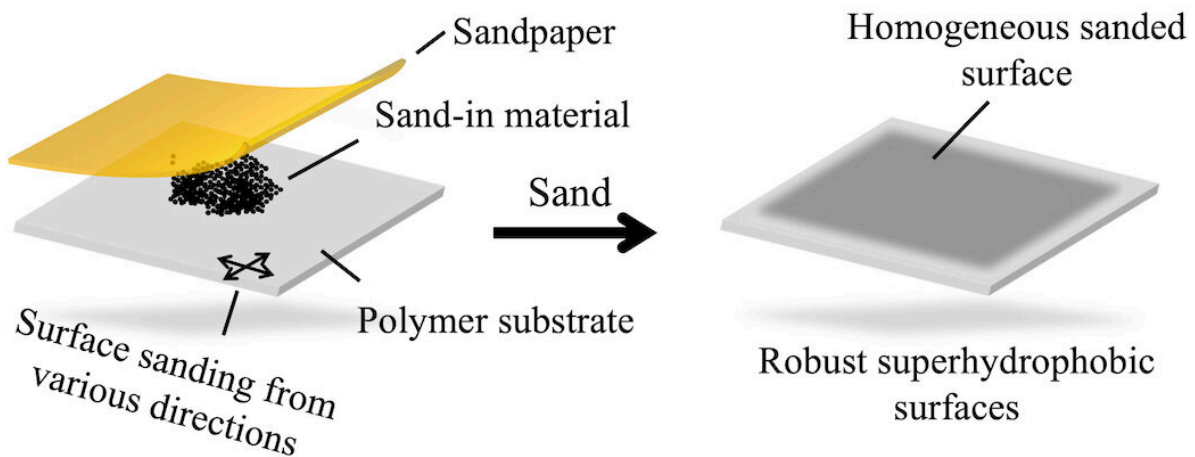


Water can't touch this sanded, powdered surface

August 4 2022, by Mike Williams



An illustration shows the sand-in technique developed at Rice to make materials superhydrophobic. The one-step method involving sandpaper and powder also gives materials enhanced anti-icing properties. Credit: Weiyin Chen

Want a surface that won't get wet? Grab some sandpaper.

Rice University researchers have developed a simple method to make surfaces superhydrophobic—that is, very water-repellant—without the chemicals often used in such processes.

Their technique involves sandpaper, a selection of powders and some

elbow grease.

The labs of Rice professors C. Fred Higgs III and James Tour, co-corresponding authors of a paper in the American Chemical Society journal *ACS Applied Materials and Interfaces*, showed that sanding a surface increases its ability to shed water without getting wet. But grinding in a powder at the same time gives it hydrophobic superpowers.

Better yet, their [superhydrophobic surfaces](#) also have excellent anti-icing properties. They found it took water 2.6 times longer to freeze on treated surfaces compared to untreated materials. They also noticed that ice lost 40% of its adhesion strength, even in temperatures as low as minus 31 degrees Fahrenheit.

How well a surface absorbs or repels water can be measured by analyzing the contact angle of droplets that settle there. To be superhydrophobic, a material has to have a water contact angle—the angle at which the surface of the water meets the surface of the material—larger than 150 degrees. The greater the beading, the higher the angle. An angle of zero degrees is a puddle, while a maximum angle of 180 degrees is a sphere that just touches the surface.

To achieve their super status, hydrophobic materials have low surface energy as well as a rough surface. The Rice team's best materials showed a contact angle of about 164 degrees.

Higgs, whose lab specializes in tribology, the study of surfaces in sliding contact, said certain types of sandpaper can provide surface roughness that promotes the desired water-repelling or hydrophobic behavior.

"However, the Tour group's idea of introducing select powder materials between the rubbing surfaces during the sand-in process means a tribofilm is formed," Higgs said. "That gives the added bonus of

functionalizing the surface to repel water ever more."

A tribofilm forms in a chemical reaction on surfaces sliding against each other. The surface of an engine's piston is a good example, he said.

Higgs said sanding roughens softer surfaces and allows the powders to adhere through van der Waals forces. "These forces are at their greatest when surfaces come into close contact," he said. "Therefore, powder particles can adhere even after the sand-in process is completed."

Structural changes and mass and electron transfer appear to lower the surface energy of the materials that, before treatment, were already either mildly hydrophobic or hydrophilic, according to the researchers.

The Rice team applied the technique on a variety of surfaces (Teflon, polyethylene, polypropylene, polystyrene, [polyvinyl chloride](#) and polydimethylsiloxane) with a variety of powder additives. These included laser-induced graphene fiber, turbostratic flash graphene, molybdenum disulfide, Teflon and boron nitride. A variety of aluminum oxide sandpapers were used, from 180- to 2,000-grit.

The resistant materials proved to be robust, as neither heating to 130 degrees Celsius (266 degrees Fahrenheit) nor 18 months under the hot Houston sun degraded them. Sticking transparent tape to the surface and peeling it off 100 times did not degrade them, either. But even when the materials began to fail, the labs found that re-sanding them could easily refresh their hydrophobicity.

The team also discovered that by changing the sand-in conditions and the powder additives, materials can also be made hydrophilic, or water-absorbing.

Tour said simplifying the manufacture of superhydrophobic and anti-

icing materials should draw industry interest. "It's hard to make these materials," he said. "Superhydrophobic surfaces do not permit water accumulation. The water beads and rolls right off if there is even the slightest angle or gentle wind.

"Now, almost any surface can be made superhydrophobic in seconds," Tour said. "The powders can be as simple as Teflon or [molybdenum disulfide](#), both of which are readily available, or newer [graphene materials](#). Many industries could take advantage of this, from builders of aircraft and boats to skyscrapers, where low-ice adhesion is essential."

"Airplane manufacturers do not want ice forming on their wings, ship captains do not want drag from ocean water slowing them down and biomedical devices need to avoid biofouling, where bacteria builds up on wet surfaces," Higgs said. "Robust, long-lasting superhydrophobic surfaces produced from this one-step, sand-in method can alleviate many of these problems.

"A limitation of other techniques to generate hydrophobic surfaces is that they do not scale up to large [surface](#) areas such as those on planes and ships," he said. "Simple application techniques like the one developed here should be scalable."

Rice graduate student Weiyin Chen, co-lead author of the new paper, said the Tour lab has also applied its sand-in technique to various metal surfaces including, as reported in another recent paper, lithium and sodium foils for metal batteries.

"The spontaneous chemical reactions cause the formation of tribofilms, in this case, the artificial solid electrolyte interphase," Chen said. "The modified metals can be used as the anodes for rechargeable metal batteries."

More information: Weiyin Chen et al, Robust Superhydrophobic Surfaces via the Sand-In Method, *ACS Applied Materials & Interfaces* (2022). [DOI: 10.1021/acsami.2c05076](https://doi.org/10.1021/acsami.2c05076)

Provided by Rice University

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