2020 Fall Image-Video 2

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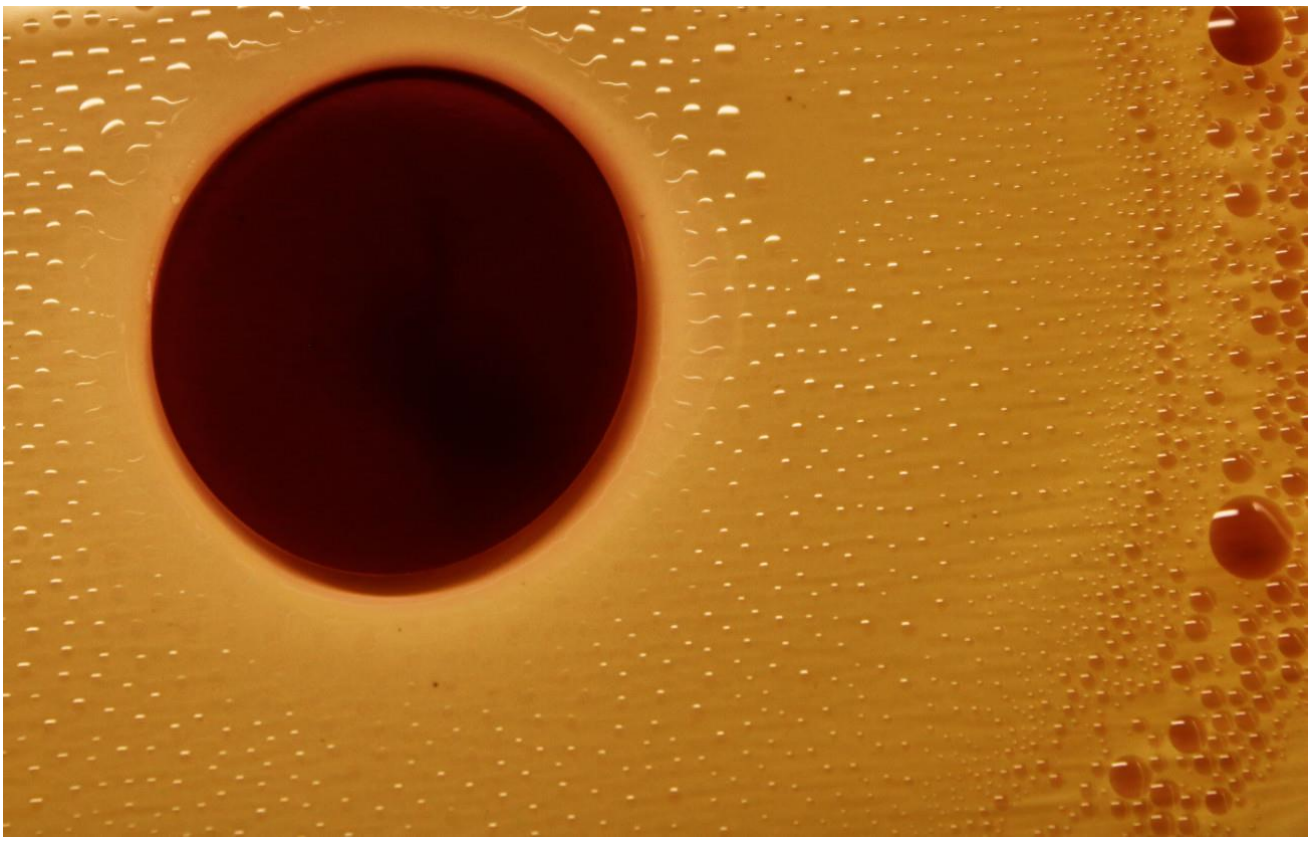
Assisted by Colton Oglesbee



I. Introduction

The purpose of this picture was to explore a concept in flow visualization of our choosing to understand more about fluid photography and its challenges. I choose to research the concept of the Marangoni effect. The Marangoni effect occurs when two fluids of different surface tensions create flow. This concept can be seen in a variety of combinations of fluids and was first referred to as the tears of wine [1]. Depending on the fluid, a strong convective motion may be produced. To create the photo that will later be analyzed in this report, I used the help of my friend and classmate Colton Oglesbee. I was fortunate enough to use be able to use the professional photography set up at Colton's workplace that included a white backdrop and lighting. Colton was also the extra pair of hands to drop the isopropyl alcohol into the oil. The following report shows the experimental set-up, the physics behind the phenomenon, and the techniques used to achieve the image.

II. Set-up and Materials

The materials used in this photograph was food colored tap water, 95% isopropyl alcohol, and glass bowl. The set up was in a dry room of a warehouse with no natural light and with the overhead florescent lights on. The only source of lighting was the overhead light that was attached to the 10 ft. ceiling.

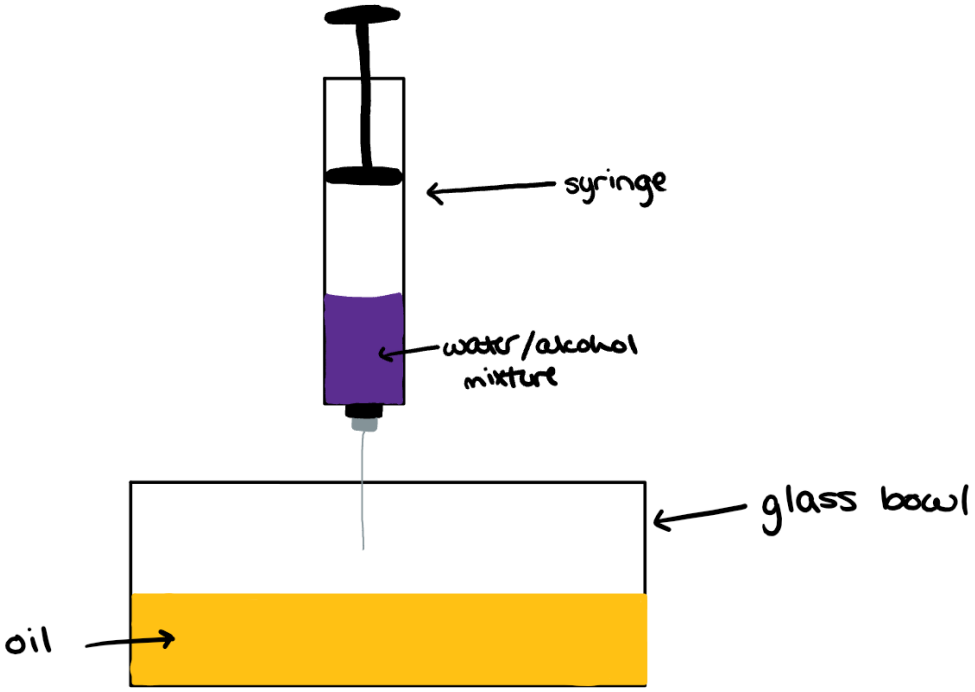


Figure 1: Experiment Set-up

To create the water to alcohol mixture, a one to two ratio was used. To get the darkest color possible the food coloring should be put in the water before adding the alcohol. The syringe was two to three inches directly above the glass bowl filled with vegetable oil. To achieve this photo the syringe was pressed for five seconds to allow about five milliliters of the alcohol and water mixture to pool in the oil.

III. Flow Phenomenon

This photograph is a prime example of the Marangoni effect and shows the phenomenon of thin film interference. The Marangoni effect created in the photo occurred when a drop of one fluid, alcohol, settled in a pool of oil that creates an effect that pulls the alcohol apart from the water. The variation of surface tension caused by the relative evaporation rates of alcohol and water creates flow. The patterns created are caused by the alcohol trying to rearrange itself into the smallest surface area possible.

The patterns of droplets seen in the photo is due to the effect of gravity on the contact angle of the water/alcohol solution. This angle can be found from the Young Equation shown in Equation 1 where theta is the contact angle and gamma are the interfacial energy between the two substances.

$$(\boldsymbol{Equation\ 1}) \quad 0 = \gamma_{oil-air} - \gamma_{oil-alcohol} - \gamma_{alcohol-air} cos\theta$$

The alcohol evaporates more quickly from the edges of the drop which creates a region of higher surface tension around the edge. This difference in surface tension pulls the water/alcohol fluid outward as seen in the photograph. As the alcohol evaporates and recedes, it leaves behind the water it was mixed with in small droplets that slowly get pushed to the edge of the glass as the inner drop sinks. This burst of fluid would not occur if it was not for the oil acting as a lubricant allowing the droplets to move away. Without it, the friction between the drop and the wall would be too high.

IV. Photographic Technique

The camera used for this image was a DSLR Cannon Rebel T7, which comes with a 0 to 55 mm zoom lens. The camera was placed about 4 inches away from the glass bowl using the 55 mm zoom which gave the field of view of the camera to be 3x3 inches. The settings where set to the following specifications, F5.61 aperture value, 1/160 shutter speed, an ISO speed of 640, and using manual focus. These settings where used to compensate for the low lighting in the room. The original photograph can be seen in Figure 2 below which has 6020 x 4015 pixels.

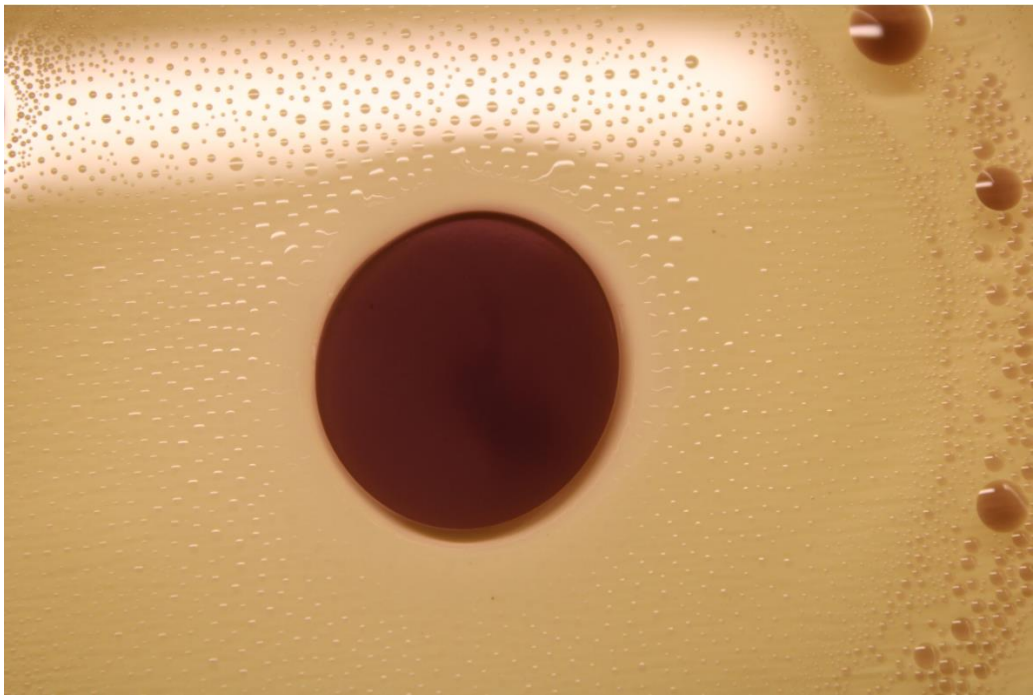


Figure 2: Original Photo of Highlighter Ink in Water

Post processing on this photo was done in Digital Photo Professional 4 by Cannon. In the processed photo, the highlight done by the overhead light was cropped out. To increase the contrast and to make the water and alcohol pop, the highlighting in the photo was increased, the color tone was decreased, and then fine-tuned the colors to make the green pop more. Finally, the photograph was cropped in closer to the phenomenon to have your eyes follow the flow of the fluid.

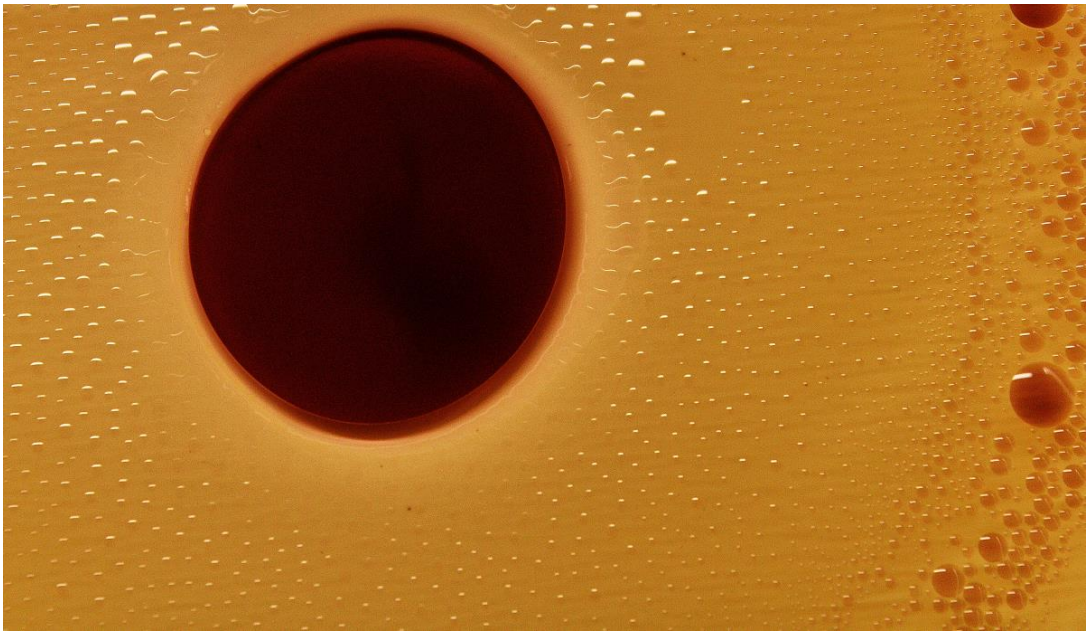


Figure 3: Post Processed Photo

V. Conclusion

Being able to see this phenomenon firsthand is an amazing thing to experience. The fluid organization that is created through this effect is very pleasing to the eye, but hard to capture. The biggest challenge in achieving this photo is being able to capture the flow phenomenon occurring. One of the difficulties is needing more than two hands. Then there is the issue of being able to capture the minuscule movement of the droplets without compromising the photo with light. To further develop this experiment, I would suggest using a camera with a better zoom quality and different lighting than florescent. It would also be interesting to see if there is away to get the food coloring to show the droplets more as it beings to get pulled from where it is inserted.

References

[1] "Highlighter Data Sheet." (n.d.): n. pag. Dokumental. 27 July 2011. Web. 26 Sept. 2020.