Team Image #1:
Water Droplets on a Hydrophobic Surface

Jonathan Cook

With Contributions from Finn Ostrem, Andrew Van Der Volgen, and Kyle Samples

Photo Taken on October 9, 2015

For the first project working together as a team, the group decided to purchase a hydrophobic applicant spray from a hardware store called Never Wet Liquid Repelling Treatment [4]. A simple and cheap applicant, Never Wet can be sprayed onto any surface and creates a barrier that protects the surface from water. To create this image the applicant was sprayed onto an L-shaped piece of aluminum sheet metal. The metal was rested on a flat surface and dyed water droplets were then placed on the surface that had been coated with the applicant.

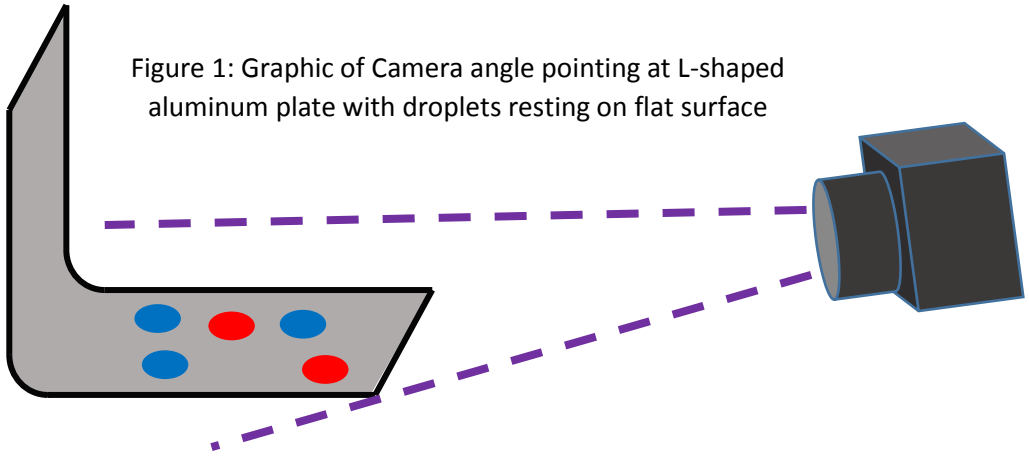

Figure 1: Graphic of Camera angle pointing at L-shaped aluminum plate with droplets resting on flat surface

Water is well known for its high surface tension, often demonstrated to young students by dripping water onto a penny until the "bubble" finally becomes large enough to burst and pour off of the sides. The same effect can be shown on surfaces besides a penny, and different materials are able to hold different amounts of water. In practice this is basically a measurement of the interaction between the material and surface tension effects in the water, commonly referred to as "wetting" [1]. If a surface has good wetting, then the water will distribute as widely across the surface as possible because the gravity of earth is pulling it down. A surface with bad wetting, however, causes the water to cling to itself rather than the material and a bubble starts to form that resists the effects of gravity. The wetting of a material is measured by observing the contact angle that the bubble makes with the surface, as shown in figure 2. A surface that results in a contact angle of greater than 90^{o} with water is called hydrophobic. A surface that achieves an angle of greater than 150^{o} is called super-

Figure 2: Examples of how contact angle reveals wetting [2]

hydrophobic. Never Wet is advertised as having a contact angle with water of between 160^{o} and 175^{o}, which does appear to be consistent with the contact angle in the final image [3].

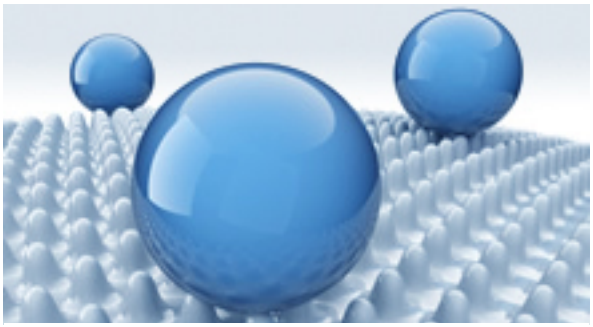

Figure 3: Water droplets sitting on a surface with high micro-roughness [1]

In order for a surface to be super-hydrophobic, it needs to have a high surface micro-roughness and a low surface energy [5]. An example image of micro-roughness is shown in figure 3. Low surface energy means that the highly polarized water molecules are more inclined to group together than interact with the surface. Never Wet applicant achieves both of these requisites.

The final image was taken outside in direct sunlight, at about 3pm. The light moves across the image at a 90^{o} angle to the camera so that the shadows are cast to the right side of the droplets, and the lensing effect of the sunlight through the droplet is visible in the shadow. The liquid used is distilled, bottled water with blue and red food dye that can be purchased from a grocery store. The NeverWet applicant can be purchased from Home Depot or any other local hardware store.

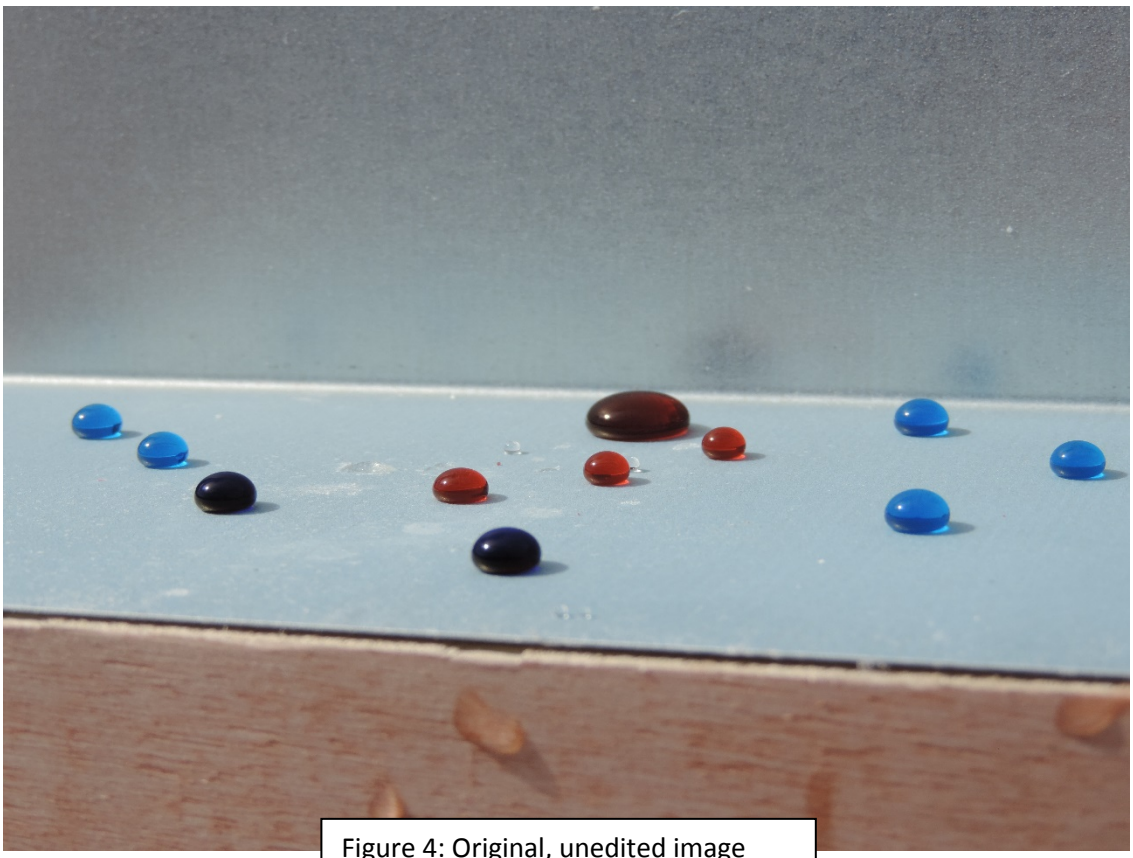

Figure 4: Original, unedited image

The raw, unedited image was taken with a Nikon Coolpix P520. The sensor was exposed for 1/1000 of a second, with an aperture of f/4, an ISO of 80, and a focal length set to 15mm. These settings were chosen so that the camera could capture an approximately 8 inch by 8 inch field of view, getting the entire aluminum surface. The camera was held approximately 10 inches from the droplets. The shutter time was set so low because there was so much light coming from the sun the image quickly became white-washed. The original size of the image was 4896 x 3672 pixels, the final image was cropped down to 3328 x 943 pixels in order to zoom in on the valuable information in the photo. The original image is pictured above in figure 4.

Post-processing of the final image was performed in GIMP. Some minor changes were made to the color curves in order to intensify the red and blue in the water droplets. Because the aluminum background was highly uniform, it was easy to use the clone stamp to move the droplets so that they appeared closer together. I made this choice so that I could zoom in closer on the droplets in the final image without cropping out any of the droplets, all of which I found to have valuable information.

I think that this image does an excellent job of showing the interaction between small water droplets with high surface tension effects and a super-hydrophobic surface. The contact angles are clearly much larger than 90^{o}. The way that the sunlight is focused through the bubble as it acts as a lens is probably my favorite part of the photo, and is shown in the very bright color spots that are inside what should be the shadow of the droplet.

References

[1] “Attension Applications - Biolin Scientific.” Accessed November 21, 2015. http://www.biolinscientific.com/attension/applications/?card=AA7.

[2] “Contact Angle.” Accessed November 21, 2015. http://www.kruss.de/services/education-theory/glossary/contact-angle/.

[3] “Hydrophobic Surfaces Coating | Superhydrophobic Coating | NeverWet.” Accessed November 21, 2015. http://www.neverwet.com/product-characteristics.php.

[4] “Rust-Oleum® NeverWet® Liquid Repelling Treatment.” Accessed November 21, 2015. http://www.rustoleum.com/en/Rustoleum/product-catalog/consumer-brands/neverwet/neverwet-kit.

[5] “Superhydrophobic What? How Rust-Oleum NeverWet Works | Water Repellants.” Accessed November 21, 2015. http://www.livescience.com/42461-how-neverwet-coating-works.html.