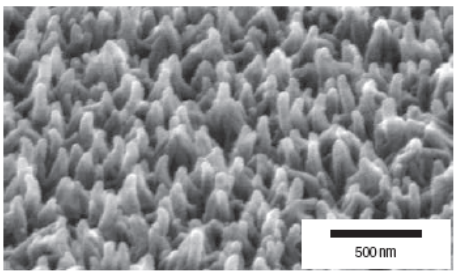
Superhydrophobicity and Superhydrophilicity:

How We Can Mimic Nature's Own "Nanotechnology"



Nanograss (Chiou et al. 2007)

Paints and windows that clean themselves and fabrics that stay dry are ideas that several years ago would have seemed like science fiction or someone's crazy get-rich-quick scheme. Today, these not only seem attainable, but products such as "stain-defender" fabrics are already showing up on store shelves, bringing these ideas to reality.

Learn From Nature

These ideas did not spring from a vacuum. People have observed these phenomena in nature and have tried to both understand and duplicate them. Water droplets roll around as near perfect beads on the surface of the lotus leaf. Not only does the leaf surface remain dry, but the droplets of water carry away dust and debris with them. Wouldn't it be great if our windows were like that? What about the fabrics in our homes?

The Lotus Effect, the superhydrophobicity (*hydro – water, phobic – fearing*) of the surface, is the result of surface features on the lotus leaf. Small nano-sized "bumps" make the contact surface area between the droplet and the leaf extremely small. This minimizes the attractive forces between the water molecules and the atoms of the surface and allows the water to "bead up" and rolls off.

Growing "Nanograss"

Aniline is an organic compound whose molecule closely resembles benzene. Polymerization, the process by which the individual molecules are linked together via a chemical reaction, forms polyaniline (PANI). In a process that was developed at The Ohio State University, an overhead transparency is submerged into a solution of HCl acid and aniline. The aniline polymerizes on the surface of the transparency to make "nanowhiskers" that stand up vertically on the surface. The coated transparency has a nice green color. After all, what would expect from nanograss? If the transparency is dipped in a basic solution, it turns blue. An acidic solution will return it to its original green color. The transparency can also be dipped in fluorinated organic compound, further altering its surface properties.

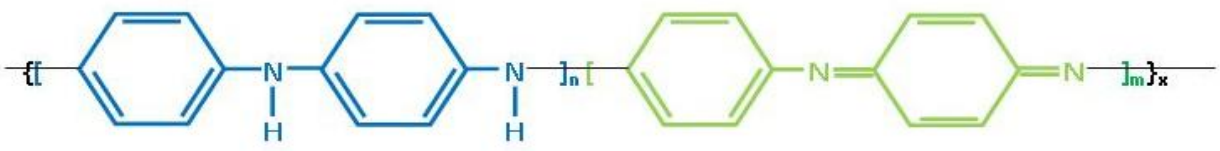


Figure 1: Structure of polyaniline

Activity: Observing the Surface Properties of "Nanograss"

You will be given five "swatches" of transparency to test the hydrophobicity/hydrophilicity of the surface. These sample surfaces will include:

- Original transparency (T)
- Transparency treated with fluorinated compound, no nanograss (FT)
- Transparency with "nanograss," green (GN)
- Transparency with "nanograss" treated with fluorinated compound, blue (FN)

Handle all of the pieces of transparency with tweezers and then only close to the edge. Excessive handling will "crush" the grass and destroy its surface properties.

Place a drop of water onto each of the pieces of transparency. Observe the shape of the drop and identify whether the surface is hydrophobic or hydrophilic. Move the drop of water around by tilting the piece of transparency. Note how easily (or not) it moves.

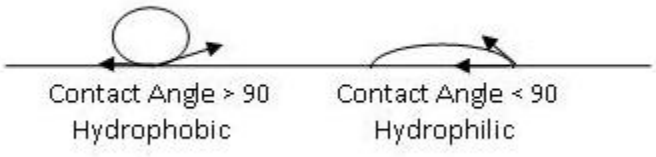


Figure 2: Observation of the contact angle

After considering the observations made, develop an explanation for hydrophobicity and hydrophilicity of the different surfaces. Include the following points in your explanation:

- The type of interaction between the water molecules and the polyaniline
- The role of the fluorinated coating
- The role of the nanostructures

References:

Roach, John. "New Water-Repellent Material Mimics Lotus Leaves." National Geographic News 27 February 2003. 6 March 2008. <http://news.nationalgeographic.com/news/2003/02/0227_030227_lotusmaterial.html>.

Chiou, Nan-Rong, Lu, Chunmeng, Guan, Jingjiao, Lee, L. James, Epstein, Arthur J. "Growth and alignment of polyaniline nanofibers with superhydrophic, superhydrophilic and other properties." Nature Nanotechnology." www.nature.com/naturenanotechnology. June 2007.