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Multibiomimetic Superhydrophobic Metamaterials for Daytime Radiative Cooling

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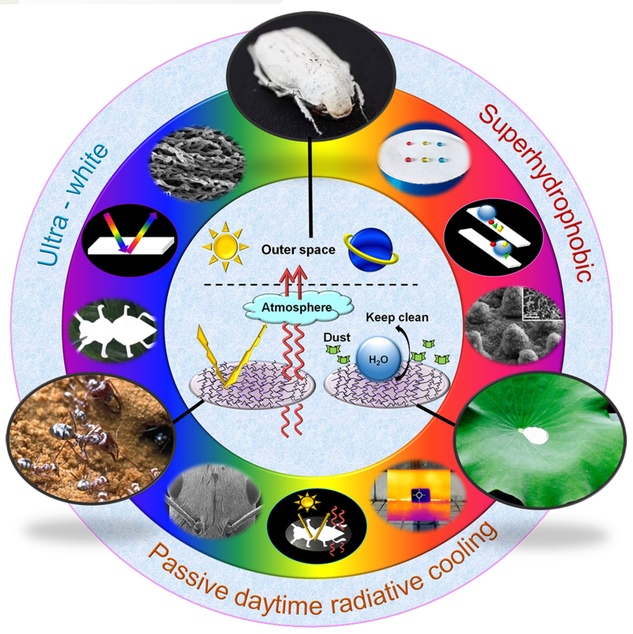
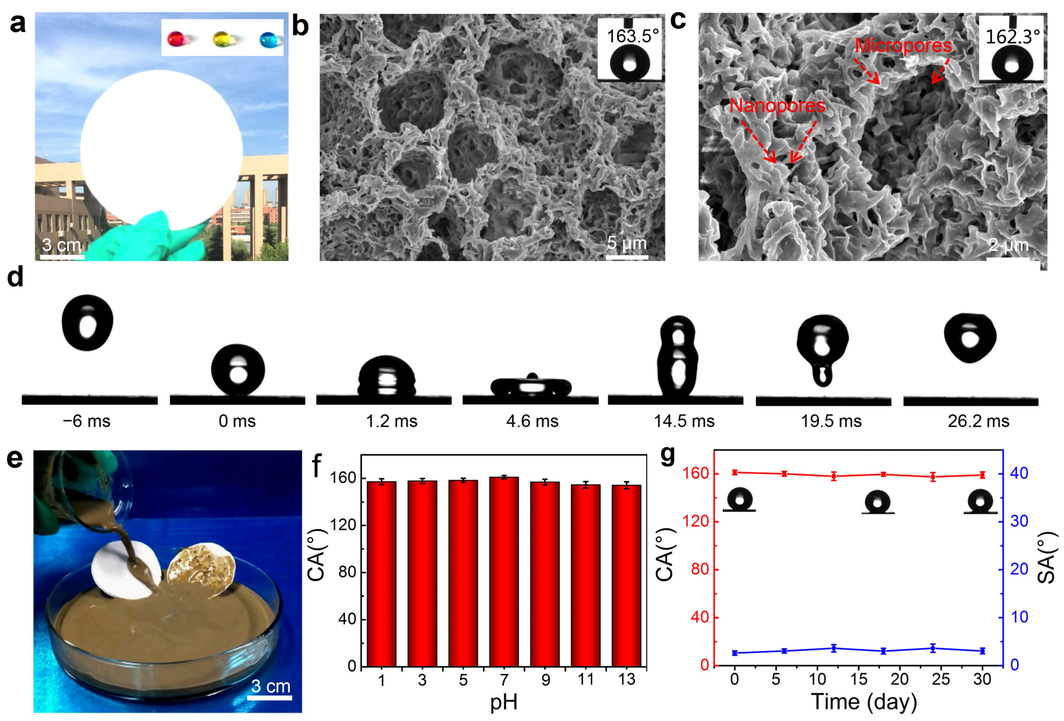
Introduction



Passive daytime radiative cooling (PDRC) presents a promising potential to reduce global energy consumption without the use of additional electricity. In spite of exciting progress, most of radiative cooling materials are limited by poor durability imposed by the surface contamination in harsh environments and complicated manufacturing processes, which hinder their practical applications. To overcome these challenges, here we developed a novel hierarchically structured coating that mimics the structures and functions of Cyphochilus beetle, Saharan silver ant and Lotus leaf, synergistically resulting in a strong sunlight reflection, high thermal-infrared emission and robust anti-contamination. This heterogeneously integrated coating is also scalable and can be utilized on arbitrary surfaces, yielding a sub-ambient temperature drop of 13.8°C under strong sunlight and a net cooling power of ~118.5 $W \cdot m^{-2}$ even under long-time outdoor exposure.

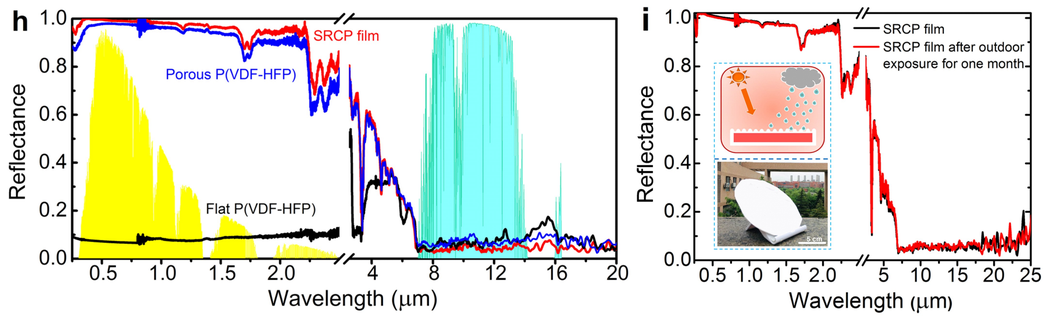
Results & Discussion

● Morphology and Wettability of the SRCP Film



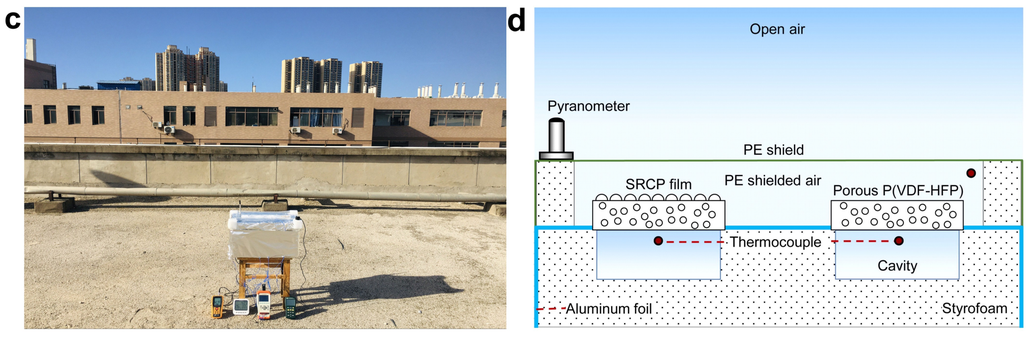
The superhydrophobic radiative cooling porous (SRCP) film shows an ultra white appearance and has excellent super-hydrophobic properties.

● Optical Characterization

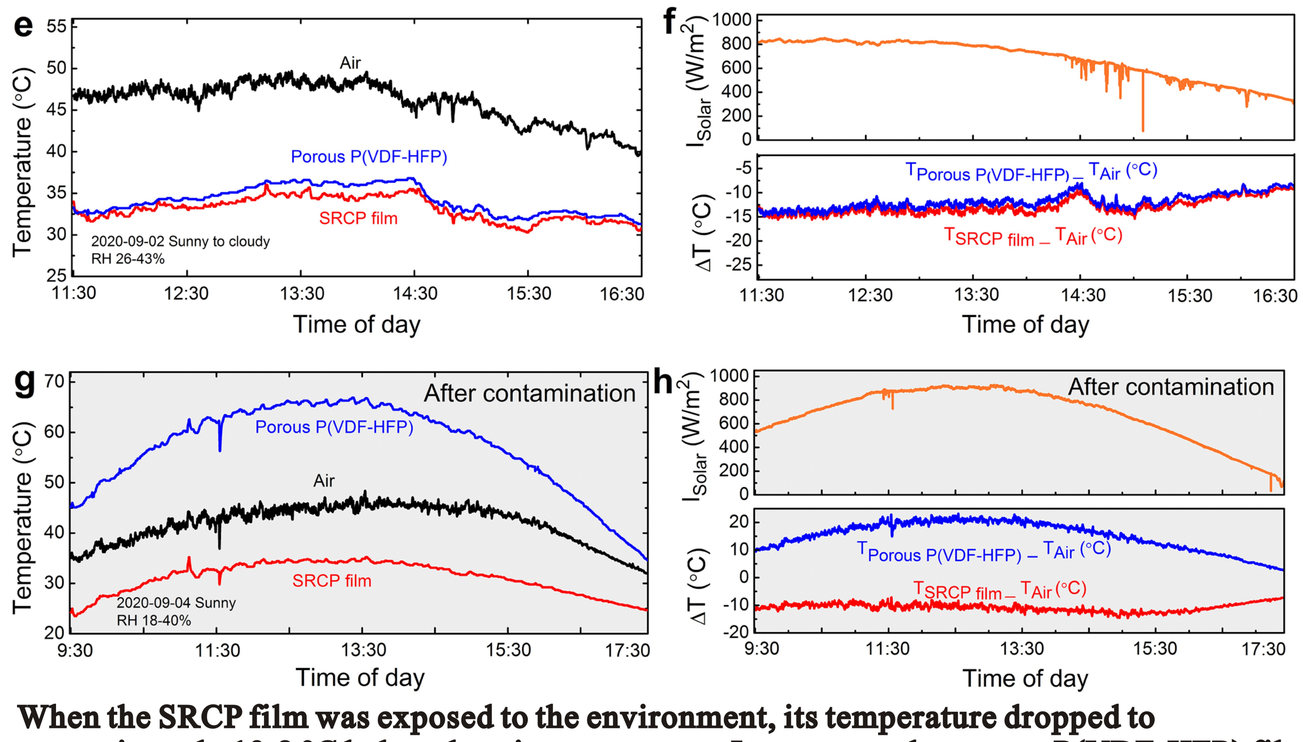


The SRCP film surface has a high sun reflectance to minimize absorption heat from sun and high thermal infrared emittance to favor sending heat loss to the sky.

● Daytime Radiative Cooling Performance

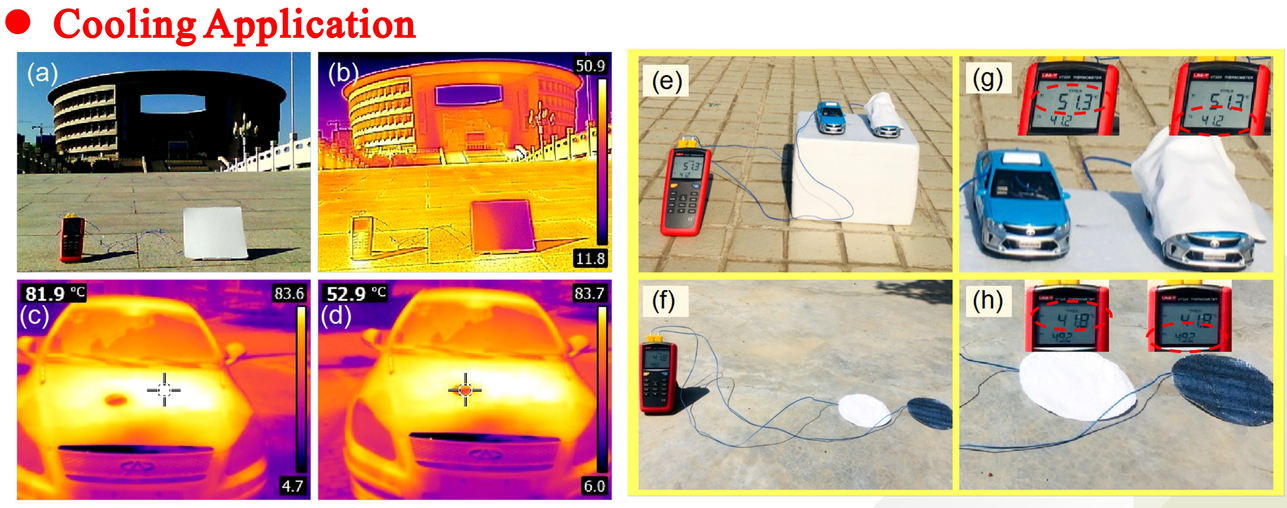


The photo of the cooling setup on the rooftop and its illustration.

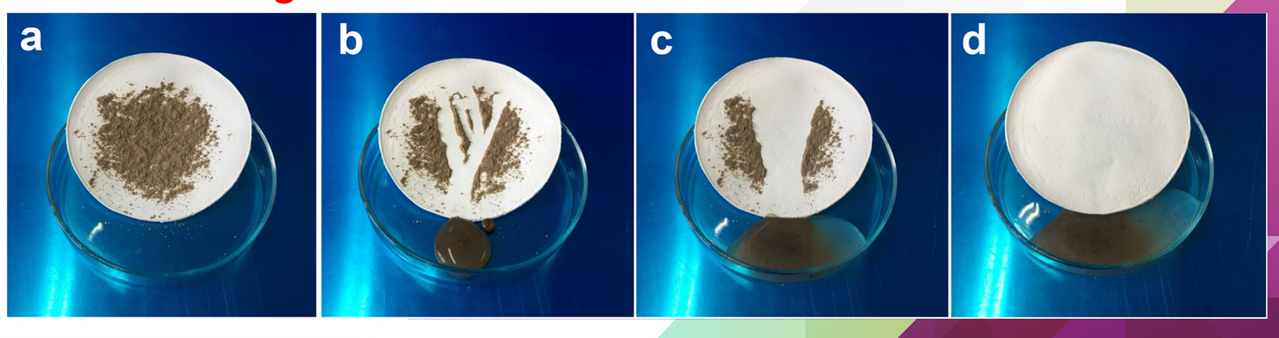


When the SRCP film was exposed to the environment, its temperature dropped to approximately 13.8 °C below the air temperature. In contrast, the porous P(VDF-HFP) film was prone to mud contamination and its surface temperature dramatically rose to 20.6°C above the ambient temperature.

● Cooling Application



● Self-Cleaning



Conclusion

- **The free-standing micro/nano porous P(VDF-HFP)/PDMS metamaterials were fabricated successfully with superhydrophobicity and daytime radiative cooling.**
- **The method might help to promote energy technology with no electricity consumption, which is simple and suitable for large-scale production.**