Water may not run uphill, but it practically flies off new surface

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(PhysOrg.com) -- Engineering researchers have crafted a flat surface that refuses to get wet. Water droplets skitter across it like ball bearings tossed on ice. The inspiration? Not wax. Not glass. Not even Teflon.

Instead, University of Florida engineers have achieved what they label in a new paper a "nearly perfect hydrophobic interface" by reproducing, on small bits of flat plastic, the shape and patterns of the minute hairs that grow on the bodies of spiders.

"They have short hairs and longer hairs, and they vary a lot. And that is what we mimic," said Wolfgang Sigmund, a professor of materials science and engineering.

A paper about the surface, which works equally well with hot or cold water, appears in this month's edition of the journal Langmuir.

Spiders use their water-repelling hairs to stay dry or avoid drowning, with water spiders capturing air bubbles and toting them underwater to breathe. Potential applications for UF's ultra-water-repellent surfaces are many, Sigmund said. When water scampers off the surface, it picks up and carries dirt with it, in effect making the surface self-cleaning. As such, it is ideal for some food packaging, or windows, or solar cells that must stay clean to gather sunlight, he said. Boat designers might coat hulls with it, making boats faster and more efficient.

Sigmund said he began working on the project about five years ago after picking up on the work of a colleague. Sigmund was experimenting with microscopic fibers when he turned to spiders, noted by biologists for at least a century for their water-repelling hairs.

As a scientist and engineer, he said, his natural tendency was to make all his fibers the same size and distance apart. But he learned that spider hairs are both long and short and variously curved and straight, forming a surface that is anything but uniform. He decided to try to mimic this random, chaotic surface using plastic hairs varying in size but averaging about 600 microns, or millionths of a meter.

The results came as a great surprise.

"Most people that publish in this field always go for these perfect structures, and we are the first to show that the bad ones are the better ones," Sigmund said. "Of course this is a finding in a lab. This is not something you expect from theory."

To be sure, water-repelling surfaces or treatments are already common, spanning shoe wax to caulk to car windshield treatments. Scientists have also reproduced other biologically inspired water repelling surfaces, including ones patterned after lotus leaves.

But Sigmund said the UF surface may be the most or among the most water phobic. Close-up photographs of water droplets on dime-sized plastic squares show that the droplets maintain their spherical shape, whether standing still or moving. Droplets bulge down on most other surfaces, dragging a kind of tail as they move. Sigmund said his surface is the first to shuttle droplets with no tail.

Also, unlike many water-repelling surfaces, the UF one relies entirely on the microscopic shape and patterns of the material — rather than its composition.

In other words, physics, not chemistry, is what makes it water repellent. Theoretically, that means the technique could transform even the most water-sopping materials - say, sponges - into water-shedding ones. It also means that Sigmund's surfaces need never slough off dangerous chemicals. Provided the surface material itself is made safe, making it water repellent introduces no new risks.

Although he hasn't published the research yet, Sigmund said a variation of the surface also repels oil, a first for the industry.

Sigmund said making the water or oil-repelling surfaces involves applying a hole-filled membrane to a polymer, heating the two, and then peeling off the membrane. Made gooey by the heat, the polymer comes out of the holes in the desired thin, randomly sized fibers.

While inexpensive, it is hard to produce successful surfaces with great reliability, and different techniques need to be developed to make the surfaces in commercially available quantities and size, Sigmund said. Also, he said, more research is needed to make the surfaces hardy and resistant to damage.

UF patents have already drawn a great deal of industry attention, he said. "We are at the very beginning but there is a lot of interest from industry, because our surface is the first one that relies only on surface features and can repel hot water, cold water, and if we change the chemistry, both oil and water."

Provided by University of Florida