk-shaped gel by rigorously solving the diffusio-mechanical coupling equation. We show that (a) while the macroscopic thickness and the radius of the gel increases monotonically in time, the gel is compressed near the mid-plane, and that (b) while the swelling time depends on the shear modulus of the gel, its dependence is weak, this time is mainly determined by the friction constant of the gel network and the osmotic bulk modulus of the gel. We also show that these characteristic features are reproduced accurately by a simple analytical calculation for the gel deformation.

INVITED LECTURE

Mechanisms of Controllable Growth and Etching of Two-Dimensional Materials

Liang Ma
Southeast University

Two-dimensional (2D) materials expose many charming properties, however, their real applications are usually limited by certain shortcomings. For example, graphene has ultra-high carrier mobility, but its zero bandgap characteristic leads to a poor on/off ratio that severely limits its application in microelectronic devices. Cutting graphene into one-dimensional nanoribbons not only can open a moderate band gap but also introduce novel physical properties. Besides, the properties and performances of 2D materials have been proved to be very sensitive to the subtle change of atomic structures. Therefore, achieving the precise control of atomic structures and the efficient modulation of properties at the nanoscale is very important for both the fundamental research and commercial application of 2D materials. However, the growth and etching of 2D materials involve multiple atomic species and complex interface interaction, resulting in poor controllability and consequently the great challenges for the precise control over the morphology, size, and layer thickness. Aiming at how to realize the controllable and scalable synthesis of large-area, high-quality two-dimensional materials and the on-demand regulation of structures/defects, we have conducted in-depth research, by the advanced simulation methods, on the growth/etching mechanism of 2D materials and their nanostructures at the atomic scale. We proposed several strategies to synthesis the nanostructures of the 2D material by cutting carbon nanotubes, etching graphene and hexagonal boron nitride (*h*-BN), and demonstrated the atomic mechanism for the surface step guided unidirectional growth of wafer-scale molybdenum disulfide (MoS_2) single crystals on sapphire, some of which have been confirmed in experiments.

INVITED LECTURE

Phase Transitions in Materials Under Terahertz Light

Jian Zhou
Xi'an Jiaotong University

Two-dimensional materials have shown tremendous interesting features with large surface area to volume ratio. Hence, they are optically addressable and accessible. In this talk, I will discuss some recent theoretical predictions from our group, focusing on 2D material's optical nonlinear responses, including their geometric phase transition and electronic responses. One famous 2D material example is monolayer transition metal dichalcogenide which exists in both 2H and 1T′ phases. Non-contacting optical readout/write with focused laser would be preferable in many circumstances. We use first-principles density functional theory calculations to theoretically and computationally illustrate an optomechanical strategy to inducing geometric phase transitions, which uses a linearly polarized laser with selected frequency. I will discuss a few examples of such ultrafast diffusionless martensitic phase transition in various materials, focusing on terahertz frequency regime, which holds the essence of next generation communication technology. We predict that topological contrasting 2H and 1T' phases have big optical responses, hence, photons would apply different work done into the system. We then suggest that THz optics irradiation could trigger 2H → 1T' phase transition thermodynamically. This prediction agrees well with recent experimental observations. We also predict phase transitions for ferroelectric/ferroelastic group-IV monochalcogenide monolayers.

INVITED LECTURE

How polymer repeating units decide stress relaxation in bulk amorphous phase

Wenbing Hu
Nanjing University

I will present our recent dynamic Monte Carlo simulations of polymer stress relaxation in bulk amorphous phase. The local intrachain and interchain interactions in both thermodynamic and kientic means were introduced into our molecular modeling, which represented the structural features of polymer repeating untis. The comparison of their contributions in the diffusion barrier of stress relaxation demonstrated that the kinetic aspects of polymer local interactions dominate the stress relaxation of bulk amorphous polymers. The structure-property relationship will guide the structure design in the materials genome for the improvement of fiber performance.
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INVITED LECTURE

Polyhedral Vesicles and Polygonal Nanosheets from Solution-State Self-Assembly of Miktoarm Star Quaterpolymers: A Simulation Study

Baohui Li
Nankai University

Polyhedral vesicles and polygonal nanosheets are predicted from solution-state self-assembly of miktoarm star quaterpolymers with one solvophilic arm and three solvophobic arms using a simulated annealing technique. It is found that two factors, the three solvophobic-arm-length ratio and the strength of the incompatibility between any two of the three solvophobic arms, can signifantly affect the phase-separated structure and the morphology the assemblies, respectively. And the geometry shape of these assemblies is affected by the symmetry of the phase-separated structure. Specifically, polyhedral vesicles and polygonal nanosheets with phase-separated structures similar to that of the [8.8.4] and [10.6.4] tiling patterns are obtained, and the geometry shape a vesicle can be a cuboid, a cube, a cylinder, a triangular prism, a regular tetrahedron, a hexahedron and a regular octahedron, while the shape of a nanosheet can be a square, a rectangle, a regular triangle, an equilateral diamonds, a parallelogram and a regular hexagon. The mechanisms for forming these complex vesicles and nanosheets are illustrated. This study provides a model system to achieve geometrically challenging assemblies.

INVITED LECTURE

High performance e-skins with

Chuanfei Guo
Southern University of Science and Technology

An electronic skin (e-skin) can respond to applied pressure. Existing e-skins, however, often shows limited sensitivity and pressure resolution at elevated pressures, limiting their applications at high pressures. In this talk, I will introduce a strategy to engineer intrafillable microstructures that can significantly boost the sensitivity and pressure resolution while simultaneously broadening the pressure responding range. Such intrafillable microstructures feature undercuts and grooves that accommodate deformed surface microstructures, effectively enhancing the structural compressibility and the pressure-response range. Sensors with such microstructures present high pressure resolution (18 Pa) over a broad pressure regime (0.08 Pa-360 kPa). This talk will also introduce a skin-electrode interface for mechanosensing, being capable of feeling touch and detecting tiny physiological signals such as fingertip pulse under different skin hydration conditions.

INVITED LECTURE

Electrospun Ultrafine Phase Change Fibers (PCFs) for Thermal Energy Storage

Linge Wang
South China University of Technology

Over the last 30 years, phase change fibers (PCFs) have been extensively investigated and applied as high-performance nonwoven fabrics and coatings. As a prospective renewable and clean material, PCFs with micro-scale have been successfully prepared by melt/wet spinning for applications in thermal energy storage (TES) and temperature regulation. With the development of fiber manufacturing techniques, e.g. electrospinning, ultrafine PCFs have been exploited and investigated in the last decade. This work considers the state of investigations and developments in ultrafine (submicro-scale) PCFs by electrospinning technique since 2006. Electrospun ultrafine PCFs individually using long-chain aliphatic hydrocarbons (and paraffin waxes), polyethylene glycol, fatty acids (and their eutectics), and other solid-liquid phase change materials (PCMs) as latent heat storage (LHS) component are reviewed. The relationship between morphology, composition, and thermal properties are discussed for providing guidance for fabricating appropriate ultrafine PCFs with desired thermophysical properties for various applications. The further challenges and opportunities of electrospun ultrafine PCFs for TES and other applications are also discussed.

INVITED LECTURE

Nonclassical Ordered Nanostructures from Designed Block Copolymers

Weihua Li
Fudan University

The self-assembly of block copolymers provides a powerful platform for the fabrication of rich ordered nanostructures. From the aspect of practical applications, it is more useful to design block copolymers for desired ordered structures. In recent years, my group have been focusing on designing block copolymers to target some nonclassical ordered structures based on the calculations of self-consistent field theory (SCFT). The chain architecture of block copolymers with variable number of blocks and topology has been demonstrated as an important parameter controlling their self-assembly behaviors. Furthermore, blending different block copolymers together also offers an opportunity for stabilizing new phases. A number of useful principles have been established to guide the design of block copolymer systems. Accordingly, a multitude of novel/nonclassical ordered phases have been successfully predicted from these designed block copolymers. With AB-type block copolymers, complex high-coordinated spherical phases beyond the classical body-centered-cubic (bcc) phase (e.g. various Frank-Kasper phases) as well as low-coordinated discrete phases (e.g. diamond-like and simple cubic spherical phases, three- and four-coordinated cylindrical phases) are predicted. With ABC-type multiblock terpolymers, a large number of binary mesocrystal phases are predicted. Encouragingly, many predicted novel phases have been observed by experiment.

INVITED LECTURE

Reconciling the Three Major Contradictions Associated with Machine Learning in Materials Science by Incorporating Domain Knowledge

Siqi Shi
Shanghai University

The research and development of secondary batteries for electrochemical energy storage, represented by solid-state lithium and sodium batteries, are deeply integrating with technologies related to national urgent and long-term demand fields, such as big data, independent software development, and machine learning (ML). As one of the key tasks for building Global Energy Interconnection in China, they have gradually become a critical support for smart manufacturing and other strategies of strengthening the nation. Specially, ML has been widely employed in materials science in recent years, but there are still barriers between purely data-driven ML and physical/chemical theories-based materials science. Herein, by focusing on the three major contradictions ML faces in materials science, namely, between high dimension and small sample data, between model complexity and ease of usage or accuracy and between learning results and domain knowledge, we explore the strategies to reconcile the above contradictions with the incorporation of the domain knowledge: the multi-layer feature selection method, the divide and conquer ML modeling method and the interpretation method of ML results.

INVITED LECTURE

Coil–Globule Transition in Polymeric Solvents

Zhen-Gang Wang[2]、Yuci Xu[1]
1. Ningbo University
2. California Institute of Technology

We study the coil-to-globule (C–G) transition of a test polymer of chain length N_1 in a polymeric solvent of chain length N using self-consistent field theory (SCFT). For short-chain solvents, the C–G transition point is given by $\chi N - 1/2 \sim (pN)^{3/4} N_1^{-1/2}$, consistent with an extended Lifshitz theory, where $p = b^2/v_m^{2/3}$ is the stiffness parameter. However, for long-chain solvents, the C–G transition becomes strongly first order, with the transition point given by $\chi N - 1/2 \sim pNN_1^{-2/3}$. A scaling analysis suggests that the transition point for any chain length combination is a universal function of the scaling variable $x \equiv (pN)^{3/2} N_1$, which has the clear interpretation as the ratio between the pervaded volume of the solvent chain and the physical volume of the test chain, and that crossover between the two transition scenarios occurs at $x \sim 1$. Furthermore, when properly nondimensionalized, the density profile and center density of the globule at the transition also exhibit universal behavior.

INVITED LECTURE

Transport of nanoscale objects on cell membrane: from passive to active particles

Li-Tang Yan
Tsinghua University

Diffusion is the essential and fundamental means of transport of substances on cell membranes, and the dynamics of biomembranes plays a crucial role in the regulation of numerous cellular processes. The understanding of the complex mechanisms and nature of particle diffusion have a bearing on establishing guidelines for the design of efficient transport materials and unique therapeutic approaches. Herein, we report our recent advances in investigating diffusion dynamics of nanoscale objects on biological membranes, focusing on the approaches of tailored computer simulations and theoretical analysis. Due to the presence of the complicated and heterogeneous environment on native cell membranes, the diffusive transport behaviors of nanoparticles exhibit unique and variable characteristics. In particular, we introduce the general aspect and basic theories of the diffusion transport of various heterogeneous nanoparticles, including charged Janus nanoparticles, two-dimensional nanosheets, and active particles. Our findings might inform approaches to program transport of various nanomaterials at bio-nano interfaces, and suggest design principles for novel composite systems integrating such nanomaterials with biological membranes.

INVITED LECTURE

Li Metal Deposition and Stripping in A Solid-state Battery via Coble Creep

Yuming Chen
Fujian Normal University

Solid-state lithium metal batteries require accommodation of electrochemically generated mechanical stress inside the lithium: this stress can be up to 1 gigapascal for an overpotential of 135 millivolts. Maintaining the mechanical and electrochemical stability of the solid structure despite physical contact with moving corrosive lithium metal is a demanding requirement. Most previous studies concentrate on improving the solid electrolyte to solve these problems. In this talk, we will introduce a promising new strategy for creep-enabled 3D lithium metal battery, which focuses on the anode side by using 3D porous architectures made of electrochemically stable Mixed Li-ion and Electronic Conductor (MIEC) as Li metal hosts. First, we will describe how to use in situ TEM technique to study the deposition and stripping of metallic lithium or sodium held within a large number of parallel hollow tubules made of a MIEC. Next, in situ TEM characterizations and the theoretical analyses will be shown to demonstrate the Coble creep mechanism for the Li metal deposition and stripping in MIEC tubules. Finally, the performance of the full cell based on the 3D MIEC design will be also present.

INVITED LECTURE

A materials genome approach towards fast-screening of comonomers for PAN-based carbon fiber

Hongkang Zhou[1,2]、Xin Wang[1]、Hsing-Lin Wang[2]
1. Songshan Lake Materials Laboratory
2. Southern University of Science and Technology

Polyacrylonitrile (PAN)-based high performance carbon fibers (CFs) require sequential stabilization and carbonization of the precursor fiber to achieve high mechanical strength and modulus. Comonomers are introduced in the preparation of PAN precursor to give mild heat release during stabilization at a lower temperature. Judicious selection of comonomers among numerous polymerizable candidates for an effective and efficient stabilization remains a challenge, partially due to that the commercial formulations are often traded secret, but mostly because of the lack of systematic study of how comonomer impacts the thermal behavior during stabilization. The traditional single batch experiment approach has failed to screen promising comonomers at high efficiency. In this work, theoretical computation along with high-throughput experiments was used to accelerate the searching of new potential comonomers. The computation of the activation energy shows that the PAN copolymers comprising carboxylic acids, amides, and sulfonic acids have lower activation energy than that of PAN homopolymer. A series of target PAN copolymers involving the pre-screened comonomers were synthesized using a custom-made high-throughput polymerization platform, giving products with comonomer content of 1-5 wt.%. The temperature of initiation (Ti), the first peak temperature (Tp1), and the velocity of heat-releasing (ΔH/ΔT) of cyclization were evaluated. The copolymers with equivalent or smaller Ti, Tp1, and ΔH/ΔT than P(AN-co-IA) in cyclization were selected. Further thermal stability results suggest that certain copolymers with an amide structure are more stable after stabilization than those with carboxylic acids and sulfonic acids. In-situ infrared spectroscopy reveals that the amide-containing PAN copolymers have higher extent of cyclization than other types after stabilization. Finally, a promising comonomer N-vinyl formamide (NVF) which gives PAN copolymers with a low onset cyclization temperature (Ti) of 155.49 ℃ and high extent of stabilization (Es) of 94%, as well as provides high thermal stability to the stabilized PAN copolymer, was discovered.

INVITED LECTURE

Graphene and Boron Nitride Foams for Batteries and Composite Materials

Xuebin Wang
Nanjing University

High-surface-area cellular carbon monolith, instead of traditional Ni/Ti foams or carbon cloths, is desired as the optimal electrode in electrochemistry, owing to lightweight, high surface area, conductivity, and stability. 3D network can improve energy and power in both non-Faradaic and Faradaic processes. The ultimate version of porous carbons, when pore-wall thins down to mono/few-atomic layers, is conceptually 3D graphene. We have developed several new synthesis routes based on pyrolysis, for producing the advanced 3D graphenes. The routes include the tiering pyrolysis [1], the oxidation-aminolysis method [2], and the blowing route [3,4]. Our created 3D graphenes possess the excellent surface area, conductivity, and mechanics, which equip electrodes for high-energy-density and high-power-density electrochemical capacitor, lithium ion battery, and electrocatalysis [1-5]. Besides, the routes are also used to synthesize the foams of boron nitride nanosheets, which are applied to the insulting thermal conductive polymeric composite materials, sorption and separation [6,7].

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INVITED LECTURE

Big data analytics for intelligent manufacturing of fiber products

Junliang Wang[2]、Jie Zhang[1]、Chuqiao Xu[3]
1. Donghua University
2. Donghua University
3. Shanghai Jiao Tong University

With the development of the Internet of Things (IoT), 5G, and cloud computing technologies, the amount of data from fiber manufacturing systems has been increasing rapidly. With massive industrial data, achievements beyond expectations have been made in the product design, manufacturing, and maintenance process. Big data analytics (BDA) have been a core technology to empower intelligent manufacturing systems. This paper investigates the framework, development, key technologies, and applications of BDA for intelligent manufacturing systems of fiber products. In particular, the BDAs for fabric defect detection and operation optimization of yarn production systems are described. Finally, the challenges and opportunities for future research are discussed.

INVITED LECTURE

Improvements of force fields guided by machine learning methods

Qiang Zhu[1,2]、Hao Dong[2]、Jing Ma[1]
1. Key Laboratory of Mesoscopic Chemistry of Ministry of Education, Institute of Theoretical and Computational Chemistry
2. Kuang Yaming Honors School, Nanjing University, 210023, P. R. China;

Machine learning could learn rules from data and is drawing more and more attentions in many fields, ranging from computer science to chemistry. Molecular dynamics simulations are powerful tools in the drug design and biological systems. Different force fields have different parameters but share the common energy expression which is composed of bonded and non-bonded term. The non-bonded term could further be divided into electrostatic and van der Waals interactions. With the help of machine learning methods, we first analyzed 2-aminoethoxydiphenyl borate (2-APB), a broad-spectrum modulator for a number of membrane proteins, together with 54 analog structures with similar backbone, and found that delicate balance between entropy and polarity plays an important role in drugs' potency.[1] It gives a clue that the electrostatic interaction plays important roles when the drug permeates into the bilayer. As a results, we take the polarization effect into consideration implicitly or explicitly, the resulted log P values matched well with experimental ones. In addition, with the help of feature learning, we analyzed 75 organic liquid molecules which contain diverse chemical functional groups and found hydrogen bonding interactions, the number of atoms and rings play important roles in the property of viscosity.[2] These results guided us to optimize the van der Waals interaction. A great improvement was observed in the viscosity prediction for alcohols while we demonstrated it in the OPLS-AA force field.

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INVITED LECTURE

Design of high-performance composite matrix resin by a materials genome approach

Jiaping Lin
East China University of Science and Technology

Advanced resin matrix composites have the advantage of lightweight and have important applications in the aerospace industry. One of the keys to developing advanced resin matrix composites is to develop matrix resins with excellent comprehensive properties. Poly(silane arylacetylene) (PSA) resin is a new type of organic/inorganic hybrid heat-resistant resin, which has wide applications [1]. However, the traditional design strategies based on scientific intuition and trial-and-error experiments are bound by high costs and time-consuming synthetic procedures. Designing high-temperature polymers with excellent processability is a long-standing challenge because of the implacable contradiction between high thermal stability and low curing energy. Traditional designs based on scientific intuition and trial-and-error experiments have not been efficient strategies for discovering new heat-resistant resins.

In this report, we developed a materials genome approach (MGA) to facilitate the design of new heat-resistant resins with the desired properties[2-4]. By defining the gene and extracting key features for properties, we proposed a two-step strategy to screen candidate resins obtained from combinations of genes. A new kind of heat-resistant resin was predicted by rapid screening and was further verified by theoretical simulations and experimental studies. In addition, by using the developed MGA, an acetylene-terminated polyimide, named ATPI, was designed and synthesized to blend with PSA resins and improve the toughness of the thermosets. It was found that the blend resins with 30% ATPI exhibit excellent toughness and high temperature resistance. The molecular dynamics simulations were carried out to understand the mechanism behind the improvement of toughness. The basic framework developed for the present MGA can be generalized for the rapid design of other high-performance materials.

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INVITED LECTURE

Functional nanocellulose-based hybrids for multi-functional sensors and energy devices

Lumin Chen, Houyong Yu
Zhejiang Sci-Tech University

Artificial intelligence is leading the new trend of life, which makes people's research interest in the fields of sensing and energy continue to rise. However, the main challenges including sustainability, low cost, safety, flexibility, and high performance still need to be solved urgently. Nanocellulose with the advantages of inexpensive, renewability, biodegradability, and appealing physicochemical properties, which have been widely used in the areas of sensing and energy. We have prepared nanocellulose-based conductive hybrid materials with various structures (such as films, aerogels/hydrogels, and fibers) by combining with metal oxides (e.g., MnO_2) and conductive polymers (e.g., PPy and PANI), which successfully employed in high-performance supercapacitor and multi-functional sensor (e.g., gas, temperature, humidity, and pressure/strain). Recently, we even innovatively proposed to directly extract intrinsically conductive CNF from biomass by controlling the continuous reaction process and isolating oxygen, achieving a breakthrough from “0” to “1”, which shows great potential for energy storage and sensing applications.

INVITED LECTURE

Machine Learning Models for Material Design

Jing Ma
Nanjing University

The development of efficient models for predicting specific properties through machine learning is of great importance for the innovation of chemistry and material science. On basis of computational or experimental datasets, several machine learning algorithms, including the explainable models, deep learning, and on-line learning methods, have been employed to predict the molecular energies, forces, optical and electrical properties of materials. For instance, explainable ML models have been learnt to construct QSPR models for predicting binding energies of nitrogen molecules with various zeolites.1 To predict the electronic structure properties with DFT or CCSD(T) accuracy, we developed a multi-level attention neural network,2 named DeepMoleNet, to enable chemical interpretable insights being fused into multi-task learning through (1) weighting contributions from various atoms and (2) taking the atom-centered symmetry functions (ACSFs) as the teacher descriptor. The efficient prediction of 12 properties including dipole moment, HOMO, and Gibbs free energy within chemical accuracy is achieved by using multiple benchmarks, both at the equilibrium and non-equilibrium geometries, including up to 110,000 records of data in QM9; 400,000 records in MD17; and 280,000 records in ANI-1ccx for random split evaluation. The proposed multi-level attention neural network is also applicable to high-throughput screening of numerous nanoparticles with good generalizability.3 Energies with DFT accuracy are achievable for large sized nanoparticles from the learned correlations and scale functions for mapping different theoretical levels and particle sizes.

INVITED LECTURE

Efficient Screening and Design of Highly Active Electrode Materials Through Charge Transfer Capacity

Jianjun Liu
Shanghai Institute of Ceramics，Chinese Academy of Sciences

Establishing quantitative description for material composition-structure effect on property is a fundamental base for designing new materials and optimizing material performance, as well as an important part of materials genomic engineering. Charge transfer capacity defined as reaction thermodynamic change with charge transfer amount is an important character for electrochemical activity. In this talk, I will take several electrochemical materials in Li-O2 battery, Li-S battery, and Li-excessive cathode, and HER electrocatalysts as examples to exhibit new materials screening and traditional materials optimization through calculating charge transfer capacity. For reducing overpotential of Li-O2 battery, surface acidity (charge acceptance) was identified as an efficient descriptor to screen cathode. For solving the shuttling effect of Li-S battery, through calculating binding strength and surface electronegativity of cathodes, we established quantitative screening factor of cathodes according to difference of atomic electronegativities between cation and anion. These predicts are partially verified by our experiment and available data. Very recently, we extended this charge transfer concept to HER electrocatalyst and found regional charge transfer as an efficient descriptor of MoS2-like 2D materials, which also has been verified by experiment. Although charge transfer is found to be efficient in predicting electrochemical activity, charge transfer amount and structural/chemical stability must be balanced to search high-performance electrochemical materials in high activity and long cyclic life.

POSTER PRESENTATION

3D-Printed Strong Hybrid Materials with Low Shrinkage for Dental Restoration

Menglu Zhao、Suna Fan、Xiang Yao、Meifang Zhu、Yaopeng Zhang
College of Materials Science and Engineering, Donghua University

Flowable photocurable resins can be printed effectively by stereolithographic 3D printing for dental applications; however, the 3D-printed objects' mechanical properties cannot meet the requirements for the dental restorative materials. In this study, a strong customized crown for tooth repair was first prepared via direct ink writing 3D printing from a high-viscosity hybrid paste of acrylic monomer and multi-scale inorganic particles. The results showed that the hybrid resin-based composites (RBCs) could be printed successfully and smoothly through a metal nozzle with a gradually shrinking channel. The theoretical simulation of finite element methods was consistent with the experiment results. The printed objects were preliminarily cured incrementally and exhibited a low shrinkage ratio of only 2.58±0.11%. The printed samples with criss-crossed layers by interrupting crack propagation exhibited superior mechanical properties (a flexural strength of 120.8±4.1 MPa and a compressive strength of 323.6±5.6 MPa) than their traditional molding counterparts. Since the deposited layers exhibited improved resistance to bending forces, the flexural strength of the sample with a print orientation in adjacent layers (45–135°) even reached 145.5±8.7 MPa. The RBCs were successfully used to print strong, high-performance and biocompatibility dental crowns, expected to provide a customized component for the clinical restoration of teeth.

INVITED LECTURE

From Single Molecule to MUSIC

Zhen Li
Wuhan University
Tianjin University

Organic opto-electronic materials play the key role in every aspect of modern life and high-tech fields, including organic light emitting diodes, sensors, anti-counterfeiting labeling for advanced data security, biological imaging, and so on. In these applications, the macroscopic performance of molecular aggregates is not just the simple overlay of single molecules, and in many cases, new properties can be created by molecular uniting with particular packing modes, which are mainly determined by the molecular structures of organic compounds. The research on the relationship among molecular structures, packing modes and opto-electronic properties is essential, and a thorough analysis of the overall picture that provides the prospective in mesoscale materials science is urgently needed. In this talk, some typical examples will be presented to partially demonstrate the interesting different properties with minor or even ignorable structural modification, the adjustment of molecular packing will be discussed in detail, including the internal mechanism, main effective factors, control methods, and preferred modes, with the aim to afford the guideline to the molecular design of opto-electronic materials, and promote their development from the internal to external.

INVITED LECTURE

AIE polymer

Anjun Qin[1]、Ben Zhong Tang[2]
1. South China University of Technology
2. The Chinese University of Hong Kong, Shenzhen

Aggregation-induced emission (AIE), conceptually coined by Tang et al. in 2001, refers to a unique phenomenon that a kind of weakly or non-emissive luminogens in solution are induced to emit intensely in the aggregate and solid states. Currently, hundreds of low-mass AIE luminogens (AIEgens) have been reported and well-applied. However, the luminogenic polymers with AIE characteristics, i.e. AIE-active polymers, which inherently possess good film-forming ability and amplification effect in sensing, have paid little attention.
In this talk, I will first present our recent efforts on preparing AIE-active polymers by our developed alkyne-based click polymerizations, such as Cu(I)-catalyzed azide-alkyne click polymerization, spontaneous amino-yne click polymerization. Then, the unique properties and potential applications of resultant polymers, such as photo-cross-linked and fluorescent patterns, and sensitive detection of explosives, as well as the advantages of them over low-mass AIEgens and conventional polymers will also be discussed.

INVITED LECTURE

AIE-type metal nanoclusters: directed self-assembly for controlled emission

Zhennan Wu
Jilin University

Luminescent metal (Au, Ag, and Cu) NCs, as the novel fluorophores, are an appealing alternative to traditional dyes and semiconductor quantum dots (QDs) with the combined consideration of their high renal clearance, ultrafine size, low toxicity, excellent photostability, and large Stokes shift. However, the emission origin of NCs remains an open problem because of their unknown interfacial structures, lack of periodic NCs as the model to reveal the relationship between the emission properties and structures, etc. Giving the credit to great efforts devoted to pursuing the origin of emission over the past decades, various emission models of metal NCs are established with continuous improvement. It has now well-recognized that one possible emission mechanism lies on the aggregation-induced emission (AIE), which is originally discovered by Tang's group in 2001 and is successfully extended by Xie's group in 2012 to allow the formation of ultrabright Au(0)@Au(I)-SR (SR: deprotonated thiol ligands) core-shell NCs. Thereafter, the development of brighter AIE-type metal NCs comes to its prosperity both in the correlated fundamentals and practical applications. Here, the colloidal self-assembly of metal NCs and the correlative implications on their luminescence, as well as the personal perspective on the AIE-type metal NCs will be presented.

INVITED LECTURE

NIR Emissive Cyanostilbene Derivatives for Biological Applications

Wenjing Tian、Lingchen Meng、Bin Xu
Jilin University

Fluorescence imaging with the advantages of noninvasive, high sensitivity, and low-cost plays an important key role in bioimaging field. Organic dyes are one kind of good exogenous contrast agents for fluorescence bioimaging due to their excellent biocompatibility and multifunctionality. But most conventional organic dyes have the problem of photobleaching and aggregation caused quenching (ACQ). Different from ACQ fluorescent dyes, a novel kind of aggregation-induced emission fluorogens (AIEgens) which were developed by Tang and co-workers in 2001, are weakly or nonemissive when molecules are uniformly dispersed in solution but have strong emission when forming aggregates. The fluorescence intensity of AIEgens can be prominent enhanced by increasing the concentration of fluorescent molecules inside, which is beneficial for improving the signal-to-noise ratio, photosensitivity, spatial resolution of imaging and resistance to photobleaching. Near infrared (NIR) dyes with emission spectra within the “optical window” of biological tissues (i.e., 650–900 nm) can efficiently reduce the interference from tissue autofluorescence can also provide deep imaging/sensing penetration depth due to the reduced optical attenuation of biological tissues in the NIR wavelength range.
Herein, by using cyanostilbene-π-triphenylamine as the core, a series of donor-acceptor (D-A) cyanostyrene derivatives are designed and synthesized. Through the single-molecule water-soluble modification and nanoparticles fabrication, we applied these cyanostyrene derivatives in specific imaging of cell microenvironment and fluorescence and multimodal imaging in vivo.

INVITED LECTURE

High Performance AIE Photosensitizers Nanoparticles for Biomedical Application

Wenbo Wu
Tianjin University

Photodynamic therapy (PDT), which relies on photosensitizers (PS) and light to generate reactive oxygen species (ROS) to kill cancer cells or bacteria, has attracted much attention in recent years. PSs with both bright emission and efficient singlet oxygen generation have also been used for image-guided PDT. The PSs with aggregation-induced emission (AIE) were firstly reported in 2014, which has been confirmed to offer both high fluorescence and ROS production efficiency in the aggregated state in physiological environment shortly after that. Several years before, the AIE PS based NPs, which were usually prepared by encapsulation PSs into amphiphilic polymer matrix, were invented for further endowing the PSs with passive targeting effect to tumor sites by the enhanced permeability and retention effect. Herein, we would like to discuss about our recently work on the design, preparation, as well as biomedical application of AIE PS NPs, including how to design high performance AIE PSs, and how to modify the components of AIE PS NPs to further endow them other properties for different biomedical application.

INVITED LECTURE

High performance nano-splitters containing AIE luminogens for stereoselective crystallization obtained via polymerization-induced self-assembly

Xinhua Wan、Bowen Li、Na Li 、Zhaoxu Wang 、Xichong Ye、Jie Zhang
College of Chemistry & Molecular Engineering, Peking University

With the development of modern pharmacy, people have been aware that two enantiomers may have totally different effects in vivo: one could be effective component while the other less effective or even toxic. Not only from the respect of practical applications, but also the necessity for thorough understanding the pharmacology and pharmacokinetics of two enantiomers, it is highly desired to seek efficient methods to obtain enantiopure compounds. Regardless of the great advances in asymmetric synthesis, the majority of chiral drugs and their intermediates are obtained by chiral resolution of racemates because of low cost, easy operation, and high reliability for mass production. Stereoselective crystallization is among the most convenient and economical chiral resolution methods to obtain enantiopure compounds in large scale.[1] For conglomerate-forming racemic compounds, preferential and reverse crystallization have been developed to obtain one enantiomorph from a pair of enantiomers.[2] Limited by the nature of kinetic resolution in crystallization, only one enantiomer can be obtained in a single unit operation and the yield is usually quite low (<20%). “Viedma ripening” can provide enantiopure compounds with nearly 100% yield merely by grinding, but only works for the substrates that can be racemized spontaneously under crystallization conditions. Collecting both enantiomorphs with high optical purity and yield in a single crystallization process can be achieved by adding aggregated polymeric “tailor-made” additives, known as nano-splitters.[3-5] Inefficient preparation and large addition amount have hindered the practical application of such amazing nano particles. Herein, we report the first nano-splitters containing aggregation induced emission luminogens (AIEgens) prepared via polymerization-induced self-assembly of block copolymer, poly[(S)-2-(tert-butoxycarbonylamino)-6-(methacrylamido)hexanoic acid]-b-polystyrene, followed by the removal of BOC groups. When added into the supersaturated solution of racemic amino acids (a.a.) with seeds, the fluorescent labeled nano-assemblies enantioselectively dyed the crystals of S-a.a. and enabled the separation from colorless R-a.a. crystals in terms of fluorescent difference. Both enantiomers were obtained with high optical purity and yield (e.g., R-Asn·H2O, >99 ee%; S-Asn·H2O, ~94 ee%; 88% total yield). Owing to a low detection limit of fluorescence, the addition amount was reduced to 0.03 wt% without remarkably compromising the ee values of both enantiomorphs. Combining with low addition amount and efficient synthesis, the output-input ratio can be increased greatly. The financial supports from the National Natural Science Foundation of China are greatly appreciated (51833001 and 21674002).

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INVITED LECTURE

NIR-II AIEgen

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NIR-II AIEgen
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The fluorophores emitting within the second near-infrared window (NIR-II, 1000–1700 nm) explicitly show the salient advantages of deeper tissue penetration, higher spatial resolution and better signal-to-background ratio, owing to reduced light scattering and autofluorescence in tissues at longer wavelengths. Therefore, NIR-II fluorescence imaging holds great promise for an accurate diagnosis of deep tissues. However, the low fluorescence quantum yield hinders the further development of this filed. To address this issue, the present study reports the molecular design strategy of highly bright fluorophores with typical aggregation-induced emission (AIE) attributes, which realizes high-quality imaging of deep tissues1,2.
Keywords: aggregation-induced emission, NIR-II, fluorescence imaging
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INVITED LECTURE

Multifunctional Molecular Probes for Unimolecular Cancer Theranostics

Liang Luo
Huazhong University of Science and Technology

In this presentation I will introduce an ultra-efficient photodynamic theranostics platform based on a dual-functional photosensitizer that demonstrates exceptional photodynamic therapy (PDT) efficacy while simultaneously self-monitoring the therapeutic response in real time. Possessing an ultrahigh singlet oxygen quantum yield in water, the photosensitizer TPCI can efficiently induce cell death in a series of carcinoma cells. In addition, TPCI can self-monitor cell death in real time. It is weakly fluorescent in living cells before irradiation and lights up the nuclei concomitantly with cell death during PDT treatment by binding with chromatin to activate its aggregation-induced emission, attributed to its strong binding affinity with DNA. In vivo studies using mouse models bearing H22 and B16F10 tumor cells validate the ultra-efficient PDT efficacy of TPCI as well as the precise real-time noninvasive readout of the tumor response from the beginning of cancer treatment. This photodynamic theranostics platform represents a new paradigm for the development of self-reporting nanomedicine for future precise tumor therapy.

INVITED LECTURE

High-efficiency AIE-active Materials and Their Application in OLEDs

Ping Lu
State Key Laboratory of Supramolecular Structure and Materials, Department of Chemistry, Jilin University, Changchun, 130012

Pure blue luminogens that can be applied in high-efficiency nondoped blue organic light-emitting diodes (OLEDs) and act as main component to generate white OLEDs with high color rendering index (CRI) simultaneously are rarely reported. Herein, two blue emitters, TPAATPE and PPIATPE, consisting of triphenylamine/phenanthroimidazole and tetraphenylethene-substituted anthracene with asymmetric structures are designed and synthesized. The nondoped OLED using TPAATPE as the emitter exhibits pure blue emission with the maximum external quantum efficiency (EQE) of 6.97% and Commission International de L'Eclairage (CIE) coordinates of (0.15, 0.16). Employing TPAATPE as the blue-emitting component, combined with a thermally activated delayed fluorescent (TADF) molecule PTZMes2B, which is adopted as the green emitter and the host for phosphors, a series of highly efficient hybrid white OLEDs are successfully achieved. Two-color white OLED exhibits eye-friendly warm white light with the maximum forward-viewing EQE of 25.2% and the three-color white OLED achieves pure white emission with CIE coordinates of (0.34, 0.38), maximum forward-viewing EQE of 25.3% and ultrahigh CRI of 92. All of blue and white OLEDs exhibit small efficiency roll-offs and excellent color stabilities.

INVITED LECTURE

Synthesis and Bioimaging Application of Anion-π+ AIEgens

Jianguo Wang
University of InnerMongolia

Noncovalent interactions, such as hydrogen bonding, π-π stacking, CH-π and anion-π+/cation-π- interactions, play significant roles in broad areas such as supramolecular chemistry, structural biology and material science. They are crucial to maintain the structures of life-related biomacromolecules like proteins and DNA/RNA and also show an determinate effect on the structures and properties of materials. In addition, noncovalent interactions exert great influence on the emission behaviors of luminescent materials. Recently, we proposed a novel strategy for developing inherent-charged AIEgens by introducing anion-π+ interactions to block the detrimental π-π stacking. A serial of anion-π+ AIEgens were designed and synthesized by using this strategy, and they were successfully applied in pure organic room temperature phospherescence, single-molecule white light emission, 3D printing and photodynamic antibacterial.

Fig. 1 Apllication of anion-π+ AIEgens

keywords：anion-π+ interactions；AIEgens；photodynamic antibacterial

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INVITED LECTURE

Through-Space Interactions in Clusteroluminescence

Haoke Zhang[1]、Ben Zhong Tang[2]
1. Zhejiang University
2. The Chinese University of Hong Kong (Shenzhen)

Apart from the traditional through-bond conjugation (TBC), through-space interactions (TSI) are gradually proved as another important interaction in photophysical processes, especially for the recent observation of clusteroluminescence from nonconjugated molecules. However, unlike TBC in conjugated chromophores, it is still challenging to manipulate TSI and clusteroluminescence. Herein, simple and nonconjugated triphenylmethane (TPM) and its derivatives with electron-donating and electron-withdrawing groups were synthesized, and their photophysical properties were systematically studied. TPM was characterized with visible clusteroluminescence due to the intramolecular TSI. Experimental and theoretical results showed that the introduction of electron-donating groups into TPM could red-shift the wavelength and increase the efficiency of clusteroluminescence simultaneously, due to the increased electronic density and stabilization of TSI. However, TPM derivatives with electron-withdrawing groups showed inefficient or even quenched clusteroluminescence caused by the vigorous excited-state intramolecular motion and intermolecular photoinduced electron transfer process. This work provides a reliable strategy to manipulate TSI and clusteroluminescence.

INVITED LECTURE

Assembling-Induced Organic Room-Temperature Phosphorescence

Xiang Ma
East China University of Science and Technology

Functional dyes are widely used in optical recording, lighting display, biological imaging, medical diagnosis and treatment. It is still an important challenge to expand the luminescent properties and function regulation of fine chemical organic functional dyes, reduce the cost of material synthesis, and improve the economy of molecular material construction process. The construction strategy of "assembling-induced emission" is proposed to effectively regulate the fluorescence emission wavelength and room temperature phosphorescence efficiency of functional dyes and build functional and intelligent organic room temperature phosphorescence product system, which effectively expands the new functions and applications of traditional organic functional dye.

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INVITED LECTURE

Enantiomeric Switching of the Circularly Polarized Luminescence Processes in a Hierarchical Biomimetic System by Film Tilting

Xiaoxiao Yu
Donghua University

Circularly polarized luminescence (CPL) switching has attracted great attention due to the potential applications in chiral photonics and electronics. However, the lack of examples to achieve switchable CPL within a single material in the dry solid state hampers the scope of applications. Herein, we demonstrate a crystalline chiral polymer film as a polarizing medium consisting of radially assembled twisted crystallites, where achiral aggregationinduced emissive luminogens (AIEgens) are confined between the twisted crystalline stacks, eventually yielding handedness-switchable CPL by simple film tilting. Hierarchically organized twisted crystallites create the selective reflection activity of the polarizing medium. Upon film tilting, enantiomeric switching is realized by selectively collecting transmitted and reflected CPL components. The confined AIEgens in the crystalline polarizing system show a great enhancement of the luminescence efficiency. Moreover, the approach is general with broadband activity, and various AIEgens could be applied to generate fullcolor-tunable CPL. Additionally, the rigid and continuous nature of this polarizing system affords enhanced optical stability and facile modulation, developing a general route for designing chiroptical materials.

INVITED LECTURE

Aggregation-Induced Emission on Supramolecular Coordination Complexes Platforms

Xuzhou Yan
Shanghai Jiao Tong University

Coordination-driven self-assembly is a well-established methodology to elegantly construct supramolecular coordination complexes (SCCs) with well-defined shapes and sizes by the spontaneous formation of dative metal-ligand bonds. In this talk, I will introduce the marriage of aggregation-induced emission (AIE) and SCCs, and then discuss the underlying mechanisms and applications behind these novel light-emitting organo-metallic materials. Specifically, the preparation and study on luminescent mechanism of the multimodal fluorescent macromolecular metallacage will be presented firstly. Subsequently, influence factors including geometrical, shape, anion, and nanoconfinement effects on their photophysics will be introduced. Finally, I will discuss their promising applications as sensors and key components of light-emitting supramolecular polymers and biohybrid metal-organic materials with responsive fluorescence. I believe the emerging platform showed in this presentation not only provides insight into the understanding and applications of aggregation-induced emission, but also serves as a foundation for light-emitting metal-organic materials.

INVITED LECTURE

Construction of AIEgen-loaded nanofibers for solar steam generation and antibiosis

Dong Wang[1]、Ben Zhong Tang[2]
1. Shenzhen University
2. The Chinese University of Hong Kong, Shenzhen

By virtue of the good biocompatibility, outstanding fluorescence property, easy processability and functionalization, as well as promoted photosensitizing efficiency, aggregation-indeuced emission luminogens (AIEgen)-loaded nanofiber exhibit inexhaustible and vigorous vitality in varous fields. We developed a series of novel nanofibers-containing functional AIEgens with excellent photodynamic/photothermal features by coaxial electrospinning. These three-dimensional allfiber aerogel that can float on the water surface and continuously self-pump water, and exhibit the superior capacity of transferring solar energy into heat, endowing with impressive solar steam generation performance. Moreover, AIEgens-loaded nanofibrous membrane sharing sunlight-triggered photodynamic/photothermal anti-pathogen functions are prepared using the electrospinning technique. Thanks to its porous nanostructure, the nanofibrous shows excellent interception effects toward ultrafine particles and pathogenic aerosols.

INVITED LECTURE

Improving the luminous efficiency of organic molecules by structural design and coassembly

Hongwei Wu
DonghuaUniversity

The construction of efficient luminescence system is of great significance for various practical applications. Herein, by adopting the strategy of connecting twisted and planar structures, we have constructed a series of molecular systems with high efficiency fluorescence emission in both dilute solution and aggregated states. Through adjusting the length of the twisted structure, planar structure and alkyl chain, the emission system with bright monomer and excimer emission was also obtined. In addition, through adjusting the size of the peripheral groups of hexakis(phenylthio)benzene molecules, we have grown different forms of crystals, and revealed the reason of the high efficiency phosphorescence emission of hexakis(phenylthio)benzene compounds through the study of luminescence properties and theoretical calculations. Then, we also coassemblied the planar conformation organic small molecule dyes with polymer, the rigid environment could greatly reduce the non-radiative transition of the excited state of small molecule dyes and promote the emission effiency of ultra-long room temperature phosphorescence. And these phosphorescent molecules also exhibitted the temperature-responsive properties. At last, we coassemblied a series of tricarbonyl-substituted benzene molecules with polyvinyl alcohol to obatin the stable free radical emission. The PVA not only promoted the production of free radicals of small organic molecules, but also provided the H-bond network to stabilize the radical emission.

INVITED LECTURE

The design and applications of organic ultralong room-temperature phosphorescence materials

Runfeng Chen
Nanjing Univeristy of Posts and Telecommunications

Organic ultralong room-temperature phosphorescence (OURTP) with luminescent lifetime over 100 ms for organic afterglow are highly attractive in the recent investigations of new-concept organic electronic materials. We carefully investigated the emission behavior of OURTP materials in the aggregated states to reveal the mechanism for their diversified and interesting luminance at room temperature. We found that H-aggregation can effectively stabilize the triplet excitons, slow down the non-radiative decay, and elongate the phosphorescence lifetime to realize multicolor OURTP from green to red. Further, with the aid of Frenkel exciton theory, we reveal that OURTP properties are closely related to the splitting energy (Δε) of H-aggregation. Specifically, the Δε-controlled thermally activated reversed phase transformation from the low-lying dark state to the high-lying transition-allowed emission state of H-aggregation was identified, for the first time, as the key process in OURTP: larger Δε leads to longer lifetime, while smaller Δε results in short lifetime but higher OURTP efficiency. On the basis of these understandings we can significantly improve the OURTP quantum efficiency. We propose a strategy to bypass the traditional ISC through facilitating singlet-triplet transition to directly populate triplet excited states from the ground state by combining synergetic effects of both heavy/hetero-atom incorporations and aromatic aggregations; this unique singlet-to-triplet absorption results in much improved organic afterglow quantum efficiency up to 9.5% with elongated lifetime of 0.25 s under visible-light irradiation. We further enhance the OURTP efficiency by thermally activated processes to release the excitons on the stabilized triplet state (T_1^*) to the lowest triplet state (T_1) and transform the spin-forbidden triplet state emission to the spin-allowed emission of singlet excited state (S_1) with a small singlet-triplet splitting energy and a shallow exciton trapping depth. The firstly realized thermally activated organic afterglow shows an efficiency up to 45% without the use heavy atoms. Very recently, we firstly present an X-ray-excitable organic ultralong room temperature phosphorescence (X-OURTP) for afterglow scintillator through implanting lone-pair electron involved n-π* transitions and efficient charge transfer characters into H-aggregations of organic crystals. Thus designed X-OURTP molecule exhibits ultralong lifetimes up to 790 ms, high phosphorescence quantum yields of ~8%, and excellent scintillation stability.

INVITED LECTURE

Long wavelength AIEgen of quinoline-malononitrile

Weihong Zhu
East China University of Science and Technolog

The development of novel building blocks as long wavelength aggregation-induced emission (AIE)-active fluorophores/chromophores is in high demand for high performance luminescent and optical bioimaging agents. In this Highlight, we summarize some recent advances in the area of red to near-infrared (NIR) fluorescent AIE-active organic materials derived from our established building block of quinolinemalononitrile (QM), focusing on the AIE mechanism, water-soluble and shape-specific effects, use as hybridized dye-doped prodrug, as well as the facile scale-up and fast preparation for AIE-active nanoparticles through flash nanoprecipitation.

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INVITED LECTURE

Aggregation-Induced Delayed Fluorescence Materials and OLEDs

Zujin Zhao
South China University of Technology

Luminogens with thermally activated delayed fluorescence (TADF) can harvest singlet and triplet excitons to afford high electroluminescence (EL) efficiencies for OLEDs. However, most doped OLEDs of TADF emitters encounter a knotty problem of swift efficiency roll-off as luminance increases. In this work, we developed a series of novel luminogens with aggregation-induced delayed fluorescence (AIDF), which can easily settle the above challenge and realize nearly nil efficiency roll-off. They are composed by a carbonyl core and various electron-donating groups. Their structures and properties are investigated by crystallography, theoretical calculation, steady and transient spectroscopies, etc. They possess eximious emission with prominent delay fluorescence component in neat films, and can facilely solve the concentration or aggregation-caused emission quenching and/or exciton annihilation problem of those current TADF emitters. The nondoped OLEDs based on the neat films of these AIDF luminogens exhibit lowered turn-on voltages and increased luminance with respect to the doped OLEDs. Thanks to the excellent exciton utility, the nondoped devices furnish remarkable electroluminescence efficiencies of up to 72.9 cd A^{-1}, 81.8 lm W^{-1} and 22.6%, and negligible efficiency roll-off.

INVITED LECTURE

AIE Nanoprobes for NIR-II/NIR-IIb/NIR-IIx Fluorescence in vivo Functional Bioimaging

Jun Qian
Zhejiang University

In 2001, Tang et al. observed a phenomenon called “aggregation-induced emission” (AIE), which provides an ideal solution to the traditional aggregation-caused quench (ACQ) problem. Based on this mechanism, hydrophobic AIE molecules can be encapsulated with certain matrix, forming fluorescent nanoparticles. AIE nanoparticles have high brightness and are very resistant to photobleaching even under high-power laser irradiation. In vivo fluorescence imaging in the second near-infrared window (NIR-II) is a promising technique. During the past few years, NIR-II fluorescence bioimaging has experienced rapid development. However, the definition of the NIR-II region and the relevant mechanism are still not complete. We confirmed the positive contribution of moderate light absorption by water in intravital imaging, based on certain simulation and experiment. We further perfected the NIR-II window as 900-1880 nm, where 1400-1500 nm and 1700-1880 nm were defined as NIR-IIx and NIR-IIc regions, respectively. In this talk, I will introduce some recent research works about AIE nanoprobes assisted NIR-II/NIR-IIb/NIR-IIx fluorescence bioimaging in our group, such as video-rate brain angiography, gastroenterography/cystography, as well as diagnosis and imaging guided treatment.

INVITED LECTURE

Clustering-triggered emission of sulfur-containing polymers

Wang Zhang Yuan
Shanghai Jiao Tong University

Nonconventional luminophores devoid of remarkable conjugates have attracted considerable attention for their unique luminescent behaviors and promising applications in diverse fields. Unlike classic luminogens consisting of molecular segments with largely extended electron delocalizations, these nonconventional luminophores generally possess nonconjugated structures based on subgroups as ether (-O-), hydroxyl (-OH), halogens, carbonyl (C=O), cyano (C≡N), thioether (-S-), aliphatic amine (-N), as well as their grouped functionalities. They exhibit intriguing intrinsic luminescence, generally featuring concentration-enhanced emission, aggregation-induced emission, excitation-dependent luminescence and prevailing phosphorescence. Different mechanisms have been proposed for various systems. Recently, we proposed the clustering-triggered emission (CTE) mechanism, which emphasizes the clustering of above-mentioned electron rich moieties and consequent electron delocalization along with conformation rigidification. The CTE mechanism seems widely applicable for diversified natural, synthetic and supramolecular systems. Herein, to verify it and to develop new nonconventional luminogens, sulfur-containing polymers were constructed through facile Michael polyadditions. The luminescent behaviors and corresponding mechanism will be discussed.

INVITED LECTURE

Optimization of molecular aggregates by structural modulation

Qianqian Li
Wuhan University

Research on molecular aggregates play the key role to the optimization and extension of opto-electronic property of organic materials. We focuses on the modulation of molecular aggregates by the rational design of molecular structures, together with the assistance of intermolecular interactions, resulting in the optimized packing modes and subtle adjustment of aggregate structures. Combined with the advantage of different materials and the synergy effect of their interactions, the imaging of lymph nodes in living mice was achieved by the near-infrared afterglow from room-temperature phosphorescence resonance energy transfer, also, the sensitive photodeformable processes are realized with the extended applications. Based on the research of molecular aggregates from different levels, and the relationship between molecular structures and opto-electronic performance, some original strategies are afforded to promote the development of opto-electronic functional materials.

INVITED LECTURE

Development of organic room temperature phosphorescence materials for bioimaging

Zhengxu Cai
Beijing Institute of Technology

Organic room-temperature phosphorescence (RTP) material with long emissive lifetime offers stable luminescent signal that may efficiently eliminate interference from biotissues. However, developing highly efficient red metal-free organic RTP materials for biological applications is a formidable challenge, which limit its development and application in the deep organism.
In our work, a series of novel host–guest organic phosphors allowing dynamic color tuning from the cyan (500 nm) to orange red (650 nm). Guest materials are employed to tune the phosphorescent color, while the host materials interact with the guest to activate the phosphorescence emission. A host matrix with suitable triplet energy level was used to bridge the huge gap between the triplet and singlet of guest molecules for highly efficient ISC process. All the RTP materials can be fabricated into the nanoparticles with long emission lifetime in aqueous media. Given the good biocompatibility and long-lived emission, dual-channel and millisecond-level time-resolved luminescence imaging both in vitro and in vivo were conducted.

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INVITED LECTURE

Fluorescence Self-Reporting Precipitation Polymerization Based on Aggregation-Induced Emission for Developing Biomedical Optical Nanoagents

Xinggui Gu
Beijing University of Chemical Technology

Precipitation polymerization is becoming increasingly popular in energy, environment and biomedicine. However, its proficient utilization highly relies on the mechanistic understanding of polymerization process. Recently, aggregation-induced emission (AIE) was developed by Ben Zhong Tang, and exhibited its potential in various areas including bioimaging, diagnosis and treatment of cancer, and luminescent device. Taking advantages of mechanism of AIE, a fluorescence self-reporting method based on AIE is used to shed light on the mechanism of precipitation polymerization. The phase-separation and dynamic hardening processes of the polymerization can be clearly discerned by tracking fluorescence changes. The nucleation and growth processes were demonstrated experimentally for the first time, and confirmed the process of “dynamic hardening” in the formation of polymeric particles via precipitation polymerization. Employing this strategy, the mechanism of the formation of polymeric particles via precipitation polymerization could be monitored without any disturb of the polymerization, which provides a new way to monitor the formation of polymeric particles though any polymerizations. Moreover, fluorescent polymeric particles (FPPs) with uniform and tunable sizes can be obtained in a self-stabilized manner. These PFPs exhibit biolabeling and photosensitizing abilities and are used as superior optical nanoagents for photo-controllable immunotherapy, indicative of their great potential in biomedical applications.

INVITED LECTURE

Tunable photoluminescence properties of microcrystalline cellulose with gradually changing crystallinity and crystal form

Man Liu、Yifeng Shen、Qing Zhou
Zhejiang Sci-Tech University

Nonconventional luminogens with persistent room temperature phosphoresce (p-RTP) are attracting increasing attention owing to their momentous significance and diverse technical applications in optoelectronic and biomedical. So far, the p-RTP emission of some amorphous powders or single crystals has been studied in depth. The p-RTP emission of amorphous and fully crystalline states and their emission properties are widely divergent, while the difference of their p-RTP emission mechanism is still controversial. The relevance between crystallinity change and p-RTP properties is rarely studied. Furthermore, there is almost no research on the photoluminescence (PL) property change and emission mechanism under the crystal form transformation of semi-crystalline polymer. Herein, we chose microcrystalline cellulose (MCC) as a model compound to explore its crystallinity and the change in luminescence during the crystal form transformation to make up for this gap. By precisely adjusting the crystallinity and crystal cellulose conversion of MCC, the changing trend of quantum efficiency and p-RTP lifetime is consistent with the change of crystallinity, and the cellulose I may be more beneficial to PL emission than cellulose II. Clustering-triggered emission (CTE) mechanism can reasonably explain these interesting photophysical processes, which also can be supported by single crystal analysis and theoretical calculations.

INVITED LECTURE

How to get published in Nature and its sister journals

Jiajun Zhu
Springer Nature

In this talk, we will introduce what we Nature editors look for in the papers we want to publish, and appreciate the key editorial differences between Nature, the Nature Research Journals, Nature Communications, Communications series, Scientific Reports, and the Nature Partner Journals. Then we will let the audience know how to write a paper that deserves to be published in a Nature journal, and understand how we make decisions on what we publish. Finally, we will introduce some of the benefits of Open Access.

INVITED LECTURE

Integrating aggregation-induced emission (AIE) with vibration-induced emission (VIE) for the development of advanced materials

Ju Mei
East China University of Science and Technology

AIE and VIE are the most shining and active “stars” receiving extensive attention in the current luminescence research field. As compared to the AIE research, the VIE-related research is still in the initial stage. VIE is referred to an abnormal luminescence phenomenon that a class of typical saddle-shaped compounds, such as N,N′-diphenyl-dihydrophenazine (DPAC) derivatives, exhibit unusually large Stokes-shifted emission due to the bent-to-planar conformation transformation in the excited state. The VIE-active compounds predominately luminesce relatively weak orange-red light in the unconstrained state due to the free and vigorous intramolecular vibrations, while mainly emit intense blue light in the constrained state as a result of the restriction of intramolecular motions. It can be seen that, similar to the AIEgens, the photophysical behaviors of VIE systems are also closely associated with intramolecular motions. Here, we would like to expound the differences and relations between AIE and VIE, exemplify the win-win effect of integrating AIE with VIE to develop advanced materials, and demonstrate the high performance of the VIE/AIE+VIE materials used as probes for the detection of chemical species, sensing of physical parameters such as temperature and viscosity, and the in-situ and real-time monitoring of specific processes such as gelation and microphase separation, or as non-solvent/non-doped fluorescent ink for dynamic anti-counterfeiting and encryption.

INVITED LECTURE

Open the Editor's Black-box and Wiley Chemistry Partner Journal Opportunities

Ying Wang
WILEY

Are you interested to know more about the Wiley journals and the development in Great China area?
Are you interested in launching partner journals together with Wiley?
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Eric-Ying Wang (Editor, Wiley) is looking forward to meeting and talking with you!

INVITED LECTURE

Temperature-independent ultralong organic phosphorescence with a symmetrical Butterfly-type structure

Hui Xiao[1,2]、Yuheng Lou[2]、Zhiyong Guo[2]、Jingyi Wang[1,3]、Ni Wu[2]
1. School of New Materials and Shoes & Clothing Engineering, Liming Vocational University
2. College of Materials Science and Engineering, Fuzhou University
3. School of Chemistry and Chemical Engineering, Nanjing University of Science and Technology

Room temperature phosphorescence (RTP) materials in the solid state have been attracting widespread attention and found broad prospects in the fields of smart wear, optoelectronic devices, bioimaging and encryption. However, purely organic RTP materials are still scarce due to weak spin-orbit coupling (SOC) and fast nonradiative transition under ambient conditions. Here, we developed a facile strategy using heavy-atom effect to construct RTP materials of commercial/lab-synthesized carbazole-based derivatives (DCzB-X). DCzB-Cl, DCzB-Br and DCzB-I have ultralong phosphorescence lifetimes of 789.0 ms, 184.3 ms and 49.6 ms, respectively. Single crystal structure analysis show that the compact packing mode of the butterfly-type packing style (BPS) with halogen substituent is favorable for long phosphorescence lifetime, which is longer than lab-synthesis as the presence of isomers in commercial samples. Theoretical calculations analysis also reveal that, compared with DCzB-H, this BPS exhibit a greater reduction from the T1 state of monomer to T1* state of dimer because of electron-withdrawing substituents and strong intermolecular π-π interactions. Impressively, an unusual phenomenon was found that the phosphorescence lifetime of DCzB-halogen does not increase with the decrease of temperature, indicating that the non-radiative transition of BPS is independent of low temperature. The result breaks through the traditional low temperature enhanced phosphorescence theory, and it take an important step forward in expanding the scope of organic phosphorescence applications.

KEYNOTE SPEECH

Multi-Physical Numerical Modelling of Hybrid Flexible Sensor

Zhuangjian Liu
Institute of High Performance Computing, A*STAR Research Entities

Numerical models of multi-sensing capability soft-matter interdigitated (IDE) capacitors sensors are studied by using the 3D finite element method. With microchannels of liquid-phase metals embedded in a flexible matrix, this type of sensors can undergo large deformations while sustaining adequate characters as comparison with to conventional rigid electronics. Therefore, the sensor are easy employed and integrated with the human body and potentially extend to be used as skin-like electrical devices. The multi-physical simulation is quantitatively verified by uniaxial testing at firstly. It shows the capacitance increases with an increasing strain along the channel's axial direction and is excellent linearity between the capacitance and strain. And more, the effect of bending and stretch strain with difference direction on the capacitance are analysed. Then, the capacitance change with a float electrode (human finger) placed at different distances from the capacitor are demonstrated. The capacitance is increased when the float electrode move towards the capacitor and decreased when float electrode away from the capacitor. These soft IDE capacitors can be used in various areas requiring human-machine interactions, such as pressure, strain, as well as the capability to detect respiration rate due to chest motion by utilizing the proximity effect.

KEYNOTE SPEECH

Super Tough and Intelligent Multi-bond Network (MBN) Hydrogels Facilitated by MXene Nanosheets

Xuming Xie、Yuxi Li
Tsinghua University

Stretchable and conductive hydrogels have emerged as promising candidates for intelligent, flexible and wearable electronic devices. The integration of intrinsically conductive 2D MXene nanosheets, which are featured with large surface functionalities, into polymeric hydrogel matrix is regarded as fascinate strategy in mechanically reinforcing hydrogels and improving their electrical performance in the meantime. Herein, based on multi-bond network (MBN) design rationale, super tough and highly stretchable MXene-poly(acrylic acid) (PAA) nanocomposite hydrogels are fabricated, in which 2D MXene nanosheets serve as multifunctional crosslinkers and stress transfer centers. Further incorporation of Fe3+ enables more coordination crosslinks between polarized groups in 2D MXene nanosheets and carboxylic groups in PAA chains with Fe3+ being as the coordination center, significantly enhancing the mechanical strength of the hydrogels with excellent stretchability even at high water content of 80 wt% (tensile strength of 3.3 MPa and elongation at break of 3085%). Besides, the obtained MXene-PAA-Fe3+ nanocomposite hydrogels possess superior conductivity as well (up to 3.8 S/m). The mechanical toughness of MXene-PAA-Fe3+ hydrogels is attributed to effective energy dissipation mechanism within homogeneously cross-linked network by means of controllable permeation method and the outstanding conductivity is ascribed to the existence of electrically conductive MXene nanosheets and large numbers of ions. What's more, the obtained super tough and conductive MXene-PAA-Fe3+ hydrogels possess superior self-healing ability and strain sensitivity (high gauge factor of 10.09), exhibiting great prospect as reliable intelligent flexible electronics, such as strain sensors, wearable detection and recognition devices and smart soft robots.

KEYNOTE SPEECH

Flexible fiber electronics with low-dimensional nanostructures

Guozhen Shen
Institute of Semiconductors, Chinese Academy of Sciences

Fiber electronics is a newly emerged flexible device developed in recent years, which offers unique ultra-flexible, shape adaptable, and weavability properties, allowing various deformations include bending, stretching, twisting, etc. Up to date, different kinds of fiber devices such as fiber generators, sensors, detectors have been reported. Due to their nanoscale characteristic size, and special morphology, low-dimensional nanostructures possess huge specific surface areas, fascinating quantum effects, unique physical and chemical properties, and have attracted extensive attention and success in fabricating fiber electronics.
In this talk, I will briefly introduce our recent work on design of flexible fiber electronics with low-dimensional nanostructures, including energy storage devices like flexible zinc-ion hybrid supercapacitors and electronic devices like wearable photodetectors for digital communications, etc.

KEYNOTE SPEECH

Novel Photodeformable Liquid Crystal Polymers and Fiber Actuators

Yanlei Yu、Xinlei Pang、Lang Qin、Bo Xu
Department of Materials Science & State Key Laboratory of Molecular Engineering of Polymers, Fudan University, China

Anisotropic contraction, notably one-dimensional (1D) contraction, is an effective motion for living creatures in nature to develop a series of self-protection and/or survival strategies. For example, mammalian skeletal muscles that are often simplified as line-segments without accounting for the large muscle attachment areas can generate active forces by 1D contraction of muscle fibers during physical exercise. Polymeric actuating materials have received widespread attention when research into stimuli-responsive materials afforded concepts and building blocks that proved to be useful in the context of 1D contraction.[4] An ideal candidate to realize large, 1D contraction is the liquid crystal polymer (LCP) because the liquid crystal (LC) molecules could be oriented in an ordered state and transform into a disordered state induced by thermal (photothermal) or photochemical LC-isotropic phase transition that gives access to large contraction. Most of the reported contractions of LCPs are induced by the thermal-driven order-disorder phase transition, where the contraction rates reach 80% at the largest. However, the contractions induced by photochemical effect only reach a largest rate of 20%, resulting from the insufficient molecular order change of LCs.

Following the principle of shape memory effect (SME), the large shape changes of polymers have been readily achieved accompanied with the storage and release of the strain energy. Herein, we present a new strategy to realize light-driven contraction as large as 81% based on the storage and release of the strain energy in linear LCP (LLCP) fibers. The basic idea for our design inherited from SME is to utilize LC phase as the switching segment to control the strain energy, which is locked by the highly ordered LC structure and unlocked by the order-disorder phase transition upon reversible trans-cis photoisomerization of azobenzene mesogens. We further demonstrated that these fibers acted as light-driven building blocks to achieve precise origami, to mimic the recovery of a 'broken' spider web, and to screen objects in different sizes.

KEYNOTE SPEECH

Bioinspired Surface Engineering for Mechanochromism and Thermal Management

Luyi Sun
University of Connecticut

In nature, some marine organisms, such as Vogtia and Cephalopods, have evolved to possess camouflage traits by dynamically and reversibly altering their transparency, fluorescence, and coloration via muscle-controlled surface structures and morphologies. To mimic these display tactics, we designed similar deformation controlled surface engineering via strain-dependent cracks and folds to realize four types of mechanochromic devices: (1) transparency change mechanochromism (TCM), (2) luminescent mechanochromism (LM), (3) color alteration mechanochromism (CAM), and (4) encryption mechanochromism (EM), based on a simple bilayer system containing a rigid thin film atop a soft substrate. These devices exhibit a wide scope of mechanochromic responses with excellent sensitivity and reversibility. Based on a similar bilayer system with strain-dependent cracks together with a stretchable heater, we developed a thermal system whose effective surface thermal emissivity originating from the combination of the film and the exposed substrate can be instantaneously and reversibly modulated simply via mechanical means. Additionally, the system demonstrates intriguing thermographic-based applications in finger motion sensing, information encryption, multiplexing display, and thermal camouflage. Both the mechanochromism and thermal management systems are expected to find widespread application.

KEYNOTE SPEECH

Hydrogen-Bonded Supramolecular Plastics and Elastomers with Superhigh Strength and Ultrahigh Toughness

Xiaokong Liu
State Key Laboratory of Supramolecular Structure and Materials, College of Chemistry, Jilin University

Supramolecular science studies the structures and functions of the molecular systems that result from the non-covalent intermolecular binding interactions of two or more chemical entities in an organized manner.[1] Since the initialization of supramolecular chemistry by J. M. Lehn in 1970s, the concept of supramolecules has been exploited for the development of supramolecular species/materials, spanning from the nano/micro-scale supramolecular assemblies to bulk polymeric materials (e.g., plastics, elastomers, hydrogels). However, low mechanical robustness is one of the long-standing problems that plague the practical applications of supramolecular polymeric materials. In recent years, our group has developed various hydrogen-bonded supramolecular polymeric materials with superhigh strength and ultrahigh toughness, including plastics and elastomers, through the regulation of synergistic and dynamic properties of the intermolecular hydrogen-bonding interactions.[2-4] Meanwhile, the as-developed supramolecular plastics and elastomers feature healability, recyclability, and degradability, thanks to the reversible nature of hydrogen-bonds. The highly robust supramolecular polymeric materials show high promise as sustainable substitutes for conventional plastics and elastomers owing to their outstanding mechanical performance, healability, recyclability, and degradability.

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KEYNOTE SPEECH

Flexible One-Dimensional Nanomaterials for Emerging Energy Storage

Liqiang Mai、Liang Zhou
Wuhan University of Technology

One-dimensional nanomaterials can offer large surface area, facile strain relaxation upon cycling and efficient electron transport pathway to achieve high electrochemical performance. Hence, nanowires have attracted increasing interest in energy related fields. We designed the single nanowire electrochemical device for in situ probing the direct relationship between electrical transport, structure, and electrochemical properties of the single nanowire electrode to understand intrinsic reason of capacity fading. The results show that during the electrochemical reaction, conductivity of the nanowire electrode decreased, which limits the cycle life of the devices. Recently, a polyester-CNTs@MnO2 cathode is designed Mn2+/Zn2+ hybrid battery (Mn2+/Zn2+ HB). Based on a hybrid storage mechanism including Mn2+ ion deposition, Zn2+ ion insertion, and conversion reaction of MnO2, the assembled Mn2+/Zn2+ HB can achieve an ultrawide voltage window (0 – 2.3 V) and high capacity (0.96 mA h cm−2). Besides, a novel procedure is proposed to fabricate an asymmetric microsupercapacitor (AMSC), employing interwoven nanowire network electrodes of poly(3,4-ethylenedioxythiophene) coated titanium oxynitride (P-TiON) and vanadium nitride (VN) NW as a cathode and an anode, respectively. The interwoven NWs with a high mass loading offer a sufficient electrochemical reaction area and rapid electron/ion transport pathway, delivering superior energy and power densities. Moreover, a gradient nanowire cathode is demonstrated for advanced interface engineering in Solid-state lithium batteries (SSLBs) by a facile solvent evaporation process. In this unique gradient cathode membrane, one side surface with more ionic conductive polymer provides a smooth contact with solid-state electrolytes (SSE), while the other side surface with more electronic conductive NW/reduced graphene oxide composite provides rapid electron transport acting as a current collector. The effective interface engineering gives SSLBs enhanced structural stability and excellent electrochemical performance. The as-obtained SSLBs can deliver 200 mA h g−1 capacity after 100 cycles at room temperature without obvious structural degradation. Our work presented here can inspire new thought in constructing novel one-dimensional structures and accelerate the development of energy storage applications.

INVITED LECTURE

A new type of anti-foreign-body response material inspired by silk protein

Donghui Zhang、Runhui Liu
East China University of Science and Technology

Nonspecific protein adsorption to implanted materials may trigger the foreign-body response (FBR) and fiber encapsulation, which causes tissue deformation and pain, and even loss of function of the implant. The FBR severely restricts the development of implantable biomaterials and devices. Polyethylene glycol (PEG) is a representative and widely used antifouling polymer, but many studies have shown that PEG based materials can cause immunogenic reaction and the FBR, and PEG is easily degraded by oxidation in the body [1]. Therefore, in recent years, more research has been focusing on new anti-FBR materials that may replace PEG. Silk has low immunogenicity, and its outer layer is composed of sericin that contains ~34% serine. Inspired the high content of serine in the low immunogenic sericin, we designed and synthesized poly-β-serine (β-HS) as a new material with low immunogenicity and low FBR after the β-HS hydrogel was implanted in mice for up to 3 months, while the PEG implantation control group with obvious FBR [2]. We further developed highly water soluble, biocompatible and easily accessible poly-DL-serine (PSer) hydrogel that resists inflammatory response and the FBR after subcutaneous implantation in mice for at least 7 months [3]. β-HS and PSer are both a new type of material that can resist the FBR, which have broad applications in the fields of implantable biomaterials, medical devices and drug delivery [4].

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INVITED LECTURE

Bio-inspired polymeric hydrogel actuators

Jiawei Zhang
Ningbo Institute of Material Technology and Engineering, Chinese Academy of Sciences

Inspired by the living organisms which are able to generate movements upon environmental stimuli to accommodate to a variety of environmental demands, polymeric hydrogel actuators that could translate various external stimuli into controllable and reversible deformation have thus aroused tremendous attention and shown promising applications in many fields including soft robots, biomimetic actuators, and so on. However, the anisotropic structures of the currently investigated hydrogel actuators are normally generated at the fabrication process, and thus has limited the deformation behaviours and potential applications. We have recently integrated thermo-responsive actuating performances and shape memory functions based on metal-ligand coordination, and endue the hydrogel with temporary anisotropic structures through the complexation between alginate and metal ions, then the hydrogel could generate programmable shape transformation upon the trigger of heat. In addition, the deformed shape of a hydrogel actuator could be fixed by photo-responsive shape memory property, and various remotely controlled movement such as grasping, maze crossing, object transportation could be realized. Our strategy may provide new insights in the design and fabrication of biomimetic intelligent actuating systems.

INVITED LECTURE

Preparation of the self-assembled poly(N-isopropylacrylamide) microgel/graphene oxide material and its gas sensor application based on quartz crystal microbalance

Zheng Cao、Yang Zhang、Zili Luo、Zhirong Lai、Lilin Fan、Haochen Liu
Changzhou University

Two-dimensional materials with large surface area, more active sites, and other excellent properties, have potential for the development of high-performance gas sensors. Quartz crystal microbalance (QCM) is a mass-sensitive sensor based on the piezoelectric effect, and can detect nanogram-level mass changes. QCM has become a new sensing and detection method that has gradually attracted attention in recent years, due to its facile operation, easy modification of the crystal surface, and real-time monitoring at room temperature. In this work, using two-dimensional graphene oxide (GO) and poly(N-isopropylacrylamide) based microgels as functional components, a series of QCM gas sensors based on two-dimensional materials/microgel sensitive films were prepared. Firstly, P(NIPAM-co-DMAEMA) microgel was synthesized, and the morphology, pH sensitivity, and self-assembly ability of the microgels were characterized by TEM, DLS and QCM technology. Two-dimensional GO materials are used as the reinforcing phase, the electrostatic interaction and hydrogen bonding are used to self-assemble layer-by-layer with microgels, and the structure and surface topography characteristics of the self-assembled GO/microgel films with different layers are studied by Raman spectroscopy and SEM. The results show that as the number of layers increases, the content of GO and microgel increases, and the film becomes more compact. The QCM ethanol sensor was prepared with GO/P(NIPAM-co-DMAEMA) as the sensitive material. The results showed that the QCM sensor modified with GO/microgels showed excellent response characteristics to ethanol gas. On the one hand, the abundant oxygen-containing groups on the surface and edges of GO have hydrogen bonding with ethanol molecules. On the other hand, after the close bonding of GO and microgel, its specific surface is greatly increased, providing more adsorption sites for ethanol molecules.

INVITED LECTURE

Tuning of microstructure and strain sensing performance of wearable and functional fibrous mat

Kun Dai
Zhengzhou University

Flexible conductive polymer composites (FCPCs) based strain sensor have shown great potential in aerospace, medical health, artificial intelligence and other fields. For improving strain sensing performance of FCPCs, we use thermoplastic polyurethane (TPU) as matrix and prepare stretchable electrospun fibrous mats by electrospinning. Conductive fillers, such as reduced graphene oxide (rGO) and carbon nanotubes (CNTs) are decorated on the surface of the fibrous mat to pre-construct conductive network for building a series of high performance FCPCs. By constructing electrospun fibrous network with aligned wavy-like structure, the strain sensing range of the FCPCs have been enlarged to 900%, which is one of the highest strain detection ranges in the available literatures. For improving the detection limit, we uses pre-stretching method to build micro-crack structure on the surface of flexible electrospun fibrous mat. Based on crack propagation mechanism, the sensitivity (gauge factor, GF can reach up to 3.92×10^7) and detection limit (0.001% strain) of FCPCs is greatly improved and the system also exhibits a good responsive stability. Through the construction of multi-layered flexible conductive composite film, the integration of responsive range, sensitivity and stability of the FCPCs is realized. In addition, the crack structure and conductive fillers with a large aspect ratio such as silver nanowires (AgNWs) are combined to prepare stretchable FCPCs with self-powering ability.

INVITED LECTURE

Two-dimensional conjugated aromatic polymers for energy applications

Wei Liu
Southeast University

The fabrication of 2D conjugated polymers with well-defined repeating units and in-built porosity presents a significant challenge to synthetic chemists. Yet they present an appealing target because of their desirable physical and electronic properties. We report the synthesis of 2D conjugated microporous polymers by a thermal-initiated polymerization strategy without using any solvents and catalysts: (a), steric hindrance between monomers in their solid state is utilized to prepare a crystalline and fully-conjugated 2D polymer based on C-C cross-coupling reaction, which was highlighted by *Nature* as a breakthrough in 2D materials; (b), a conjugated microporous thermoset combining the processability of plastics with the extreme rigidity of cross-linked organic networks is fabricated through a thermosetting process. This allows the preparation of large-area conjugated microporous polymeric membranes, which are highly attractive for molecular/ionic sieving processes and demonstrate great potential in hydrogen separation, Li metal battery and Li-S battery. (c), solution-processable conjugated porous polymeric membranes with free radicals are prepared. They show superb performances as solar vapor generation membrane and CO2 capture membrane.

INVITED LECTURE

Hydrogels with Unprecedented Mechanics for Human-Machine Interfacing

Ji Liu
Southern University of Science and Technology

The human tissues and organs are mostly soft, wet and bioactive; however, machines are commonly hard, dry and biologically inert. Bridging human-machine interfaces is of importance to address those grand challenges in health, energy and suitability. Functional soft materials emerging at the interface between electronics and biological systems are challenging our fundamental knowledges, motivating technological innovations, and enabling impactful applications. Inspired by the nature's design principles, a great variety of functional hydrogels with unprecedented properties and functions could be readily manufactured for human-machine interfacing. In this talk, I will mainly focus on how to engineer hydrogel materials with unprecedented mechanics, such high toughness and fatigue-resistant properties, by rational control of the multi-length scale structure. Such emerging soft materials could be further engineered as the ingestible electronics for long-term monitoring important physiological conditions and biomarkers, important loading bearing components for soft robots or hydrogel armours. Moreover, fatigue-resistant adhesion between soft materials and engineering matrix, i.e. metals, ceramics, elastomers, will also be discussed.

INVITED LECTURE

Display textile and functional system based on polymer composite fiber electrodes

Peining Chen
Fudan University

Displays are a core component in many modern electronic devices; they allow humans to interact with machines. Integrating displays into textiles to form smart electronic textiles (e-textiles) that are interactive and responsive could transform the way we use and interface with electronic devices. It is challenging to achieve textiles with functional, large-area displays by obtaining small illuminating units that are both durable and easy to assemble over a wide area. Here we show a functional, large-area display textile by weaving transparent conductive gel weft and luminescent warp fibers. The electroluminescent (EL) units are constructed directly at the weft-warp contact points during weaving, which allowed us to produce a 6 m (L) x 25 cm (W) display textile consisting of approximately 5×105 EL units. The display textile is flexible and breathable like normal cotton textiles, making them suitable as wearables. Their luminance is uniform (< 10% variation) and stable after repeatable deformations and even machine washing. We further show that other interactive functionalities such as power supply and sensing can also be integrated with the display textile to form an integrated textile system, which can potentially drive the Internet of Things in various areas.

3D printing of low concentartion GelMA-based scaffolds with nanoclay

Xiaokang Liu、Xinliang Zhou
Donghua University

Photocrosslinked GelMA hydrogel ink is widely used in 3D pneumatic extrusion printing due to its gel forming at low temperature and rapid crosslinking under UV. Due to the low viscosity of GelMA hydrogel itself, the concentration of most GelMA inks is higher than 5% w/v. Few people have explored the printing of low-concentration GelMA inks. Low-concentration GelMA inks have better flexibility. The porosity is better, which is conducive to the material exchange in the cell culture process. In this paper, the rheological properties of GelMA ink were adjusted by adding different proportions of the thixotropic agent laponite (XLG), and successfully printed the scaffolds with high resolution and certain space complexity. The scaffolds can reach 16 layers without collapsing. Moreover, the added laponite (XLG) can also adjust the porosity of the scaffolds, improve the mechanical properties of the scaffolds, and affect the degradation ratio of the scaffolds. In short, this paper provides a low-concentration GelMA hydrogel ink extrusion printing strategy, by adding nanomaterials to adjust the ink performance. Which provides a new idea for future hydrogel ink bioprinting.

INVITED LECTURE

Highly transparent, stretchable, and self-healable ionogel for multifunctional sensors, triboelectric nanogenerator, and wearable fibrous electronics

Wei Sun、Lijie Sun、Zhengwei You
Donghua University

Ionogels with high transparency, stretchability and self-healing capability show great potential for wearable electronics. Here, a kind of highly transparent, stretchable and self-healable ionogels are designed using double physical cross-linking including hydrogen bonding and dipole–dipole interaction. Owing to the dynamic and reversible nature of the ion–dipole interaction and hydrogen bonds of polymeric chains, the ionogel possesses good self-healing capability. The multifunctional sensors for strain and temperature are fabricated based on ionogel. The ionogel can serve as strain sensor that exhibited high sensitivity [gauge factor (GF) = 3.06] and durability (1000 cycles) to a wide range of strains (0–300%). Meanwhile, the ionogel shows rapid response to temperature, due to the temperature dependence of its ionic conductivity. Furthermore, the ionogel fibers with excellent antifreezing (– 20 °C) capability are fabricated, and the fibers show the good sensing performance to human motions and temperature. Importantly, the antifreezing ionogel-based triboelectric nanogenerator (ITENG) is assembled for efficient energy harvesting. The ITENG shows a short circuit current (ISC) of 6.1 μA, open circuit voltage (VOC) of 115 V, and instantaneous peak power density of 334 mW m–2. This work provides a new strategy to design ionogels for the advancement of wearable electronics.

INVITED LECTURE

Mechanoluminescent Polymers

Yulan Chen[1]、Yuan Yuan[2]
1. Jilin University
2. Tianjin University

Stress induced covalent bond scission underlies the macroscopic failure of polymeric materials. The possibility to monitor mechanical stress and/or deformation at broader time scales is of fundamental research interest. We are interested in creating more sophisticated mechano-responsive polymers for self-reporting excessive stress with clearly perceptible optical signals, meanwhile with the rupture force tailored over a wide range. Recently, several strategies towards sensitive mechanoluminescent polymers have been developed by our group, by making use of 1,2-dioxetane and rhodamine derivatives as mechanophores. These strategies empower polymeric materials with abilities to report whether, where and when mechanical events take place, which can work as a full day stress-sensitive sensor responsible at an expanded force range.

INVITED LECTURE

Programmed Stimuli-Responsive Carbon Dot-Nanogel Hybrids for Enhanced Imaging-guided Tumor Phototherapy

Hengwei Lin、Shan Sun
Jiangnan University

Harmonizing the contradiction of nanotheranostic agents among enhanced tumor accumulation and penetration, efficient cell internalization and fast elimination is one of the key taches for promoting their clinical applications. Herein, programmed stimuli-responsive poly(N-isopropylacrylamide)-carbon dots (PNIPAM-CDs) hybrid nanogels are designed to address the above-mentioned conflicts. The enlarged particle size of PNIPAM-CDs enables effective improvement of their accumulation at tumor sites. Once the hybrid nanogels docking in tumors and being exposed to near-infrared (NIR) light irradiation, heat and reactive oxygen species (ROS) are generated from the CDs, consequently activating photothermal therapy (PTT) and photodynamic therapy (PDT) effects, and meanwhile inducing partial degradation of PNIPAM-CDs for deep tissue penetration. Further, enhanced cellular internalization of the functional components can be achieved owing to the pH-responsive charge reversal and temperature-dependent hydrophilic/hydrophobic conversion characters of PNIPAM-CDs. Finally, the over-expressed glutathione (GSH) in tumor cells would trigger further cleavage of the partially degraded hybrid nanogels, which is beneficial for their rapid clearance from body. This work not only proposed a novel strategy to fabricate nanotheranostic agents using just a single functional component (i.e., the versatile CDs) to simplify the preparation process, but also achieved effective delivery of agents into tumor cells by overcoming the multiple biological barriers to enhance efficacy and decrease side effects.

INVITED LECTURE

Periodic Curved Fiber Materials for Artificial Muscles, Electronics, and other smart fibers

Zunfeng Liu
Nankai University

Functional polymer fibers show promising mechanical, thermal, and electrical properties, and may find important applications in wearable electronics, cooling, and tough fibers. Here by mimicking the nature, we designed functional fiber materials with periodical geometrical structures, such as twisting, coiling, and buckling. These fiber materials exhibit interesting properties, due to the periodical twisting, coiling, and buckling of the macromolecular chains. (1) We prepared artificial spider silks by using “twisted sheath-core” hydrogel fibers with chemical and physical cross-linking points, whose mechanical strength and toughness are close to those of the natural spider silk. (2) Twist insertion in natural fiber materials e.g. silkworm silk, cotton, bamboo fiber, hair fiber produces moisture driven artificial muscles, which can rotate, contract, and elongate in response to moisture. (3) Inserting twist highly improved the cooling efficiency of elastomer fibers from 32% to 67%, and rigid polymer fibers also show high cooling temperature by twist insertion. (4) We prepared highly elastic conductive fibers by using buckled conductive layer with zero-Poison’s ratio, realizing ultra-stable resistance during large elongation. (5) Based on the above periodical structures, we designed multi-functional materials with hierarchical geometrical structures, realizing strain sensors, artificial muscles, and robotics.

INVITED LECTURE

Flexible mechano-to-electrical energy conversion materials and devices

Xiong Pu
Beijing Institute of Nanoenergy and Nanosystems, Chinese Academy of Sciences

The technology of mechano-to-electrical energy conversion had promoted the second industrial revolution in history, and is still now one of the foundations of modern electrical industry. Recently, there are following new demands and impacts to develop new flexible mechano-to-electrical energy conversion devices, due to the booming of flexible electronics or bionic electronics. First, they can harvest low-grade environmental mechanical energy and serve as power sources for electronics; second, they can serve as force-sensitive sensors or interaction devices, as human bodies express information mainly by mechanical motions or vibrations, such as “speaking and writing”. However, traditional mechano-to-electrical energy conversion devices, such as the electromagnetic generator, can hardly achieve flexibility, and their outputs are low at low frequency and low mechanical amplitude. Therefore, we present our progresses on flexible mechano-to-electrical energy conversion devices based on fiber and elastomer materials. We will also introduce the mechano-to-electrical conversion based on dynamic interfaces of dielectric, semiconductor, and electrolyte materials, respectively. Our new progresses on solid polymeric ionic conductors will also be reported.

INVITED LECTURE

Supercoiling Artificial Muscle Fibers

Geoffrey Spinks
University of Wollongong

This talk describes a new mechanism for generating large contraction strains caused by swelling of pre-twisted fibres and yarns. The swelling generates torsional strain energy that is released by converting twist to writhe and leading to the formation of loops or 'supercoils' along the fibre length. The same process occurs naturally in double stranded DNA and is partially responsible for the packing of the long DNA molecules into chromosomes. Supercoiling is a common everyday experience that occurs by adding twist to fibres, ropes, cables etc. and produces irritating tangles. However, our study is the first to demonstrate supercoiling without any addition of twist.

The supercoiling muscles utilised helically oriented filaments embedded in a swellable poly(arcylic acid) (PAA) matrix. The helical arrangement of the filaments directed the swelling towards a partial untwist. However, if the sample ends were held to prevent rotation but still allow translation, then the swelling caused supercoiling with concomitant reduction in the end-to-end sample length of up to 90%. The amount of contraction strain was strongly influenced by the applied tension because the number of supercoil loops and their diameter depends on the applied stress. Samples that were over-twisted to form coils before crosslinking the PAA were able to generate 'coiled coils' on swelling. These samples showed an unusual combination of both high stroke (70%) and high work capacity (1 J/g) which exceeds the performance of natural muscle by more than 35 times.

INVITED LECTURE

Polymers for photoinduced reversible solid-to-liquid transitions

Si Wu
University of Science and Technology of China

I will present that light can switch the Tg of azobenzene-containing polymers (azopolymers) and induce reversible solid-to-liquid transitions of the polymers.[1-4] The azobenzene groups in the polymers exhibit reversible cis-trans photoisomerization. Trans azopolymers are solids with Tg above room temperature, while cis azopolymers are liquids with Tg below room temperature. Because of the photoinduced solid-to-liquid transitions of these polymers, light can reduce the surface roughness of azopolymer films, repeatedly heal cracks in azopolymers, and control the adhesion of azopolymers for transfer printing. The photoswitching of Tg provides a new strategy for designing healable polymers with high Tg and allow for control over the mechanical properties of polymers with high spatiotemporal resolution.

Figure 1. (a) Photoisomerization of azopolymers P1, P2, and P3. (b) Optical microscopy images of P1 powders before and after UV irradiation. (c) Schematic and optical microscopy images of healing of P1 with light. (d) Schematic and confocal microscopy images show photoinduced reduction of surface roughness. (e) Schematic and photographs of transfer printing based on the photoinduced solid-to-liquid transition.

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INVITED LECTURE

Computational Design of Ultra-High-Performance Fibers

Enlai Gao[1]、Ruishan Li[1]、Ray Baughman[2]
1. Wuhan University
2. The University of Texas at Dallas

The demand for high-modulus, high-strength,lightweight materials has continuously driven the bottom-upassembly of carbon nanostructures into high-performance fibers. Carbyne, often called linear carbon, has a higherpredicted gravimetric modulus and gravimetric strength thanany other form of carbon, but possibly reacts under nearambient conditions because of the extended sp1 hybridization. Herein, we designed a type of carbon fiber that includes a possibly large array ofcarbyne chains confined within a single-walled nanotube sheath (nanotube wrapped carbynes, NTWCs), in which carbynechains act as reinforcing building blocks, and the carbon nanotube sheath protects the multiple carbyne chains againstchemical or topochemical reaction. We showed that NTWCs exhibit confinement-enhanced stabilities, even when they containmultiple neighboring carbyne chains. We developed a mechanics model for exploring the mechanical properties of NTWCs.On the basis of this model, the gravimetric modulus (and strength) of NTWCs was predicted to increase from 356.4 (50.25) to977.2 GPa·g−1·cm3 (71.20 GPa·g−1·cm3) as the mass ratio of carbyne carbons to sheath carbons increases, which is supportedby atomistic simulations. The highest calculated gravimetric modulus and strength of NTWCs are 174.2% and 41.7%,respectively, higher than those of either graphene or carbon nanotubes. The corresponding highest values of engineeringmodulus and strength of NTWCs with a density of 1.54 g·cm−3 are 1505 and 109.6 GPa, respectively. Hence, NTWCs arepromising for uses in high-modulus, high-strength, lightweight composites.

INVITED LECTURE

Engineering cellulose into cellulosic poly(protic ionic liquids) for gelatinous reactor

Haibo Xie
Guizhou University

The design and fabrication of functional hydrogel materials for environmental catalysis is a frontier topic both in fields of material science and catalysis. In this study, a new cellulosic hydrogel anchoring 1,1,3,3-tetramethylguanidinium–based ionic liquids moiety (CHI) was firstly prepared by simply adding bicyclic anhydrides into newly developed 1,1,3,3-tetramethyl guanidine/DMSO/CO2 solvent system for cellulose. The presence and amount of bicyclic anhydrides as a cross linker was proved to be an important factor for the hydrogel formation. And then, Pd nanoparticles (NPs)@CHI composites were fabricated by the reduction of the absorbed Pd(II) ions on CHI using $NaBH_4$ as reducing agent. The samples were characterized by techniques of ^{1}H NMR, ^{13}C NMR, FT-IR, SEM, TEM, EDX, XPS, XRD and ICP-OES analysis. It was identified that the CHI presented good immobilization capacity of Pd NPs, and the achieved Pd NPs@CHI composite can act as a reactor with had high catalytic activity and excellent reusability for the reduction of 4-nitrophenol in water. The activation parameters of the reduction reaction of 4-nitrophenol catalyzed by Pd NPs@CHI using $NaBH_4$ were calculated as $Ea=10.8\ kJ\ mol^{-1}$,$\Delta H\#=8.1\ kJ\ mol^{-1}$ and $\Delta S\#=-234.8\ J\ mol^{-1}K^{-1}$

INVITED LECTURE

Artificial Spider Silks And Their Bottleneck

Jinlian HU
City University of Hong Kong

Spiders can produce up to seven different types of silk fibers with varying mechanical properties and functions to support their survival. These interesting properties can serve the requirements for high performance, smart functionality of materials for various applications. However, unlike silkworm silk spiders cannot be farmed due to their cannibalistic nature. This limits utilization of spider silks in their natural form for real world applications. The understanding of molecular structure of silks has inspired research by utilizing the repeating modules of spider silks with different gene sequence motifs to develop biomimic, novel and high performance materials. There are so far a range of recombinant spider silk proteins, namely, spidrions, being genetically produced by a variety of host organisms. Although such produced spidroins have been shown to be versatile proteins with the capability to be processed into diffeent morphologies, fibrous materials are still one of the most attractiveand yet difficult due to lack of full undestanding . By reviewing the recent progress in protein fibrilation conditions and fiber spinning, this talk will present key issues in making biomimetic fibrous materials for practical applications including textiles and apparel.

INVITED LECTURE

Microstructure Control of Graphene Oxide Gel Fibers for Enhanced Charge Storage

Zhenjie Yao、Gengzhi Sun
Nanjing Tech University

Graphene hydrogel fibers are promising candidates for emerging wearable energy storage devices. They shrink significantly during dehydration accompanying with complex internal structure transformation when trapped solvents are removed. Herein, we present a detailed study to correlate the dehydration of graphene hydrogel fibers with their porous structures and electrochemical properties. It is found that the fibers dried on glass substrate have the smallest shrinkage with a diameter of 49.02 μm, the largest surface area (310.90 m2 g-1), relatively high electrical conductivity (34.22 S m-1) and mechanical properties (227.6 MPa). Subsequently, the electrochemical properties of graphene fibers are investigated and used for solid-state supercapacitors. These new fundamental insights provide useful guides for controllable assembly of 2D materials into fiber architectures for energy storage applications and beyond.

INVITED LECTURE

Spider silk acts as a smart actuator

Dabiao Liu
Huazhong University of Science and Technology

Spider dragline silk has attracted tremendous attention due to its remarkable mechanical properties, including high strength and great extensibility, supercontraction. It is well-known that spider dragline silk is particularly sensitive to water. When wetted or saturated in high relative humidity, it can shrink up to 50% in length concomitantly with radial swelling, a phenomenon described as supercontraction. In this study, we show that the behavior of humidity-induced twists is related to the supercontraction behavior of spider dragline silk starting from the molecular scale. The characteristic 'memory torsion' of spider dragline silk derives from the specific molecular architecture foundational to the material. Given this new insight, we propose that tunable actuation can be designed more precisely than ever because the responsiveness of the material is encoded in individual molecules of silk. As a result, new designer materials can be built with specialized actuation properties from the nanoscale to the macroscale. As an additional innovation, we show that this material is hypersensitive to humidity and characterize the response spectrum for precision design with possible applications to highly sensitive humidity sensors. In particular, this material is ideal for its quick response time, reliability, repeatability, and accuracy. Humidity sensors have vast-ranging applications from health monitoring and HVAC systems applications, to greenhouse monitoring and meteorology/weather prediction. In the design of artificial muscles, as another example, multiple functions and mechanisms are important, so precise design is key. We demonstrate how to design for torsion in particular, as contraction, expansion, and rotation must be embedded for functionality. Our work presents a case study for multidimensional, multifunctional design.

INVITED LECTURE

Thread/yarn-based microfluidic devices for wearable applications

Zhisong Lu
Southwest University

Wearable devices have received tremendous interests in human sweat analysis in the past few years. However, the widely used polymeric substrates and the layer-by-layer stacking structures greatly influence the cost-efficiency, conformability and breathability of the devices, further hindering their practical applications. Herein, we developed a low-cost, light-weight and skin-conformable microfluidic thread/yarn-based system using a needle and a pair of scissors for rapid and accurate in situ analysis of human sweat. In the system, hydrophilic thread/yarn serves as the micro-channel to guide the liquid flow. The smartphone-based quantitative APP was applied to analyze the colorimetric sensors for sensitive and reliable detection of sweat pH, lactate and glucose. The system was also integrated with microbial fuel cells to harvest energy from human sweat. This work not only extends the applications of thread-based microfluidic device to human sweat analysis, but also provides a very promising approach to fabricate thread-based wearable systems for point-of-care diagnostics.

INVITED LECTURE

Bioinspired Polymer Nanocomposites

Qunfeng Cheng
Beihang University

With excellent mechanical and electrical properties, the two-dimensional nanosheets (TDN) such as graphene, MXene, have promising applications in many fields, especially in the area of nanocomposites. However, processing TDN-based nanocomposites is very difficult. So far, TDN-based nanocomposites exhibit rather poor properties. Nacre, the gold standard for biomimicry, provides an excellent example and guidelines for assembling two-dimensional nanosheets into high performance nanocomposites. The inspiration from nacre overcomes the bottleneck of traditional approaches for constructing nanocomposites, such as poor dispersion, low loading, and weak interface interactions. Herein, we summarizes our recent work on nacre-inspired TDN-based nanocomposites and focuses on the design of interface interactions and synergistic effects.[1-5]

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INVITED LECTURE

Fabric-type solar-powered integrated electronic circuit

Xing Fan、Xiaofei Wei、Siwei Xiang
Chongqing University

With the development of smart electronics, the problem of power supply for portable and distributed electronic terminals has become increasingly prominent. How to balance the electronic functions and power supply within a limited space, such as human-body wear, has become an important issue. Our researches have developed a series of all-solid photovoltaic fabrics, by directly weaving from fiber-shaped electrodes using shuttle weaving and stitch embroidery techniques, which has given energy devices a high degree of structural flexibility. The photovoltaic fabrics were then woven with fiber-shaped energy storage devices, including Zn-Mn battery and capacitors, to achieve a flexible fabric-type light energy harvesting and storage hybrid system. On this basis, we have further developed a series of fiber-structured sensors for monitoring environment emergency and body motion, and fiber-structured transistor devices for sensor signal processing. Following a proper circuit design, the above-mentioned various fiber devices were integrated in a novel all-woven way, to successfully realize an uninterrupted fabric-type integrated electronic circuit system. By collecting solar energy, this fabric-type integrated electronic system can continuously accomplish a set of electronic functions, including signal collecting, signal amplifying, logic computing, and real-time wireless transmission. Thence, it can be widely used in various scenarios, which can not only collect health data in a wearable way, but also act as a smart emergency assist by autonomously selecting the appropriate alarms for health or safety emergencies.

Integrated Dynamic Wet Spinning of Core-Sheath Hydrogel Fibers for Optical-to-Brain/Tissue Communications

Guoyin Chen、Kai Hou、Meifang Zhu
Donghua University

Hydrogel optical light-guides have gained significant interest for applications such as deep-tissue bio-sensors, optogenetic stimulation and photomedicine due to their biocompatibility, (micro)structure control and tissue-like Young's modulus. However, despite recent developments, the large-scale fabrication with a continuous synthetic methodology of core-sheath hydrogel fibers with desired optical and mechanical properties suitable for deep-tissue applications has yet to be demonstrated. In this study, we report a versatile concept of integrated light-triggered dynamic wet spinning (ILDWS) capable of continuously producing core-sheath hydrogel optical fibers having tunable fiber diameters, mechanical and optical-propagation properties. Furthermore, this concept also exhibited versatility for the various kinds of core-sheath functional fibers. The wet spinning synthetic procedure and fabrication process were optimized with the rational design of core/sheath materials with interfacial compatibility [core = poly(ethylene glycol diacrylate-co-acrylamide); sheath = Ca-alginate], optical transparency, refractive index and spinning solution viscosity. The resulting hydrogel optical fibers exhibit desirable low optical attenuation (0.18 dB cm-1 with 650 nm laser light), excellent bio-compatibility and tissue-like Young's modulus (< 2.60 MPa). The optical-waveguide hydrogel fibers (OWHF) were successfully employed for deep-tissue cancer therapy and brain optogenetic stimulation, confirming that they could serve as an efficient versatile tool for diverse deep-tissue therapy and brain optogenetic applications.

INVITED LECTURE

Stimulus-Driven Liquid Metal and Liquid Crystal Smart Actuators for Programmable Soft Robotics

Ling Wang
School of Materials Science and Engineering, Tianjin University, Tianjin 300350, China.

Sophisticated soft matter engineering has been endorsed as an emerging paradigm for developing untethered soft robots with built-in electronic functions and biomimetic adaptation capacities. However, the integration of flexible electronic components into soft robotic actuators is challenging due to strain mismatch and material incompatibilities. In this talk, I will demonstrate a general strategy to integrate electrically conductive liquid metals (LMs) and shape-morphing liquid crystal networks (LCNs) towards multifunctional and programmable soft robotics. A unique colloidal LM ink with superior adhesion and photothermal conversion efficiency was judiciously designed and fabricated by ultrasonicating LMs and miniature carboxylated gold nanorods (MiniGNR-COOH) in an aqueous suspension of biological bacterial cellulose. The designed nanocellulose-based colloidal LM ink is used for shape-deformable and electrically conductive LM–LCN soft robots that can be electro- and photo-thermally actuated. As proof-of-concept demonstrations, I will present a light-fueled soft oscillator, an inchworm-inspired soft crawler and programmable robotic Shadow Play exhibiting multifunctional controllability. The strategy disclosed here could open up a new technological arena for advanced multifunctional soft materials with potential utility in bioinspired soft machines, integrated soft electronics, human–computer interaction and beyond.

Bioinspired hierarchical helical nanocomposite gel fibers with rapid kinetic energy dissipation and hygroscopic actuation

Tao Chen、Peiling Wei、Guoyin Chen、Kai Hou、Meifang Zhu
Donghua University

As a kind of soft and elastic materials with high water content, hydrogel fibers have stimulated interest over several years due to their many similarities with biosynthesized fibers. However, to date, it has been difficult for hydrogel fiber to possess all high strength, high toughness and fast kinetic energy dissipation. While natural structural materials such as lignocellulosic fibers and collagen fibers have shown extraordinary tensile strength and toughness due to the hierarchical helical structure and rigid/elastic composite. Inspired by such natural structure, a series of hierarchical helical gel fibers through the combination of dynamic cross-linking microstructural gel networks and bioinspired helical macrostructural fibers are reported. Such helical gel fibers exhibit high tensile strength (>16 MPa) and outstanding toughness (~21.67 MJ·m-3), which enable them to effectively dissipate stress. In addition, the inherent dynamic cross-linking network and large number of hydrophilic polymers make such helical gel fibers capable of rapid kinetic energy dissipation (~0.5 s) and hygroscopic actuation.

Thermoplastic Photoheating Polymer Enables 3D-Printed Self-Healing Light-Propelled Smart Devices

Huixia Xuan、Yang Wang、Zhengwei You
Donghua Univercity

Swimming devices have shown great potential in various fields. Future swimming devices are expected to be capable of facile fabrication, smart on-demand transportation, and self-healing. Here, a swimming device is developed with the aforementioned features based on a newly designed photoheating thermoplastic poly(sebacoyl diglyceride-co-4,4′-azodibenzoyl diglyceride) (PSeDA). PSeDA). PSeDA can be instantly heated by ultraviolet light to modulate its spatiotemporal viscoelasticity. Accordingly, a series of swimming devices are customized via single integrated 3D printing. The micrometer-scale grid structure enables versatile multimode motion and generates a higher propulsive force than that of typical molded analogs based on the photoheat-induced Marangoni effect. The device exhibits smart transportation capabilities, including capture, conveyance, and release, and is also the first of its kind to achieve self-healing. This work provides a design principle for swimming devices in which the key is photoheating thermoplastics. This design principle of material is further demonstrated by synthesizing photoheating thermoplastics responsive to visible and near infrared light and will inspire an exciting field of thermoplastics.

对位芳纶/交联树形分子镀银纤维的制备及性能

耿雪、曲荣君、孔祥宇、耿胜男、张盈、孙昌梅、纪春暖
鲁东大学化学与材料科学学院

对位芳纶纤维 (PPTA) 是一种应用广泛的高性能纤维，具有耐磨、耐化学腐蚀、阻燃等优良性能[1]。但它们往往电绝缘性高，使用过程中易产生和积累大量静电，不仅会影响产品品质和人体健康，也会造成灾害事故[2]。若以合理的方法赋予芳纶纤维导电性，可使其消除静电，同时具有导电、电磁屏蔽的功能，可作为屏蔽材料和导电材料应用于航空、航天、军工、通讯等特殊部门[3]。化学镀法是制备导电纤维的一种常用方法，它无需大型仪器设备，操作简单、镀覆过程基本不会损伤纤维的力学性能[4]。由于对位芳纶纤维表面光滑，缺少活性位点，金属颗粒很难附着，因此在化学镀之前需要对芳纶纤维进行改性。超支化聚酰胺-胺树形分子 (HPAMAM) 末端含有大量氨基，反应活性高且价格低廉，其内部的空腔结构和外部的官能团可以有效地螯合、吸附金属离子，从而为化学镀提供催化活化中心。

本文以对位芳纶纤维为基材，用交联超支化聚酰胺-胺树形分子对其进行表面涂覆改性，然后通过化学镀的方法制备得到了一系列镀银导电芳纶纤维，研究改性过程对导电性能和力学性能的影响。

对原始对位芳纶纤维 (PPTA)、交联树形分子改性后的芳纶纤维 (PPTA-HPAMAM) 以及镀银后的导电芳纶纤维 (PPTA-HPAMAM/Ag)进行了扫描电镜表征，发现原始对位芳纶纤维表面光滑，粗糙度很低；经过交联树形分子改性之后的芳纶纤维表面有一层薄膜，粗糙度增加；镀银之后的芳纶纤维表面被银层覆盖，且银层是致密、均匀的。

力学性能测试表明改性和镀银对芳纶纤维的力学性能没有产生明显的影响。

通过用万用表测定镀银纤维的定长电阻来分析导电性能。镀银后的芳纶纤维展现出良好的导电性，定长电阻最低达到 0.11 Ω/cm。而且随着 HPAMAM 浓度的增加，镀银纤维的电阻逐渐降低，在浓度为 20 g/L 时电阻达到最低值，导电性最好，随着 HPAMAM 浓度的进一步增大，镀银纤维电阻变大，导电性减弱。这可能是因为 HPAMAM 溶度过高时，改性纤维上树形分子膜的厚度增大且不均匀，导致镀银纤维上的银层不均匀，导电性减弱。

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仿生复杂多相功能力学凝胶材料

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自然界中的生物凝胶利用多组分生物大分子的协同作用实现多种生命学功能。聚合物的多组分复合已经成为发展高性能高分子水凝胶的一种卓有成效的途径，是高分子材料领域一个重要前沿课题。我们围绕“凝胶网络中多组分聚合物可控微相分离与界面调控”这一关键科学问题开展了系统的研究，向自然学习，模仿肌肉组织，制备的油水凝胶互穿网络，在复杂环境下具备高强、稳定、可编辑等特性。（1）提出亲水/亲油高分子协同网络的设计理念，制备了异质高分子互穿网络的自适应耐低温油水凝胶，并应用于耐低温柔性传感器、超级电容器及抗生物粘附等领域。（2）利用界面反应构筑了微相界面稳定的油水复合网络，实现了油水凝胶的功能化、力学性能响应性及形变可控性，并应用于可变形智能微流体通道及自适应软体机器人等领域。（3）揭示了限域环境下凝胶表面的超铺展特性，基于此发展了一种流体剪切取向纳米片的普适性方法，实现了高强度层状结构复合材料的大面积可控制备。

光热电和水电效应协同作用的多级结构光热电纺织品

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多功能人体微环境自适应微型发电器对便携式可穿戴设备的发展具有巨大的潜力。因此，通过两步复合聚合策略开发基于 PDA 调控的 PEDOT 基的多级梯度结构光热电纺织品。所得的 PEDOT 基热电纺织品上表面具有优异的热电性能(PF=88.70 nW/(m•K²))，而具有“光陷阱”的下表面具有优异的光热效应，其在 175 W IR 光下可达 70°C 左右。基于此，采用缝纫技术将 PEDOT 基织物和镀银织物间隔组装得到织物太阳能板。干态织物太阳能板在 500 W 光照下可 输出 1.23 mV 的电压。有趣的是，在光热电和水电效应的协同作用下，湿态织物太阳能板在 500 W 光照下可产生~11.4 mV 的电压和 2.03 μW 的功率；同时，在 1 小时内还可以产生~2 g 水蒸气。因此，织物太阳能板可以同时收集、转化太阳能并产生太阳能蒸汽，并为制造可用于人体温、湿度管理的智能可穿戴能量收集器提供新途径。

利用全因子实验设计模型优化角蛋白载药 pH 响应型纤维的释药性能

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为研究纤维基载药羊毛角蛋白支架的肠道抗癌释药性能，以 5-氟尿嘧啶（5-FU）为药物模型，采用全因子矩阵实验设计（DoE），在不同酸碱环境下，以多个显著性因子在两水平上优化 pH 敏感性释放性能。这种全因子 DoE 方法既可用于识别复合生物功能系统的主要效应，也可用于研究多因素相互作用的影响。利用扫描电子显微镜（SEM）图像显示，在较低的 15kV 电压下，可以得到到具有均匀结构的复合纳米纤维基质；同时傅里叶变换红外光谱（FT-IR）证实羊毛角蛋白在 1630 和 1550cm−1 处有特征峰；最后，药物缓释测试结果表明，角蛋白与聚 L-丙交酯（PLLA）的比例是控制药物缓释性能的主要因素。通过 DoE 优化后，角蛋白含量为 50%的复合载药纳米纤维在 120h 的缓释过程中，在 pH7.4 的环境中释放 48.5%的药物，而在 pH6.0 的环境中时释放出 83.7%的药物。通过 DoE 优化调整操作因子，使得羊毛角蛋白纤维支架的 pH 响应性显著提高。

高导 PEDOT:PSS 电极的制备及在柔性器件上的应用

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导电聚合物 PEDOT:PSS 具有由于具有可水溶液加工、高透光率（大于 90%）、高电导率(＞1000S/cm)、功函数可调、良好的柔韧性及空气稳定性等优点，成为当前柔性电极的希望。本报告将汇报 PEDOT:PSS 高导柔性电极的制备、表征及在柔高性能超级电容器、热电及光电容器组合器件上的应用。

在前期研究工作中，汇报人聚焦高导透明 PEDOT:PSS 电极和非透明自支撑 PEDOT:PSS 电极的制备及应用.（1）通过在 PEDOT:PSS 溶液中掺入新型表面活性剂 PEG-TmDD，同时解决了溶液的浸润性及材料的导电性问题，作为顶电极应用到 Metal-free 太阳能电池中；（2）在柔性基底上 PES 制备了电导率高达 2700 S/cm 的柔性透明电极，作为底电极应用到全塑料有机太阳能电池中；（3）发展了一种新的快速制备自支撑 PEDOT:PSS 电极的方法，创造了自支撑导电高分子材料的电导率记录，实了该自支撑薄膜在高性能超级电容器、热电及电池-电容组合器件上的应用；（4）基于前期在透明电极和自支撑电极上的研究成果，全溶液发制备了大面积光电容器模组器件，展示了其较好的应用前景。

纳米银抗菌芳纶纤维的制备及其性能研究

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鲁东大学

对位芳纶（PPTA）是一种性能优异的的高性能聚合物纤维，具有高抗拉强度、高模量、轻量化、阻燃等优异性能，被广泛应用于个体防护服装[1,2]，如消防工作服、防弹衣等。防护服装在实际使用时环境较为极端，不能及时维护，容易滋生细菌，不仅会降低服装的舒适性，还会对人体健康产生威胁。因此对位芳纶纤维的抗菌功能成为其应用的重要要求。但是 PPTA 纤维分子之间具有较强的相互作用力，分子链排列取向度高，导致结晶度高，难以改性；而且纤维表面光滑、表面自由能低，呈化学惰性[3,4]，常规的物理方法在其表面负载的抗菌剂容易脱落，为此，我们采用超声溶胀的方法，将银离子引入到溶胀后的纤维当中，然后使用还原剂在原位还原形成银纳米颗粒，得到的纳米银抗菌芳纶纤维（PPTA/Ag）具有极强的抗菌能力。

本文提供了一种在 PPTA 纤维中原位还原制备纳米银抗菌芳纶纤维方法：PPTA 纤维在丙酮中回流抽提，以去除表面杂质，随后于 60℃烘箱中干燥备用。将干燥好的 PPTA 纤维浸没在一定浓度的硝酸银的 N-甲基吡咯烷酮溶液中，避光超声预定时间，随后在一定温度下使用还原剂还原，将得到的纤维冲洗、干燥，制得 PPTA/Ag。

使用扫描电镜对 PPTA/Ag 进行表征可以发现，在改性之后 PPTA 表面出现了颗粒状的物质，大小在 10-20nm 左右，通过 EDS 分析，这些颗粒是纳米银颗粒，证明了纳米银颗粒成功负载到 PPTA 纤维上。随后使用 FT-IR、XPS、XRD 表征了 PPTA/Ag 的结构。

使用振荡法和琼脂平皿法研究了 PPTA/Ag 对大肠杆菌和金黄色葡萄球菌的抗菌性能，结果显示，纤维对大肠杆菌的抗菌性能基本达到 100%，对于金黄色葡萄球菌的抗菌性能达到 99%以上。

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原位合成芳纶纳米材料及其在超滤膜中的应用

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芳纶纳米纤维作为一种极具潜力的纳米级构筑模块，继承了宏观纤维的优良性能，同时兼具独特的量子尺寸效应[1]。芳纶纳米纤维与基体间相互作用的有效性放大了人们对芳纶纳米纤维的研究热情，更由于其本质上具有的有序且不对称的纳米分子链结构和分子间氢键，因此在膜分离领域[2, 3]及在多种复合材料中的应用[4]受到广泛关注。然而宏观纤维的耐溶剂、耐高温、耐腐蚀等特性阻碍了其可控纳米化过程。广泛应用的碱熔法[5]虽降低了芳纶纳米纤维的制备难度，但存在着制备周期长、所得聚合物含量少、难以从制备体系中分离提纯等缺点。为克服以上弊端，本文提出了于聚氯乙烯（PVC）体系中“自下而上”的策略原位合成芳纶纳米材料，无须分离纯化可直接作为铸膜液，后经相转化法制备超滤膜。

本文直接在聚氯乙烯中，经对苯二胺（PPD）和对苯二甲酰氯（TPC）两种单体低温聚合形成芳纶纳米材料。通过改变两种单体的比例制备不同含量芳纶纳米材料的铸膜液，后经相转化法制备复合超滤膜。

通过透射电镜对芳纶纳米材料的形貌进行观察，结果显示合成的芳纶纳米材料呈现纳米微球状且在 PVC 基体中分散良好；扫描电镜对复合超滤膜的横截面观察显示，复合超滤膜具备一般超滤膜的结构，即致密的皮层、多孔亚层和指状孔结构；使用实验室自制的超滤装置，对复合超滤膜的超滤性能进行表征，截留动力学曲线显示其保持了良好的截留性能。

因此本文希望能够提供了一种快速制备含芳纶纳米材料的超滤膜的新方法。

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有机无机杂化绿色钛系缩聚催化剂及其聚酯工业应用

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目前，国内 90%以上聚酯生产采用锑系催化剂，锑为重金属危害人体健康，并且锑系催化剂在染整、碱减量处理和纺织退浆时容易从纤维/织物中析出进入废水而对生态环境造成危害，因而开发生态、环保型绿色高效催化剂变得尤为迫切。
钛系催化剂是绿色聚酯催化剂产业应用研发的重点。本文综述了典型钛系催化剂的性质和应用性能，重点介绍了东华大学蒙泰课题组基于有机无机杂化原理，研制的杂化型钛基聚酯催化剂（DH-HyTi）及其产业应用进展，比较分析了不同钛系催化剂基聚酯树脂的结构性能差异，发现钛系催化剂对聚酯树脂的结晶行为有显著影响。DH-HyTi 钛基聚酯催化剂具有耐水解、高活性且催化效能稳定和活性可调可控的特点，目前已实现批量生产和半连续、小型连续聚酯生产线应用。

闪蒸法医用防护纤维与健康材料

罗章生
厦门当盛新材料有限公司

为拓宽防护服的材料来源，提升防护服产品质量水平，推广国产闪蒸纤维材料的产业化应用，对闪蒸法纳微米非织造材料与市场上典型的防护服材料的差异作了对比分析。分别从材料形态结构、材料强度及防护性、摩擦后防水防化学品渗透方面比较闪蒸非织造材料与微孔膜材料、SMS 材料的表现，介绍了闪蒸非织造材料在不同灭菌方式适应性及耐老化的优点。

Abstract:

In order to broaden raw material source for protective clothing, improve protective clothing product quality, promote industrialization for nationalized flash-spun fiber material, this article analyzed and discussed the differences between flash-spun nano/micro-fiber nonwoven and typical protective clothing material. It compared flash-spun nonwoven to Microporous film and SMS material in respects of morphological structure, strength and water-resistance and anti-permeation to chemicals performance after abrasion. Compatibility to different sterilization process and better ageing resistance performance are also introduced.

低碳背景下纤维产业发展趋势

王华平
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低碳背景下纤维产业发展趋势

The release of microplastic fibers from wiping materials and masks

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Microplastics (MPs) released from textile washing represent a growing and alarming terrestrial source for microplastic contamination. However, there is limited information considering other domestic usages of textile fabrics as important pathways for MPs entering the environment. In order to evaluate the role of wiping processes on the release of MPs, an analytical protocol was set up to quantify MPs shedding from wiping materials and masks on domestic wiping conditions. Given the widespread distribution and projected increase of wiping materials and masks in the global market, there is an urgent need for raisingpublic awareness of microplastic pollution in our daily usage and putting forward appropriate disposal methods for end-of-life management.

The Preparation and Properties of Para-aramid /Polyphenylene Sulfide Composites by Wet Papermaking

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With the development of science and technology, high performance paper-based materials have become the development direction and trend of special paper industry. The development of special paper with excellent mechanical properties is one of the hot topics in the field of special paper. The aramid paper-based material is generally prepared by aramid chopped fibers (ACFs) and fibrids fiber through modern wet paper process. They inherit a number of excellent properties of aramid fiber, and show good processability and redesign. There, it is widely used in rail transportation, electronics and electricity, aerospace, national defense and other high-tech fields. In addition, aramid paper-based materials also play an important role in the modern industry. Polyphenylene sulfide (PPS) has a very high bonding strength for aluminum, titanium, stainless steel, glass fiber and other metal materials. In the PPS ultrafine fiber prepared by melt-blown method, various fibers with different diameters form intersecting network structure. The obtained PPS ultrafine fiber has the advantages of small linear density, large specific surface area, excellent high temperature resistance and strong thermal stability. PPS bond aramid chopped fiber composite is a new type of structural composite fiber, which has excellent thermal stability, structural stability, water performance and dielectric properties. In this paper, the ACFs/PPS composites were prepared by wet paper making process and hot-pressing method, using para-aramid chopped fibers (ACFs) as the skeleton and PPS as the filler and binder.

智能纤维的制备及产业化研究

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智能纤维可感知外界环境变化并做出响应，主要有智能变色纤维、形状记忆纤维、智能调温纤维等。本研究深入探索了智能交互纤维和智能热湿调节纤维的制备工艺及性能影响，实现了智能纤维的产业化，拓展了智能纤维在纺织品中的应用。智能交互纤维在光、热、湿或辐射等刺激下纤维自身会发生可逆响应。通过引入具有光照、温度和外力刺激响应功能的小分子或赋予纤维加捻结构，制备了在外界刺激条件下可发生变色、旋转和收缩的智能交互纤维。智能热湿调节纤维能够根据外界温湿度变化吸收/释放能量或改变自身结构，实现对微环境中温湿度的动态调节。通过在纤维中复合相变材料或构建非对称结构复合纤维的方法，制备了能够依靠织物调节人体热湿舒适性的智能热湿舒适纤维。

有机无机杂化构筑多功能纤维材料

周哲、孙宾、相恒学、成艳华、朱美芳
东华大学材料科学与工程学院 纤维材料改性国家重点实验室

纤维材料是关乎国计民生和国防建设的重要基础材料，2020 年我国化学纤维产量高达 6000 多万吨，占全球总量 70%以上。在化学纤维产量稳步增加的同时，如何赋予纤维高品质多功能性，成为化纤产业的国家战略需求和国际竞争焦点。针对纤维材料发展中面临的关键科学难题和技术瓶颈，东华大学朱美芳院士团队历经多年研究攻关，创新性地提出了有机无机原位杂化构筑多功能纤维的新思路。本报告介绍近年来团队在有机无机功能杂化材料基础理论与多功能纤维制备关键技术及产业开发方面的进展，并围绕行业高质量发展所面临的挑战和机遇，提出若干思考和建议。

可穿戴敏感材料与传感器

王冉冉、杨以娜、李毓祥、闫秋阳
中国科学院上海硅酸盐研究所

传感器作为信息采集的前端基础，是可穿戴电子设备的核心器件，在健康医疗、人工智能、先进作战等国家重点部署领域具有广阔的应用前景。刚性传感器与人体皮肤或内脏器官的机械属性不匹配，导致生理信号测不到、测不准或测试信息有限等问题。相比之下，柔性传感器具有更高的适形性和生物安全性，在穿戴式健康监测和疾病诊疗领域更具有优势，成为近年来的国际学术前沿研究热点。新型柔性敏感材料的发展是实现传感器本征柔性化的关键。本汇报将围绕新型敏感材料的制备、敏感器件构筑、柔性传感器在可穿戴健康监护、疾病诊断等领域的应用，详细介绍汇报人团队在新型敏感材料的设计与研制、柔性传感器应用探索工作以及汇报人关于柔性敏感电子学发展的一点思考。

磁透镜静电纺丝纤维的可控制备机理研究

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静电纺丝是生产纳米级纤维最直接且高效的技术之一，但其射流的弯曲不稳定性与纤维直径分布的不均匀性一直是阻碍其进一步发展的瓶颈。与电子显微镜中的发散电子束受磁控而聚焦类似，静电纺丝射流表面在电场的作用下附着电荷，在磁场中同样会受到磁场力的作用。因此本文首次构建一种主要由励磁线圈、极靴和磁轭组成的磁透镜装置应用到静电纺丝系统来约束静电纺丝带电射流的弯曲不稳定性。首先从电场、磁场和流体的多物理场角度对磁透镜静电纺丝纤维的可控制备机理进行研究，然后从仿真和实验的角度分别比较了其与传统静电纺丝和引入励磁线圈对射流和纤维直径的控制效果。研究结果表明磁透镜对静电纺丝带电射流弯曲不稳定性有更好的聚焦作用，可使射流摆动幅度趋于更小更稳定的状态。在本文所做的实验中，与传统静电纺丝相比，引入磁透镜之后的纤维膜面积平均缩小了 19%，纤维直径平均减小了 8%，均匀度平均增加了 47%。

电纺微纳三维打印在生物医药领域的应用

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本团队致力于发展静电纺丝微纳三维打印装备，通过加工工艺研究、设备开发、应用探索来推动纳米纤维的产业化发展。在最新的应用研究中，制备了 PCL/PEG/ROX（罗红霉素）复合纤维抗感染载药支架，用于骨修。结果表面，加入的 PEG 可以加快罗红霉素的释放，并随着 PEG 含量的增加，速率有微小的加快，实现控制释放的目的；在 5%PEG 含量的支架中表现出最大的细胞增殖。

百草原茶改性粘胶大生物纤维的制备及其性能

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为了解决天然活性成分在粘胶纤维生产过程中易损失导致功能下降的问题，本研究将茶的生物活性成分（儿茶素类物质）采用自主研发的分子巢技术进行装载，对生物活性成分进行耐酸碱和耐高温保护，制备出具有良好抑菌、抗病毒、抗氧化效果的功能性纤维，即百草原茶改性粘胶大生物纤维。通过比较不同产地、不同生长时期茶叶中儿茶素类活性成分含量、组分和生物学功能，选取功效最优的原料；选择超临界 CO2 萃取技术进行活性成分萃取，保证活性成分多功效的保留；采用扫描电镜、HPLC、力学测试和功效测试对其大生物纤维的性能开展研究。结果表明：山东崂山绿茶（夏季采摘）含有优质的儿茶素类活性物质；介孔 SiO2 颗粒对活性物质的载物量达 60.3%；纤维的分子巢分布于纤维内部，粒径大小为 100 nm 左右；纤维断裂强度为 2.47 cN/dtex，纤维中儿茶素类活性成分总含量为 4.35mg/kg，纤维抑菌率≥90%，抗病毒率≥99%，抗氧化 ABTS 自由基清除率≥80%，均显著优于对照纤维（P<0.01）。研究可为今后天然活性成分改性纤维的制备提供参考。

艾草改性涤纶纤维及其性能研究

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目前，国内外市场上的功能性聚酯类产品主要通过添加有机、无机、天然材料实现其功能。但是有机和无机材料对人体有一定的刺激性和毒副作用；而天然材料在高温过程中容易碳化失活。本研究首先超临界 CO2 萃取技术萃取艾草的有效成分、制备介孔 SiO2；然后将艾草有效成分装载到制备的介孔 SiO2 中，进而与聚酯切片熔融共混，制备功能性母粒；最后制备功能性母粒与普通聚酯切片共混纺丝、得到艾草改性涤纶纤维。熔融过程中介孔 SiO2 对艾草活性成分进行高温保护。研究采用正交实验确定介孔 SiO2 的粒径、孔径、比表面积、载物量以及熔融体系中介孔 SiO2 与 PET 的比例。结果表明：制备的 SiO2 的粒径、孔径、比表面积分别是 100±5nm，3±0.5nm，730±5m2/g；载物量可达 65%；制备的艾草改性纤维断裂强度 3.3cN/dtex，具有良好的抑菌、驱蚊等功效，对金黄色葡萄球菌、大肠杆菌、白色念珠菌的抑菌活性率≥99%；50 次洗涤后可达 AAA 抗菌；驱蚊率＞34%。

熔融纺丝制备羟基功能化聚丙烯/聚丙烯复合纤维

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Hydroxy-functionalized polypropylene(PPOH)/polypropylene(PP) blend fiber with the ratio of 10/90 was successfully prepared through melt spinning. Morphology analysis of fiber surface was obtained by SEM micrograph and mechanical properties of fiber was studied. SEM mages showed that polar PP copolymer was tend to reduced crystal grain size and crystallinity. The addition of polar PP copolymer was decreased the breaking strength and elongation. Breaking strength and elongation of PPOH fiber was 25.3 cN/dtex and 104%.