Beyond the Coating: How Glass Chemistry Drives Adhesion

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What determines how well coatings adhere to glass, and why does adhesion change over time? To answer these questions, we must look beyond coating formulations and recognize glass itself as an active player in adhesion. By leveraging ToF-SIMS and other analytical tools to examine the chemistry on both sides of the adhesion equation (coatings and glass), we uncover how subtle variations in glass composition trigger chemical interactions and degradation of the film, particularly over extended periods at elevated temperature and humidity. Through examples—including model ink coatings with silanes that promote stronger adhesion and polyolefin-based film laminates, which are largely governed by van der Waals forces—we demonstrate how detailed analysis of the glass–coating interphase can expose root causes of failure that are often overlooked in conventional adhesion science. These insights highlight the value of chemically resolved interfacial analysis for understanding, predicting, and ultimately improving the durability of glass–organic interfaces.

Figure 1 shows an example of ToF-SIMS assessment of a model ink coating on soda-lime glass before and after accelerated aging. The analysis reveals significant alkali migration into the coating, and accumulation of alkali reaction products at the coating/glass interface, providing direct insight into the chemical processes that contribute to adhesion loss. As will be discussed, the migration of sodium-containing species into the coating can promote coating degradation, further influencing adhesion. Although multiple tools were used in this study, ToF-SIMS is particularly powerful because it enables characterization of all interfaces while providing 3-D chemical information from both the glass and coating sides.

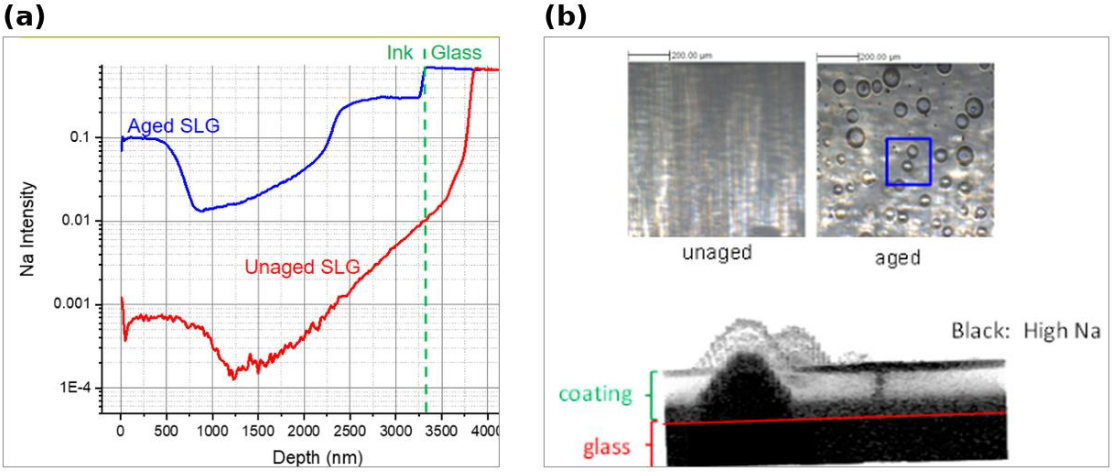

Figure 1. (a) ToF-SIMS depth profiles of a model ink coating on unaged and aged soda-lime glass: after aging (85 °C, 85% RH, 500 h) considerable sodium migration is observed into the coating. (b) Optical images of the coating before and after aging, together with a 3-D ToF-SIMS reconstruction, reveal that the migrated sodium forms sodium-rich corrosion products and pinhole defects localized precisely at the coating/glass interface—the sites where adhesion ultimately fails.