**Ella McQuaid**

IV1: Get Wet
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MCEN 4151

**Overview:**
This image was created for the first visualization assignment of the Flow Visualization course. The intent of the image was to show the effect of the hydrophobic nature of oil in conjunction with the different densities of oil and water when the two fluids are mixed together. Initial attempts included bouncing a laser off the water layer through the oil, but the low intensity of the laser and the small scale made effective visualization difficult. The final setup involved vigorously stirring the fluids and taking photos continuously as the oil formed bubbles and rose to the top of the water, creating a color gradient from dark purple to yellow.

**Fluid Dynamics:**
The reason this visualization is possible has to do with the polarity of water molecules and the non-polarity of oil molecules. Rather than distributing themselves evenly in water, oil molecules "stick" together and form bubbles, which will in turn stick to each other to minimize contact with water[1]. By Archimedes' Principle, the bubbles experience buoyant force equal to the weight of water they displace[2]. Because water has a higher density than oil, as seen in Table 1, the buoyant force on the oil bubbles is greater than their weight force, and they rise to the top of the water.

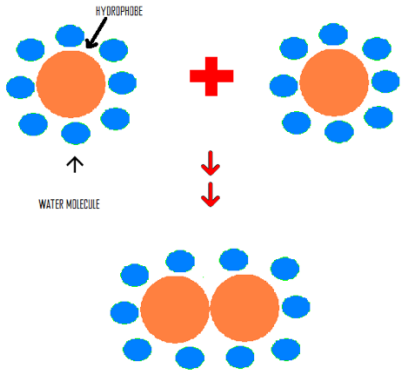


*Figure 1: Bubbles of a hydrophobic substance minimize contact with water by sticking together[1]*

*Table 1: Fluid Densities[3]*

| Substance | Density (g/mL) | Temperature Range (°C) |
|---|---|---|
| Water | 1.00 | 15-25 |
| Vegetable oil | 0.91-0.93 | 15-25 |

**Visualization Method:**
The visualization method for this setup was the purple food dye mixed into the water. The dye used was a purple gel dye from the brand Favorite Day found at Target. Because the dye was water soluble, the oil and water could be vigorously mixed without the oil picking up any pigment. The pint glass used for this setup held approximately 200 mL of water, into which about ½ tsp of the dye was dissolved. On top of the water was a layer of approximately 150 mL of Signature Select 100% Vegetable Oil found at Safeway. The liquid came to just below the bulge near the top of the glass in order to avoid distortion in the image. To light the image evenly, an overhead light about 6 feet to the right of the glass was balanced out with a lamp about 6 feet to the left. A gooseneck lamp was used to backlight the glass through a sheet of white paper, as shown in Figure 2.

*Figure 2: Photographic setup*

**Photographic Method:**

The camera used for this image was a Nikon D5000 with a 55 mm focal length, and f-stop of f/7.1, a shutter speed of 1/8, and an ISO of 200. These settings were used because there was sufficient light in the environment to not need a high ISO or low f-stop. The shutter speed could have been lower but was sufficient as set. The original image size was 4288 x 2848. The distance between the glass holding the fluids and the end of the camera lens was around 10 inches, because this was the closest distance at which good focus on the bubbles could be achieved. Focus was set by placing a measuring tape against the front of the glass and focusing on the numbers printed on the tape. Once the fluid had been stirred, photos were taken every 3 seconds for 90 seconds, and the photo with the most well defined layers and gradient was chosen. The original image included most of the height of the glass and a large amount of blank background, so it was cropped to equal bands of dark purple water, light purple bubbles, and yellow oil. The saturation was increased to emphasize this gradient, and reflections at the bottom corners were retouched, as was a red pixel near the middle of the image.

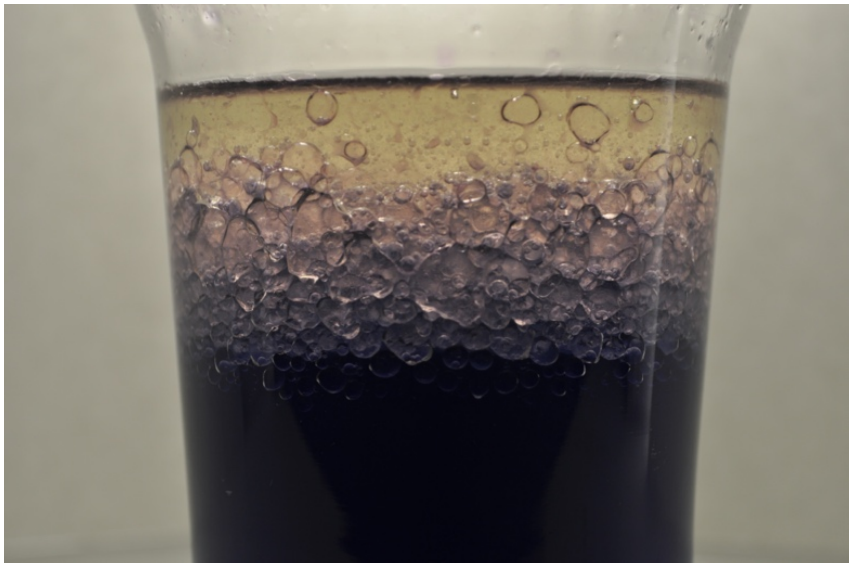

*Figure 3: Unedited image*

**Final Thoughts**:
This was my first time shooting on my own DSLR camera, and I am very proud of how it turned out. I spent a lot of time getting the lighting and focus right and redid the continuous shooting of the de-emulsification multiple times to find a good image. I was also able to practice post-processing to eliminate some of the reflections and get the coloration to a place I was happy with. The image could have been improved by having the fluids in a larger container with a flat face so that the front of the mixture could have all been in the same focus plane, but considering what I had available at the time I am happy with my final image.

**References:**


[1] "Hydrophobic Interactions", LibreTexts, Chemistry LibreTexts, (2022), https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Physical_Properties_of_Matter/Atomic_and_Molecular_Properties/Intermolecular_Forces/Hydrophobic_Interactions.

[2] The Editors of Encyclopaedia Britannica, "Archimedes' principle", Encyclopedia Britannica, (2022), https://www.britannica.com/science/Archimedes-principle.

[3] Dorfman, I., & Elert, G, "Density of Cooking Oil", The Physics Factbook, (2000), https://hypertextbook.com/facts/2000/IngaDorfman.shtml#:~:text=The%20density%20of%20the%20oils,cooking%20oil%20is%20less%20dense.