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Team Second Image/Video
MCEN 5151: Flow Visualization
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I. Introduction

For our team's second assignment, we decided to experiment with superhydrophobic surfaces. I decided to focus on individual water droplets for my pictures, as opposed to trying to take pictures of many droplets at once. This led to many different setups, with droplets of each of the four colors being tried out, before settling on this picture of a green droplet. I would like to acknowledge Jennifer Kracha and Peter Rosenthal as contributors to my image. They each contributed items for the experimental setup and assisted with the photographic setup of my images.

II. Photographic Setup

For this picture, our team used two white shirts that had been sprayed with Rust-Oleum 278146 NeverWet superhydrophobic spray. The shirt used in my picture was only sprayed with one layer, while the other shirt was sprayed with multiple. In order to control the size of the water droplets, we used a syringe to transfer the water from the cups to the shirt. The droplet seen in my picture was created using one "drop" from the syringe. Its size is roughly 4mm in diameter, or about the same size as a pencil eraser. The shirt was laid on a workstation in the ITLL, and was kept relatively flat. There were some wrinkles in the shirt from the way that the spray dried, as it caused a stiffer finish on the fabric than the shirt originally had. My phone was between 6-8 inches away from the droplet, and was also held at an angle so as not to cast shadows from the lights directly above us. Below is a diagram depicting the photographic setup. The diagram is not to scale.

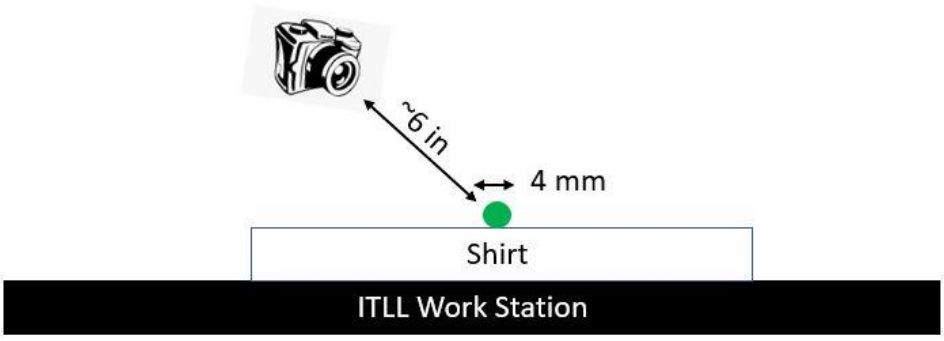

Figure 1: Diagram of Photographic Setup

III. Fluid Dynamics

A superhydrophobic surface is one that repels water, and has a contact angle of at least 150°.

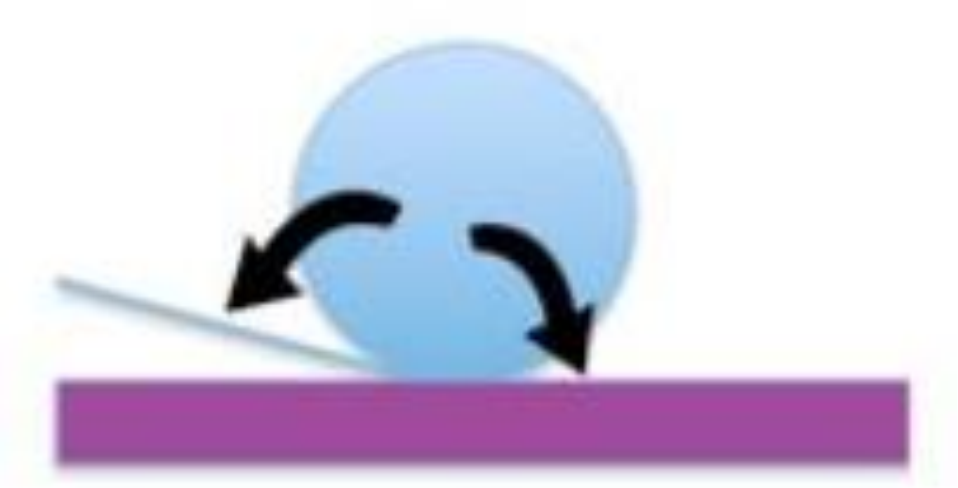

Figure 2: Diagram of Contact Angle for Superhydrophobic Surfaces [1]

The two main factors that effect a surfaces wettability are “surface roughness and surface chemistry” [2]. Surface chemistry, or surface energy, is important because a lower surface energy means increase superhydrophobicity [2]. This is because the lower surface energy allows for the high surface tension of water to go undisturbed, and therefore allows the water droplets to stick together instead of dispersing over a surface [1]. Surface roughness is important because the rougher the surface, the more air bubbles are trapped between the surface and the liquid, and therefore creates a barrier [1]. Our team experienced this roughness after spraying the shirts, noticing the noticeable change in texture of the shirts from before and after being treated.

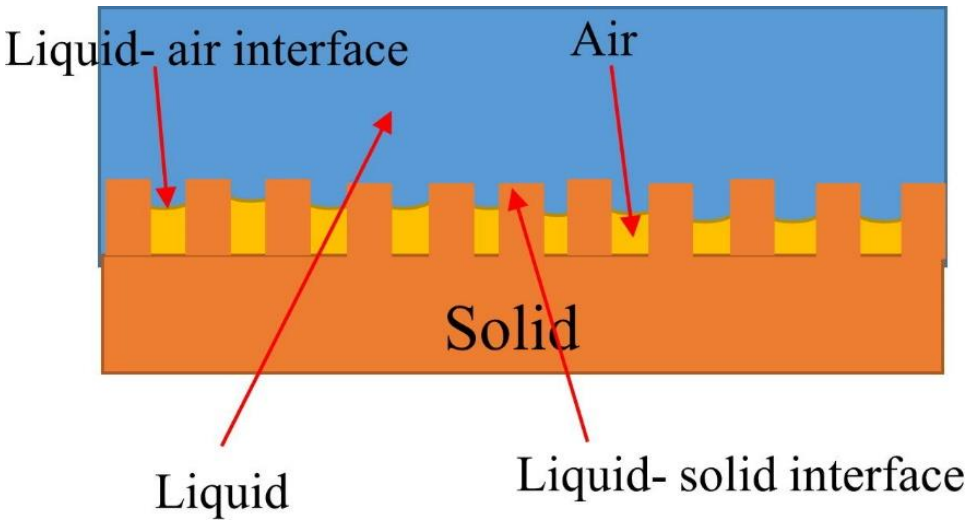

Figure 3: Diagram of Air Trapped Between Surface and Liquid [2]

Superhydrophobic surfaces can be observed in nature, such as the surface of lotus leaves. Lotus leaves are superhydrophobic due to the presence of “epicuticular wax crystals” [3], as well as “papillae or hairs” [3]. The combination of a surface coating (changing the surface chemistry)

and texturing (changing the surface roughness) is a perfect example of superhydrophobicity in nature, and exemplifies the effects our team aimed to capture in our photographic setup.

IV. Visualization Techniques

In order to clearly capture the effects of superhydrophobic surfaces on water, our team knew that using clear liquids would not suffice, especially since our superhydrophobic surface was off-white. We added dyes to the water so that they would stand out more against the background. The dyes we chose to use were standard cooking dyes, in the colors green, yellow, red, and blue. Five drops of dye were put into about a half cup of water. These were then stirred together to ensure maximum mixing before being put into the syringe and then onto the shirt.

V. Photographic Techniques

This picture was taken using my Google Pixel 3 smartphone. The settings were automatic, and were aperture f/1.8, shutter speed 1/120 of a second, focal length 4.44mm, and ISO 443. Originally, I tried to use my Nikon D3500 camera, which I have been using for all other assignments except the Clouds assignments, but I was unable to get the sharpness in the focus that I desired. The pictures captured with my Nikon camera were also considerably darker, despite having a large enough aperture to allow the necessary amount of light in.

When I started post processing the image, I knew that I wanted to focus on the clearest droplet of water, which lead to my decision to crop out the yellow droplet. I felt that while the difference in clarity and focus was interesting, it ultimately distracted the audience instead of enhancing the picture. After cropping the picture, I decided to increase the contrast slightly in order to help the green color pop against the off-white background.

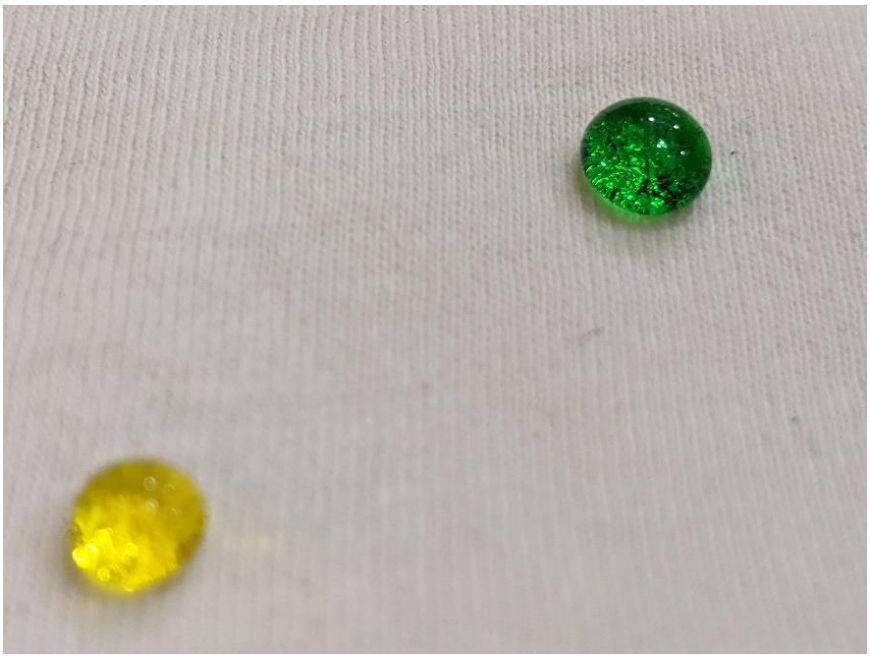

Figure 4: Original Picture

Figure 5: Edited Picture

VI. Results

The results of using superhydrophobic spray and colored water together were quite beautiful. The clarity of the edges of the water droplets against the white shirt, even after only one coating of the spray, surprised every team member. Despite the frustrations I faced with using my Nikon camera and not getting the results I originally hoped for, I am happy that I was able to capture clear and unique pictures with my phone camera. If I were to do this experiment over again, I would probably try to take the pictures outside to use the natural lighting, and spend more time picking the best camera settings so that I could use my Nikon like originally planned. I think it would also be a good idea to borrow or invest in a macro-lens for my camera so that I could get the clearest pictures possible.

VII. References

[1] Lewarchik, Ron. “Hydrophobic and Superhydrophobic Coatings Explained.” *Prospector Knowledge Center,* 12 May 2017, knowledge.ulprospector.com/2530/pc-hydrophobic-coatings/.

[2] Darband, Gh. Barati, et al. “Science and Engineering of Superhydrophobic Surfaces: Review of Corrosion Resistance, Chemical and Mechanical Stability.” *Arabian Journal of Chemistry*, 23 Jan. 2018, doi:10.1016/j.arabjc.2018.01.013.

[3] Ensikat, Hans J, et al. “Superhydrophobicity in Perfection: the Outstanding Properties of the Lotus Leaf.” *Beilstein Journal of Nanotechnology*, vol. 2, 2011, pp. 152–161., doi:10.3762/bjnano.2.19.