Wetting states on superoleophobic surfaces

Periklis Papadopoulos[1], Doris Vollmer[2] and Hans-Jürgen Butt[2]
[1]*Department of Physics, University of Ioannina, GR-45110, Greece*
[2]*Max Planck Institute for Polymer Research, Mainz, D-55128, Germany*

Water repellency on superhydrophobic surfaces is achieved thanks to asperities that favor the entrainment of air cushions beneath the drop. This so-called Cassie state competes with the Wenzel state, in which the liquid fully wets the substrate. In case of liquids with low surface tension, the Wenzel state is always the thermodynamically stable one. A metastable Cassie state is obtained by using structures with overhangs. These structures are superoleophobic, repelling nearly all types of liquids. The Cassie-to-Wenzel transition can be triggered by vibrations, impact, rapid deceleration, or evaporation.

Here we image the Cassie-to-Wenzel transition of drops on superoleophobic surfaces, by laser scanning confocal [1] and reflection interference contrast microscopy [2]. Two scenarios are common: depinning and sagging. In depinning, the three phase contact line, or briefly contact line, unpins from the edge of the asperity. Then the contact line slides down the pillar wall, beginning the transition to a fully wetted state. The intermediate wetting states may be unstable, in case of pillars, or metastable, in case of overhangs. In the latter case these states may be long lived, effectively prohibiting the transition to the Wenzel state. On superoleophobic surfaces the energy barrier slows down the transition. Whereas most liquids with low surface tension are repelled efficiently at short times of a few seconds, at longer times – from minutes to hours – the liquid may penetrate slowly the structure.

References

[1] Papadopoulos P., Mammen L., Deng X., Vollmer D., Butt H.-J., (2013) “How superhydrophobicity breaks down” Proc. Natl. Acad.Sci. USA 110(9), 3254–3258.
[2] Papadopoulos P, Vollmer D., Butt H.-J., (2016) “Long-term repellency of liquids by superoleophobic surfaces” (submitted).