Wetness-defying water? Physicists discover a paradox: hydrophobic water

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Now you can extend that truism about oil and water to water and itself. Water and water don't always mix, either.
The textbooks say that water readily comes together with other water, open arms of hydrogen clasping oxygen attached to other OH molecules. This is the very definition of "wetness." But scientists at Pacific Northwest National Laboratory have observed a first: a single layer of water--ice grown on a platinum wafer--that gives the cold shoulder to subsequent layers of ice that come into contact with it.

"Water-surface interactions are ubiquitous in nature and play an important role in many technological applications such as catalysis and corrosion," said Greg Kimmel, staff scientist at the Department of Energy lab and lead author of a paper in the current issue (Oct. 15 advance online edition) of *Physical Review Letters*. "It was assumed that one end of the water molecule would bind to metal, and at the other end would be these nice hydrogen attachment points for the atoms in next layer of water."

A theory out of Cambridge University last year suggested that these attachment points, or "dangling OH's," did not exist, that instead of dangling, the OH's were drawn by the geometry of hexagonal noble-metal surfaces and clung to that.

Kimmel and his co-authors, working at the PNNL-based W.R. Wiley Environmental Molecular Sciences Laboratory, tested the theory with a technique called rare gas physisorption that enlists krypton to probe metal surfaces and water layers on those surfaces. They found that the first single layer of water, or monolayer, wetted the platinum surface as they had expected but "that subsequent layers did not wet the first layer," Kimmel said. "In other words, the first layer of water is hydrophobic."

The results jibe with an earlier Stanford University study that used X-ray adsorption to show that rather than being fixed pointing outward in the dangling position, wet and ready to receive the next water layer, the arms of a water monolayer on a metal surface are double-jointed. They swivel back toward the surface of the metal to find a place to bind. To the water molecules approaching this bent-over-backward surface, the layer has all the attractiveness of a freshly waxed car's hood.

The second layer beads up, but that's not all: Additional water's attraction to that first hydrophobic water monolayer is so weak that 50 or more ice-crystal layers can be piled atop the first until all the so-called non-wetting portions are covered--akin to "the coalescence of water drops on a waxed car in a torrential downpour," said Bruce Kay, PNNL laboratory fellow and co-author with Kimmel and PNNL colleagues Nick Petrik and Zdenek Dohnálek.

Kimmel said that self-loathing water on metal is more than a curiosity and will come as a surprise to many in the field who assumed that water films uniformly cover surfaces. Hundreds of experiments have been done on thin water films grown on metal surfaces to learn such things as how these films affect molecules in which they come into contact and what role heat, light and high-energy radiation play in such interactions.

Source: Pacific Northwest National Laboratory

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