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Hydrophobic Surfaces

Hydrophobic molecules are non polar and are thus not attracted to polar molecules such as water. Water on hydrophobic surfaces exhibits a high contact angle (larger than 90^o), and with the addition of surface roughness becomes superhydrophobic (with a contact angle of more than 150^o, as seen with Wenzel's equation). Many interesting applications arise from hydrophobic and superhydrophobic surfaces. I found the following three to be particularly interesting.

Lotus effect:

Superhydrophobic surfaces have recently received a lot of attention due to the advent of new nano-material fabrication techniques.

If a surface is made hydrophobic (usually chemically, with some sort of silane, protein, etc.) and then patterned with a structure to provide roughness, a drop may be able to remain on top of the microstructure, forming air-liquid interfaces (Cassie-Baxter regime). This drop will have greater mobility and a higher contact angle than a drop in the Wenzel regime (**Fig. 1**)[1].

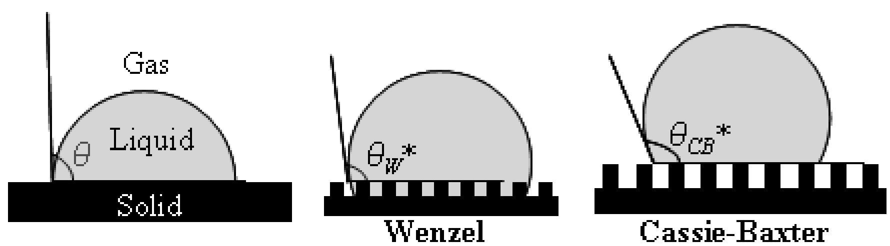

Figure 1: Shown are a droplet on a flat hydrophobic surface; a drop on a rough hydrophobic surface (full contact of water with substrate); and a superhydrophobic droplet (both air-liquid and substrate-liquid contacts).

One of the more popular applications of these types of structures is their so-called "self-cleaning" capability. The highly-mobile water droplets on superhydrophobic surfaces tend to pick up dust particles as they roll off the surface. This is because it is energetically favorable for the particle to adsorb to the surface of the water droplet (due to increased surface contact with the drop) [2]. This effect has many applications in coating, paints, roof tiles, etc.

Colloidal deposition:

One of the most common methods of fabricating colloidal photonic crystals is by vertical deposition[3]. A hydrophilic substrate is placed vertically into a colloidal suspension and a meniscus with an angle smaller than 90^o forms. As the water evaporates, the meniscus moves down the substrate, leaving behind a colloidal crystal. This meniscus "contributes to the generation of capillary forces, which causes the spheres to assemble" (**Fig. 2**) [3]. When the substrate is hydrophobic, the meniscus has an angle greater than 90^o and the capillary forces necessary for colloidal assembly are no longer present.

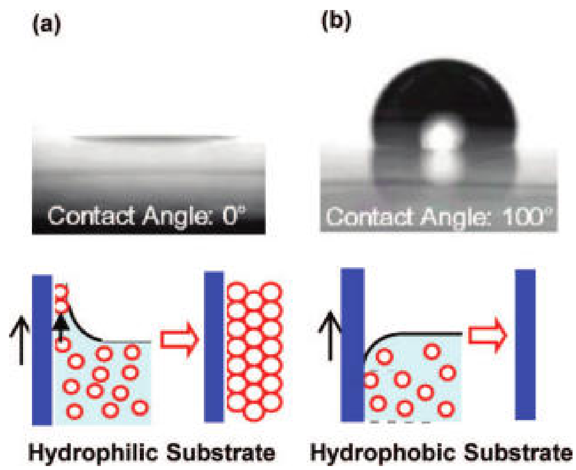

Figure 2: Vertical colloidal deposition on hydrophilic and hydrophobic substrates.

Thus, one may be able to use the chemistry of a substrate to template colloidal growth. As a simple proof of principle, one particular group (Sato, et. al.) coated a glass substrate with a thin film of titania, followed by a hydrophobic coating of a silane. The substrate was then irradiated with UV light, through a patterned photomask. The irradiated areas became hydrophilic due to the photoinduced hydrophilic properties of titania. The other parts remained hydrophobic. After colloidal deposition was preformed on this substrate, a colloidal film was observed only on the hydrophilic parts of the substrate (**Fig. 3**).

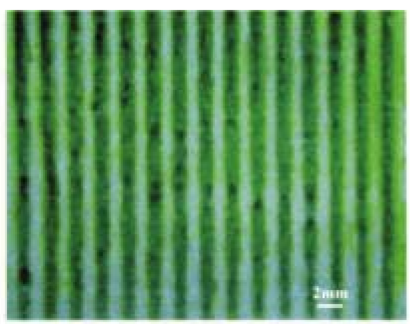

Figure 3: Templated colloidal deposition.

Liquid marbles:

This simple method involves rolling a drop of water in a hydrophobic powder. The powder spontaneously migrates to the surface of the drop (**Fig. 4**). The resulting "liquid marble" behaves like a soft solid and can be used to study drops in non-wetting situations[4].

Figure 4: 1mm liquid marble on glass surface. A water drop would normally wet a glass surface.

These marbles may be a useful transport vehicle in microfluidic devices. Interesting possibilities may also result from assembly of the surface particles as the water droplet evaporates.

References:

1. “Lotus Effect”, http://en.wikipedia.org/wiki/Lotus_effect#cite_ref-7
2. Lai, S.C.S., *Mimicking nature: Physical basis and artificial synthesis of the Lotus-effect*, http://members.ziggo.nl/scslai/lotus.pdf
3. Sato et al., *Structural Color Films with Lotus Effects*, **Acc. Chem. Res**., 2008
4. P. Aussillous, *Liquid marbles*, **Nature Lett.,** 2001