The Society of Rheology
K12 Outreach Activities

Science is FUN!

The Lotus Effect - Part 1

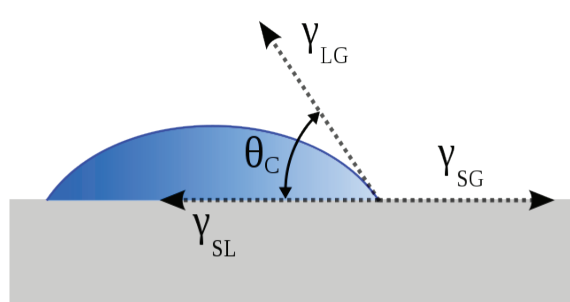
In nature, you can find plants, insects and animals that have evolved with some incredible adaptations for surviving in their natural habitat. Take for example the lotus plant. The lotus grows in swamps where dirt and mud can get on its leaves blocking out the sun making it harder to grow through photosynthesis. Not a problem!. The leaves of the lotus plant have evolved to be naturally self-cleaning. Scientists classify lotus leaves as *superhydrophobic* surfaces meaning that water beads up on the surface of the plant and moves freely with almost no resistance. When it rains, the raindrops roll down along the lotus leaves collecting any dirt or mud in their path. The lotus leaf has been mimicked by scientists and engineers to create self-cleaning surfaces and stain resistant clothes, but it has also been used to stop ice formation, reduce bacteria growth and even reduce the drag of boats moving through water. Here we will make our own *superhydrophobic* surfaces that mimic the properties of the lotus leaf.

What you will need to get started

- 2 identical pieces of Teflon
- 240 grit sandpaper
- Water
- Transfer pipette
- Paper towels for cleanup

What does superhydrophic mean?

- Liquids and solids interact through surface tension, γ, and contact angle, θ
- If water likes a surface it will spread, the contact angle is small, $\theta < 90^o$, and the surface is hydrophilic
- If water dislikes a surface, the contact angle is large, $\theta > 90^o$, and the surface is hydrophobic
- If water really dislikes a surface, it beads up like a sphere and its contact angle approaches, $\theta = 180^o$.
- This is *superhydrophbic*. This is a lotus leaf.



rothstein@ecs.umass.edu

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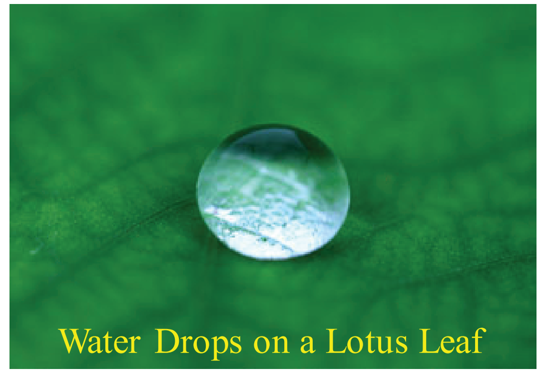
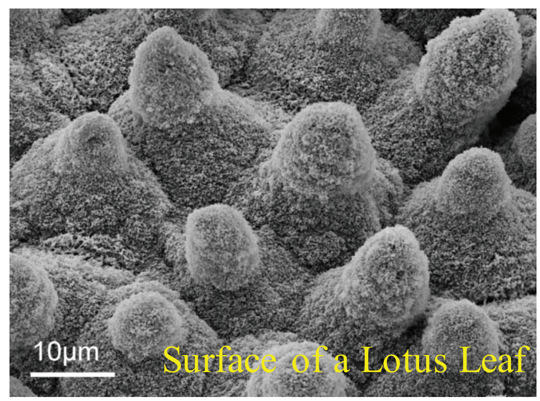
Let's experiment!

The incredible properties of the lotus leaf come from a combination of chemistry which makes the surface hydrophobic and roughness. We will use sandpaper to add roughness to a piece of Teflon which is naturally hydrophobic to make it superhydrophobic.



Water Drops on a Lotus Leaf

1. Set one piece of Teflon aside to keep it smooth for comparison. Now lightly sand the second piece of Teflon with a random motion of the sandpaper to make it rough. This can take some time. You cannot over sand. So keep sanding. More sanding is always better.

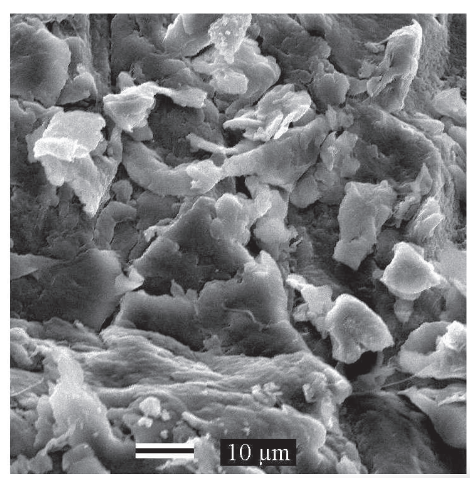


Surface of a Lotus Leaf

2. Place a small drop of water on the smooth Teflon surface.Tilt the surface through vertical.
   - What does the drop look like? Is it flat? Is it a sphere? Is it a hemisphere? Does the drop stick or slide when you tilt the Teflon?

3. Place a small drop of water on the smooth Teflon surface.Tilt the surface through vertical.
   - What does the drop look like? Compare it to the drop on the smooth surface? Does the drop stick or slide when you tilt the Teflon?

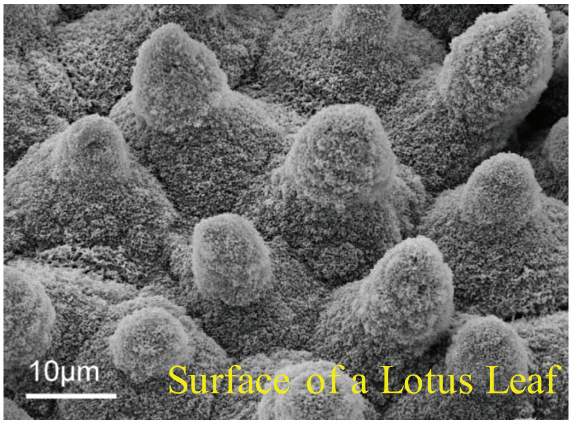
Sanded Teflon



4. Now use your pipette to squirt a jet of water at your sanded Teflon surface.
   - What happens? Does the jet run down the surface of the Teflon or does the jet bounce off like a stone skipping across a lake? Compare this to the smooth Teflon surface.

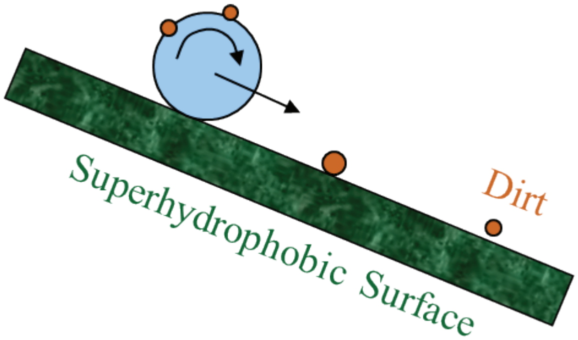
rothstein@ecs.umass.edu

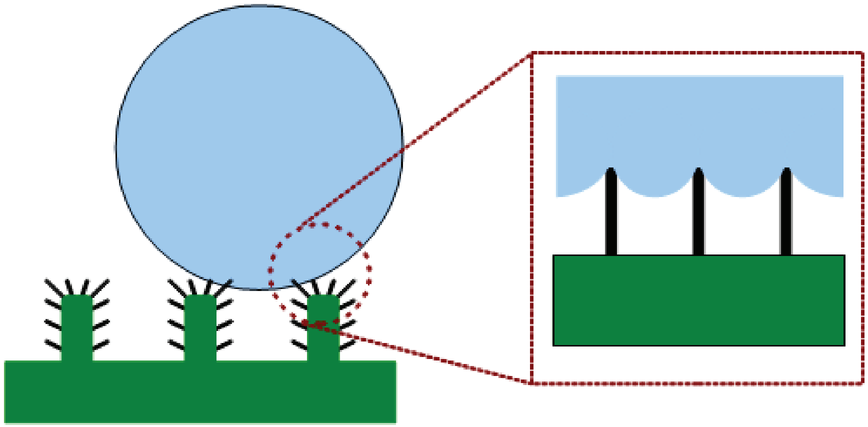
How does it work?



The surface of the lotus leaf is covered by 10μm wide bumps which are coated by waxy crystals that are even smaller and extremely hydrophobic. Even without the surface bumps, a surface coated with just the crystals would be extremely hydrophobic. By adding the micron sized bumps, the surface becomes superhydrophobic.

The bumps serve a very important purpose. The water does not wet the entire surface of the leaf, but instead it only makes contact with the very tops of the bumps trapping air between the drop and the surface. This trapped air is what gives the surface its incredible properties. The contact angle between water and air is $\theta = 180^{o}$. the more air that is trapped, the larger the contact angle and the more mobile the drops become.





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