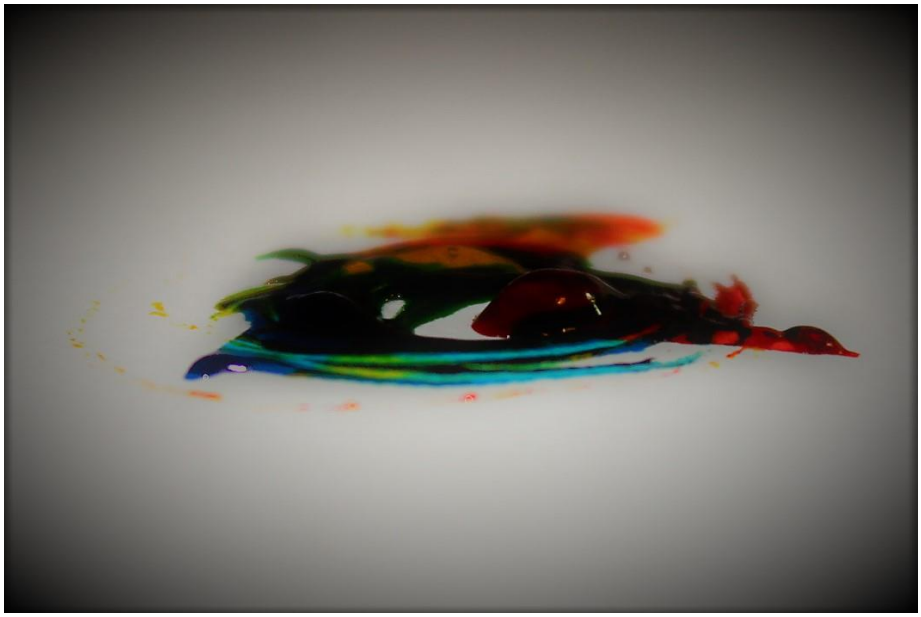
Brent Bauer, Get Wet Report
MCEN 4151 Flow Visualization
2/19/18

Non-Newtonian Fluid Droplets



The image I created was four drops of ooblek gel dyed different colors and then dropped onto a white sheet of printer paper and swirled with a toothpick. The first thing I needed to do was create the ooblek gel which I learned how to make from a scientific American article [1]. This gel was made using a mixture of corn starch and water, which was then dyed and heated in a microwave to obtain the intended thickness of the material. Since the fluid was a gel and was extremely viscous there was not significant flow within the image. The phenomena observed would be a combination of surface tension and intermolecular resistance. The intent of the image was to show the effects of a non-Newtonian fluid on a smaller scale to identify any unique reactions.

Since this image does not depict a flow that is currently moving, but rather one that has been halted due to intermolecular forces, no depiction of the flow can be made or sketched. Viscosity is often referred to as the thickness of a fluid. You can think of water (low viscosity) and honey (high viscosity). However, this definition can be confusing when we are looking at fluids with different densities. At a molecular level, viscosity is a result the interaction between the different molecules in a fluid. This can be also understood as friction between the molecules in the fluid. Just like in the case of friction between moving solids, viscosity will determine the energy required to make a fluid flow. [2] Viscosity (η) can be calculated by comparing the ratio of shearing stress to the velocity gradient.

$$\eta = \frac{F/A}{\Delta v_x/\Delta z}$$

While the shearing stress could not be determined, the liquid was not moving giving it a velocity gradient close to zero which would make viscosity extremely high. This is what we would expect when looking at a fluid that holds its form outside of a container. The image depicted above has a total size of about 1" x 1" and approximately ¼" tall and was taken from between 2" to 4" away. Since the liquid was not moving no special resolution or shutter times needed to be used.

For this image, the photographing technique was quite simple. I had an extra light on top of a ceiling light from above to help reduce shadows on the paper, and then I put the camera on full zoom and leaned inwards until the image was both in focus and filled the sensor. The extra light was a flashlight from a Samsung Galaxy S8 and was held approximately 24" above the paper. After taking several images of this liquid, I decided on this one because it not only showed the viscosity of the fluid, but it also had the best clarity in presenting the four bright colors used; red, yellow, green, and blue.

This image was taken using a Cannon model DS 126311 with a standard 18-55mm lens and a shutter speed of approximately 1/60. In terms of post processing I used Photoshop to get the vignette effect around the image which helped put focus on the liquid. I also increased the brightness just slightly to further help the dye colors pop.

As aforementioned this image depicts how high viscosity materials act with minimal force acting on them at low velocities. Each drop of ooblek was drawn outwards except the fourth drop which was placed in the middle of the previous three drops. The four colors were then swirled spirally going outward which produced the final image seen above. Overall I am really pleased with how the image turned out. I am quite the novice when it comes to photography so being able to produce something that I consider to be "good art" is a real moment of pride for me. Since the image is not moving, and all forces are intermolecular the physics cannot be seen directly within the image, but are more inferred. I would say though that my intent for the photo was fulfilled and if I had to do it again I would try repeating it with different temperatures or in different volumes.

Source links:

1. https://www.scientificamerican.com/article/bring-science-home-gooey-gels/
2. http://www.rheosense.com/what-is-viscosity