A novel salvinia-like slippery surface

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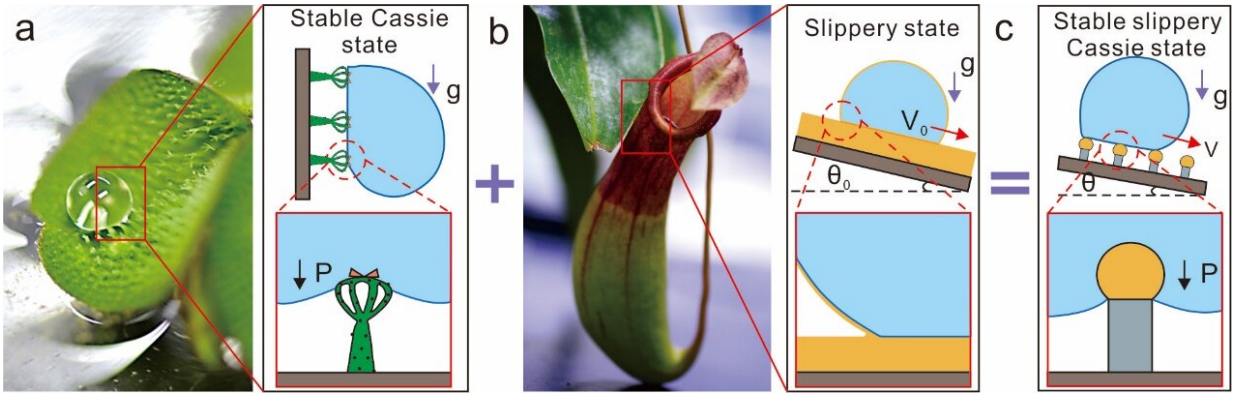

Design of the Salvinia-like slippery surface. (a) Salvinia molesta floating leaf on which water drop displays stable Cassie state. Though the rational design of elastic eggbeater-shaped microstructure with surface energy gradient in vertical direction could stabilize the contact line to prevent impalement, such structure has strong adhesion because of the hydrophilic patches. (b) A pitcher plant-inspired slippery surface with molecularly smooth lubricant fixed on the top of the microstructure which enable fast drop or liquid transportation. (c) The combination constitutes the SSS on which water drop shows slippery stable Cassie state. The black, purple, and red solid arrows represent the directions of pressure (P), gravity (g) and the velocity of drop transport (V), respectively. Credit: ©Science China Press

Superhydrophobic surfaces are widely used in many industrial settings, which mainly consist of rough solid protrusions that entrap air to minimize the liquid/solid area. The stability of the superhydrophobic state favors a relatively small spacing between protrusions. However, this

in turn increases the lateral adhesion force that retards the mobility of drops. Thus, the simultaneous optimization of both stability of the Cassie state and minimization of the lateral adhesion force remains a great challenge for SHPOS with high performance.

In nature, Salvinia leaves show a long-lasting Cassie state under water, owing to the hydrophobic eggbeater-like trichomes with hydrophilic pins on the top. The hydrophilic-to-hydrophobic boundary pins the water/air contact line in the vertical direction. However, the pinning effect also diminishes the mobility of the contact line in the horizontal direction. In another research line, slippery liquid-infused porous surfaces (SLIPS) inspired by the Nepenthes pitcher plants, have been demonstrated as promising substrates where low lateral adhesion force for drops of any liquid is required. A drop on a liquid-infused slippery surface, however, shows both smaller contact angle and shedding velocity compared to the SHPOS. Thus, to get a structure with both stability of the Cassie state and minimization of the lateral adhesion force, we need to combine SHPOS and SLIPS. However, the introduction of a stable air cushion between protrusions with slippery surface is challenging because of the low surface tension of the lubricant.

In response to this challenge, recently, inspired by the Salvinia leaf with stable water/air contact line and Nepenthes pitcher plants with mobile water/air contact line, the materials surface science research team led by Professor Xu Deng from the University of Electronic Science and Technology of China (UESTC) cooperated with professor Periklis Papadopoulos (University of Ioannina) proposed a Salvinia-like slippery surface (SSS). The SSS consists of lubricant-infused cross-linked polydimethyl siloxane (PDMS) layer on the top of pillars with hydrophobic side walls. The lubricant creates an additional energy barrier, against quasi-static and dynamic impalement. Furthermore, the oil layer on the top of the structure also works as a lubricant which reduces the adhesion and improved the drop mobility significantly.

Therefore, drops on the SSS show stable slippery Cassie state, avoiding the strong pinning effect on the hydrophilic pitches of the Salvinia plant. Compared with a control surface with the same structure without lubricant, the SSS exhibits increased stability against pressure and impact, the enhanced lateral mobility of water drops as well as the reduced hydrodynamic drag. Owing to its easy fabrication and enhanced performance, the SSS will be useful in transport of viscous fluids, pipelines and microfluidic devices.

More information: Xiaomei Li et al, Salvinia-like slippery surface with stable and mobile water/air contact line, *National Science Review* (2020). DOI: 10.1093/nsr/nwaa153

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