Studies reveal new way to make superhydrophobic surfaces with better self-cleaning capabilities

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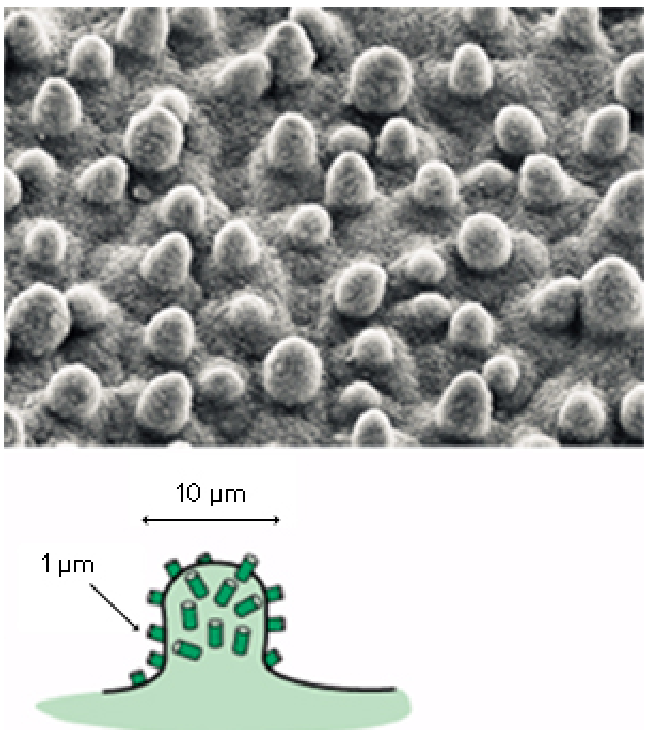

Image of a natural lotus leaf surface with bumps in size of about ten micrometers and spikes of below one micrometer.

Many plants and animals have textured surfaces on their body for manipulating water. Some textured surfaces are designed, for example, to improve adhesion, while others may enable the collection of water from fog in arid regions. The lotus leaf, in particular, is the most widely cited example of having a textured surface with self-cleaning properties (see image).

The surface of the lotus leaf has a hierarchical structure — comprising both micrometer and submicrometer features — that makes it difficult for water droplets to spread. As a result, water droplets form tight spheres that easily roll off the leaf, picking up dirt particles en route. Such functionality can become useful if applied to textiles or windows, and may also be used in analytical techniques for controlling fluid flow.

Linda Yongling Wu at the A*STAR Singapore Institute of Manufacturing Technology and co-workers have now developed a fast and cost-efficient way to fabricate large-scale superhydrophopic surfaces on a hard material — silica. The researchers used a laser to carve out a microstructured template that they then used to pattern a sol-gel coating. Nanoparticles were subsequently bound to the surface of the cured sol–gel surface to create a second level of hierarchy. The fabrication methodology can be adjusted to achieve different degrees of micro- and nanostructures.

In addition to the new fabrication methodology, Wu and co-workers considered various ways to optimize the water repellency of the textured surface. They found that increasing the surface roughness increases the true area of contact between the liquid and the solid, enhancing its intrinsic wetting properties. However, if the surface features are small enough, water can bridge protrusions leading to the formation of air pockets; the wettability of such a nanostructured material is then calculated as a weighted average of the wettability of the pure material and that of air. These two effects are known respectively as the Wenzel and Cassie-Baxter states.

The researchers derived an equation for calculating the surface contact angle between a water droplet and a silica surface with a certain degree of roughness. They found that there was a transition between the Wenzel to the Cassie-Baxter state, as surface structuring enters the nano dimension. The researchers found that for an optimum superhydrophobic effect, the Cassie–Baxter state must dominate the surface structure to allow a massive 83% of the surface state to be involved in air trapping with only 17% of the liquid drop surface actually in contact with the silica itself.

The researchers are hoping that their findings will generate new ideas for making innovative self-cleaning materials. “We are now developing the technology for real applications, such as easy-clean coating for solar films and structured surfaces for personal care products,” says Wu.

More information: Wu, L. Y. L., Shao, Q., Wang, X. C., Zheng, H. Y. & Wong, C. C. Hierarchical structured sol–gel coating by laser textured template imprinting for surface superhydrophobicity. *Soft Matter* 8, 6232 (2012). dx.doi.org/10.1039/c2sm25371b

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