September 25, 2015

Get Wet Image Report

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Flow Visualization
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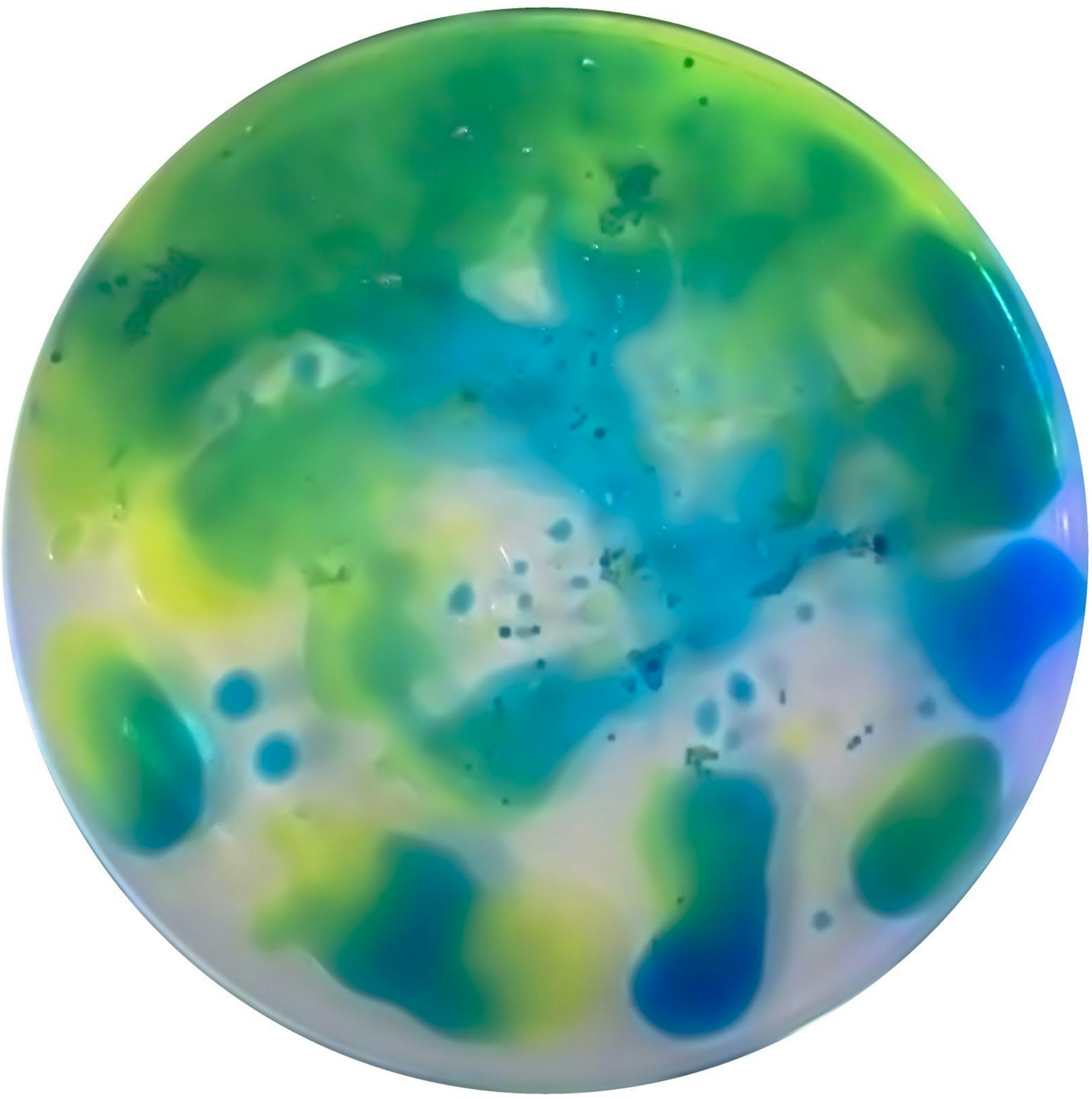

Motivation

This image was created for the first assignment in a course called Flow Visualization, taught by Dr. Jean Hertzberg at The University of Colorado, Boulder. The ultimate goal of this work was to create an aesthetically pleasing image of a dynamic fluid. A fluid is any substance that continuously deforms under shear stress [1]. Dynamic implies that the fluid is moving, as opposed to being still. The assignment was completed individually.

In order to avoid potentially harmful fluids, edible substances were used. The first trial began using 100% pure canola oil and two different flavored Mio Drops. The fluid phenomenon to be captured was the interaction between hydrophobic and hydrophilic substances. The canola oil is hydrophobic, meaning it will not dissolve in water. The Mio Drops are a solution of sugar, water, and food coloring, making it hydrophilic. In order to capture a well defined image, the canola oil was placed in a clear Pyrex dish and illuminated from below with diffused white light from a LED. No other sources of light remained.

Background

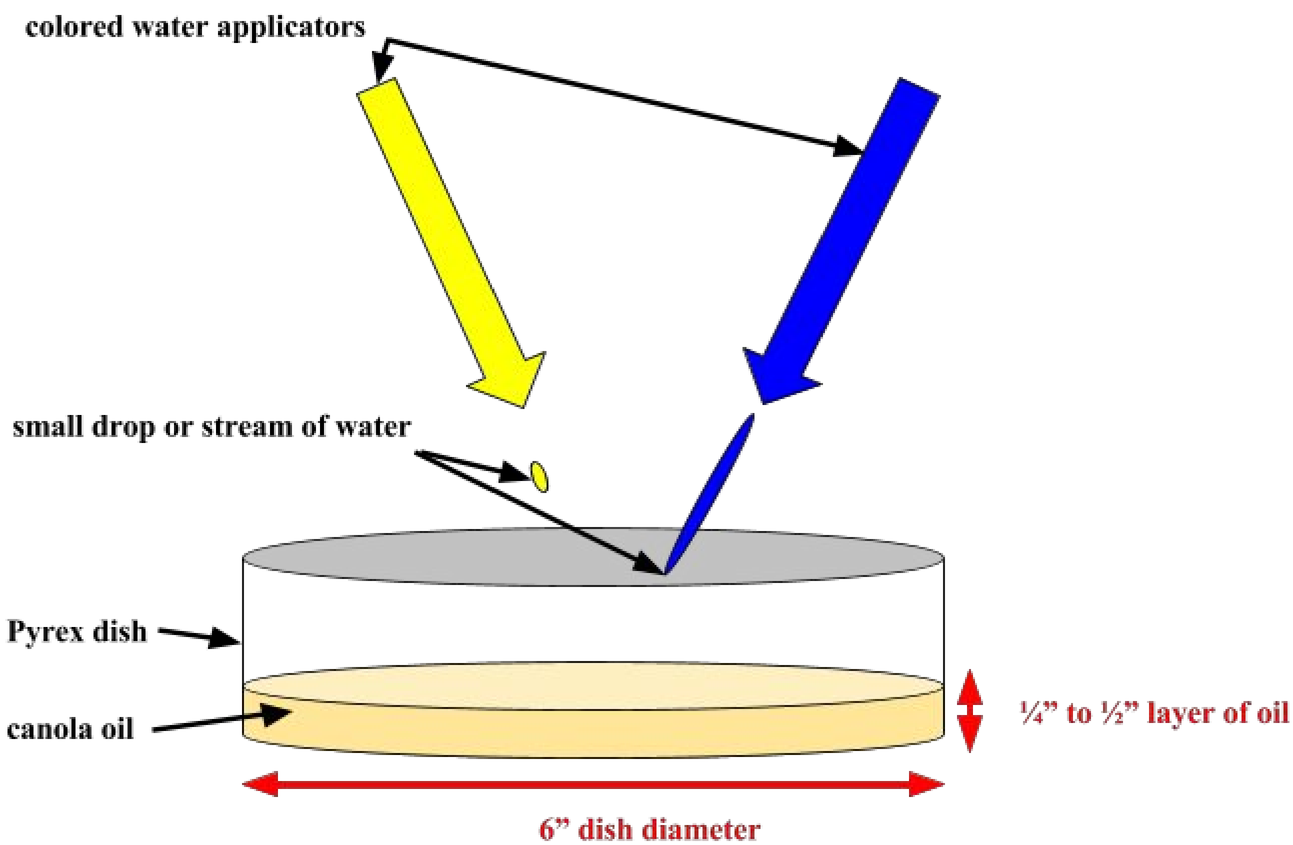

Figure 1) Apparatus and approximate dimensions.

Figure 1 above shows how the flow was created. After the canola oil was poured and allowed to settle in the dish, small drops or streams were added by squeezing the Mio bottle. The height above the dish where the drops fell from was varied from two to eighteen inches. The water droplets become suspended in the oil and slowly moved around the dish, sometimes combining with their neighbors.

In order to analyze this flow, one must understand the forces that act on the fluids involved. What force allows for the food colorings and water to mix, but not the water solution and oil? The answer lies within the mechanics of molecular chemistry. The oil and water are both comprised of covalently bonded molecules, meaning they share electrons. However, the difference in electronegativity and the asymmetry of the water molecule make it polar, whereas oil is nonpolar because the molecule is more symmetric and the atoms have a smaller difference in electronegativity. Polar substances and nonpolar substances do not mix do to these intermolecular forces [2].

This phenomenon between polar and nonpolar fluids can be seen using the above apparatus. At first, droplets of each color are suspended in the oil, not mixing. As more droplets are added, drops of different colors touch and mix as their chemical bonds break and reform freely. After time and some agitation of the fluid, the droplets will mix completely to form one color, but they never mix with the oil.

Visualization Technique

Although canola oil and water vary slightly in appearance, water soluble dye was used to emphasize the difference between the two. The dye used was food coloring, specifically blue 1 and yellow 5. Different primary colors were used so the interaction between the two could be observed and compared to the oil. The dye was an ingredient in a consumer product called Mio, which is commonly found at grocery stores. It is a water soluble flavored concentrate for use in water bottles.

Originally, the lighting was set as described in the background but was modified. Upon review, the original lighting is best for this type of shot. The figure on the following page shows the modified set up.

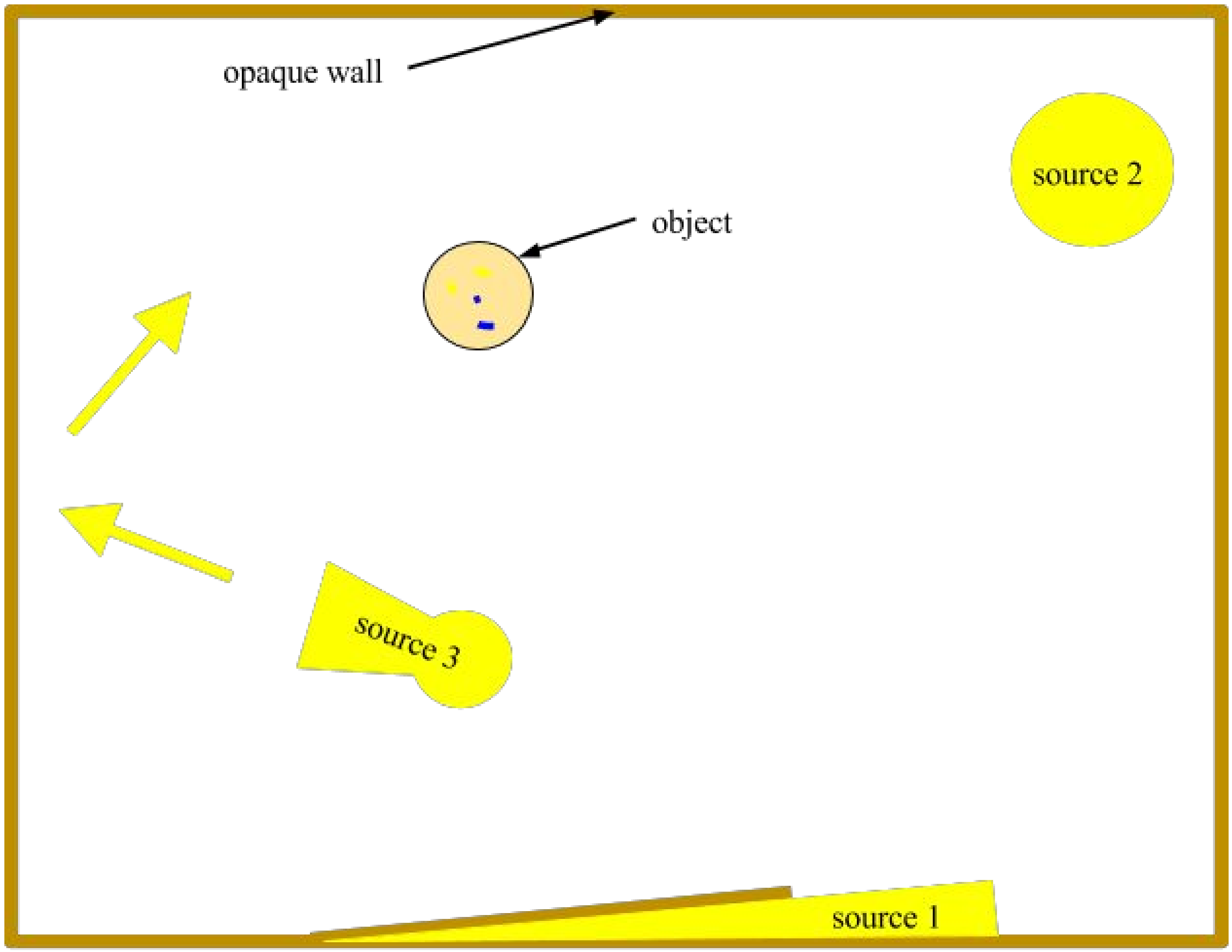

Figure 2) sources of light and object location.

The object was placed in a room where the sources of light could be completely controlled. There were three light sources, located above. The first source was soft light coming through a partially open door. The second was coming from two household bulbs, heavily diffused with paper towel. The third source came from a bright white LED after being reflected off a concrete wall with a rough surface.

Photographic Technique

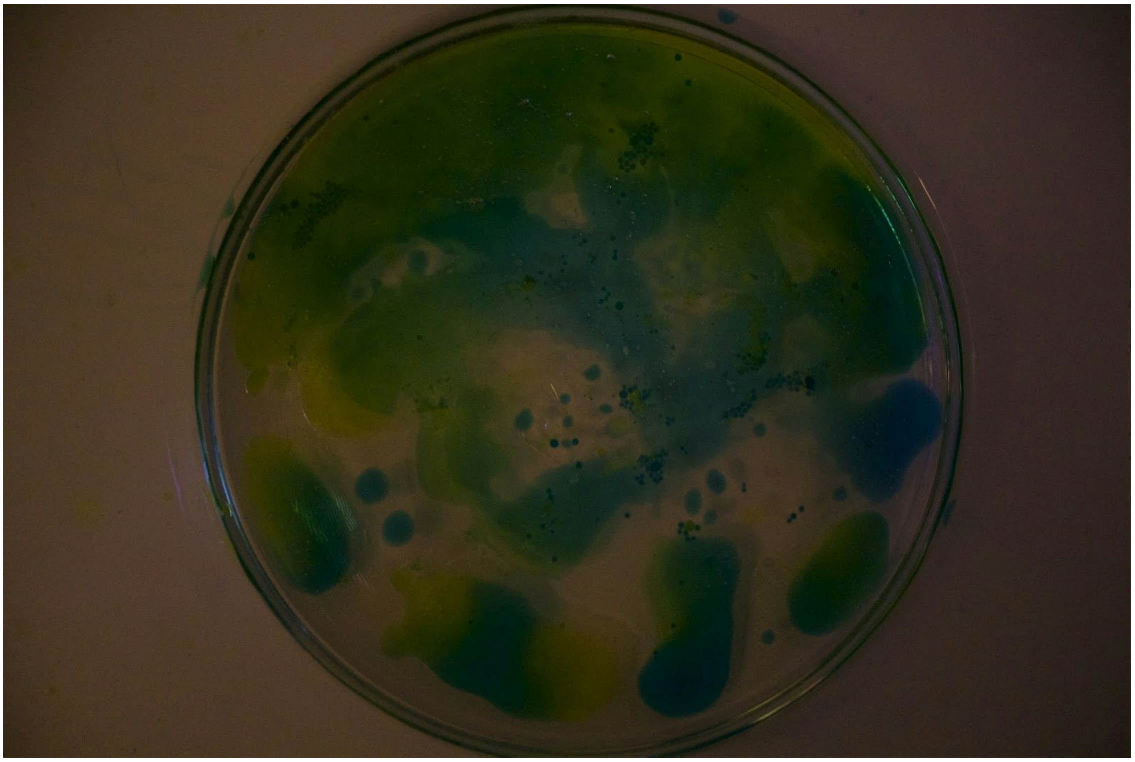

figure 3) Original image before post processing

The image was taken using a Canon Rebel T5i with a 18-55mm Macro lens. The focal length for this shot was 18mm. The size of the field of view is approximately 6” by 6”. The lens was about 8” from the object. The F stop was set to f3.5 so the reflection of light would not whitewash the image. The ISO was set to 1600 and the exposure time to 1/50.

Post processing of the image was performed using Adobe Photoshop. The image was not distorted in the sense that no pixels were moved. The color and exposure was balanced using automatic curve adjustment. The original image was grainy due to a high ISO value, so the luminance was adjusted to give the image a more smooth and glossy look. The white balance was altered to make the subject of the photo stand out. Finally, the image was cropped at the bottom edge of the bowl. The original image is 5184 x 3456 pixels and the final image is 3420 x 3396.

Conclusion

The variety of shades of green in the image do a good job of showing the mixing of the hydrophilic fluids. Similarly, the sharpness between white and color shows the lack of mixing between the oil and water. The final result was aesthetically pleasing and thought provoking, despite the graininess caused by the high ISO setting. The physics of the swirling and mixing of the water could have been captured better. If to be repeated, different lighting techniques and camera settings should be investigated. Fluids with greater differences in density may also result in better illustration of the dynamics at hand.

References

[1] Munson, Bruce R., and Donald F. Young. "Introduction." *Fundamentals of Fluid Mechanics*. 6th ed. Don Fowley, 2009. 3. Print.

[2] "National Nanotechnology Infrastructure Network." *The Water Race: Hydrophobic & Hydrophilic Surfaces*. Web. 26 Sept. 2015. <http://www.nnin.org/education-training/k-12-teachers/nanotechnology-curriculum-materials/water-race-hydrophobic-0>.