Liquid-like layers for ubiquitous solid and liquid repellency

K. Golovin.

University Of British Columbia - Kelowna (Canada)

Grafting polymeric chains to solid surfaces affects their wettability and adhesive properties. If the polymer chains remain liquid-like, the alterations in both wettability and adhesion can be startling. In this talk I will discuss some of our recently work developing liquid-like omniphobic (all liquid repellent) layers using the covalent attachment of linear polydimethylsiloxane (PDMS). In terms of liquid repellency, these surfaces can repel almost any liquid with near non-existent contact angle hysteresis. This includes the repulsion of fluorinated liquids with lower surface tension than the surface energy of either crosslinked or liquid PDMS. The contact angle hysteresis with both high and low surface tension liquids is so low on these surfaces that we were forced to develop a new characterization technique, based on tilt angles, that reduces the inherent inaccuracies associated with traditional contact angle goniometry. Further, when deposited on materials with inherent re-entrant texture, the resultant surfaces display superomniphobic properties without the use of perfluorination. For example, the liquid Krytox 100, a perfluorinated oil, beads up and rolls off these surfaces although its surface tension is 16 mN/m. Counter intuitively, liquids that swell bulk PDMS (toluene, heptane, etc.) are repelled by these layers as well, although the mechanism for this repellency is still not fully understood. The solid adhesion properties of these liquid-like layers is equally interesting. The fracture of solid foulants like ice, wax, and dried mud requires minimal shear force, and these solids slide on the surface of the PDMS chains without de-bonding. However, in tension the adhesion is orders of magnitude higher due to capillarity, in line with the idea that the chains act as a liquid. Further evidence is demonstrated when altering the shear rate during adhesive fracture, as the liquid-like layers behave exactly like a non-Newtonian fluid. For low shear rates the force required to slide solids adhered to these layers is minimal and on par with state-of-the-art anti-adhesion surfaces. Increasing the shear rate increases the necessary force required to fracture the interface. Overall, their solid and liquid adhesive properties make these liquid-like layers an exciting new type of surface that shows promise in a number of different applications ranging from food packaging to anti-icing coatings to waterproof clothing.

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References

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