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Vibrations Keep Water Out of Lotus Leaves

By HENRY FOUNTAIN

Scientists have solved a longstanding mystery about the water repellency of lotus leaves, and in doing so might have discovered a way to make better self-cleaning and low-drag materials.

The secret, according to a study in Physical Review Letters by Chuan-Hua Chen, an assistant professor of mechanical engineering and materials science at Duke University, and Jonathan B. Boreyko, a graduate student there, lies in how the leaves vibrate on their stems.

The surface of a lotus leaf is all nooks, crannies and tiny hairs. Researchers have known for decades that this highly textured surface is the key to the leaf's superhydrophobicity, or extreme water repellency: droplets are kept off the surface, in effect, by all the air trapped within the cavities. Scientists have mimicked the lotus leaf, creating textured materials and coatings that are highly water repellent.

But those materials don't work so well if rather than falling on the surface, water condenses directly within the nooks and crannies. That makes the surface sticky. In a laboratory setting, even the lotus leaf can be affected by condensation. "If water penetrates into the cavities, then the water repellency is gone," Dr. Chen said.

In nature, though, dew that appears on lotus leaves at night is gone by morning. "There's something in nature that we're missing in the lab," he said.

Dr. Chen, who was raised in Honghu, in central China, developed a hunch based on his childhood experiences of seeing lotus leaves swinging in breezes. "It's a huge leaf standing on a thin long stem," he said. "It's very conducive to vibrations. I had the idea that maybe that's what's missing in the lab."

So he and Mr. Boreyko bought an inexpensive loudspeaker from RadioShack, fixed a lotus leaf to it, allowed water to condense within the leaf's surface and then made it vibrate at about 100 hertz. High-speed videography showed what was happening: the droplets were literally bouncing up out of the surface. The vibrations supply enough energy to overcome the adhesive forces between the droplets and the textured surface, Dr. Chen said. "By vibrating at the right conditions, we were basically forcing the drops out of the cavities."

Those conditions could easily exist in nature, he added, given the leaf-stem morphology. "We're not talking about very high-speed vibrations," he said. So it's plausible that lotus leaves take advantage of natural vibrations to retain their water repellency after dew forms on them.

The findings, Dr. Chen, suggest that water-repellent materials could be created that make use of other naturally occurring vibrations, like the 60-hertz hum produced by electrical current. One possible application is for a coating for the interior of condenser pipes of the kind used to transfer heat in power plants. By maintaining water repellency, the effect would be to reduce drag in the pipes and increase flow, improving efficiency.