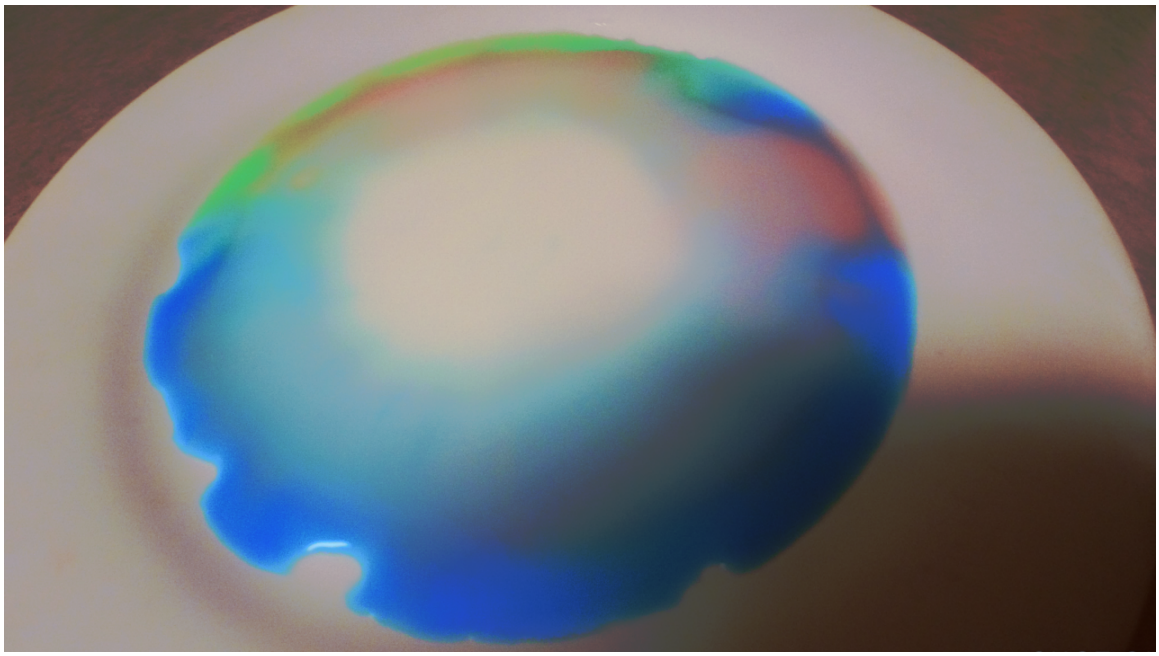
Bryce Gallo

First Image/Video Assignment

MCEN 4151

9/27/21

# Colored Milk Experiment



For the first image assignment, I decided to run the colored milk experiment to photograph the Marangoni effect. At the beginning of the test, I didn't know much about the Marangoni effect, or the milk experiment other than that they would make cool colors. My goal was to better understand the physics involved, and also to also showcase flow visualization in the picture. I also wanted to conduct a fairly simple experiment using household items to focus more on the process of capturing the flow, rather than worrying about the procedure.

The supplies for the experiment consisted of:

- ½ cup of milk
- Red, green, blue, and yellow food dye
- Dish soap
- Q-tip (optional)
- Plate

The procedure to set up the demonstration would be to first pour the milk into the plate. Then, add the food dye towards the center of the milk. For this test, I added the dyes at equal quarter intervals, so each of the four sections of the plate had one solid color of dye. I found after running the test a few times that mixing a bit of water to my food dye before adding it to the milk would make the colors a bit more vibrant. I then added a few drops of soap to the edge of a Q-tip, however the soap could be placed on anything that can be dipped in the milk. When the Q-tip is briefly placed at the center of the milk and food coloring, it causes the colors to mix and run to the sides of the plate.

The physics behind the experiment mostly occur because the fats and proteins inside of the milk have the ability to demonstrate flow visualization very well. The surface tension of the milk can be changed visibly and physically by adding a hydrophilic and hydrophobic compound respectively. The hydrophilic substance, in this case food coloring, will stick to the areas of high surface tension for the visual effect. Meanwhile, the hydrophobic substance, in this case dish soap, will cause the physical effect of lowering the surface tension of any portion of the surface of the milk it comes into contact with due to the proteins and fats separating away from the soap. This is an example of the Marangoni effect since, “Marangoni convection is the tendency for heat and mass to travel to areas of higher surface tension within a liquid,” (Meggs 2011).

The camera used was the Insta360 One R with a 4K wide angle lens. The camera is usually used for 360 degree videos and more action shots with motion, however it is also modularized to be capable of taking good pictures with the 4K lens attached. I used the overhead lights in my kitchen and a flashlight positioned overhead towards the right side of the frame to light the photo. The camera was mounted looking at a slight angle overhead as well. I can control the camera with my phone, so I was able to take burst photos just after dipping the soap into the milk. The settings of the camera are below:

| Camera | |
|---|---|
| Camera Maker | Insta 360 |
| Camera Model | One R |
| F-stop | f/2.8 |
| Exposure Time | 1/60 |
| ISO Speed | ISO-400 |
| Exposure bias | 0 step |
| Focal Length | 16.4mm |
| Dimensions | 4000 x 3000 |
| Width | 4000 pixels |
| Height | 3000 pixels |

**Figure 1**: Camera Settings

I did some minimal post processing to the photo for the final result. I cropped out the watermark, and also adjusted the color levels to make the dye stand out a bit more. In doing that, I also raised the darkness levels of the shadow in the bottom right corner of the image. I had originally tried hiding the shadow in post processing, but I found that it muted the image too much for it to demonstrate flow visualization. The comparison can be seen below:

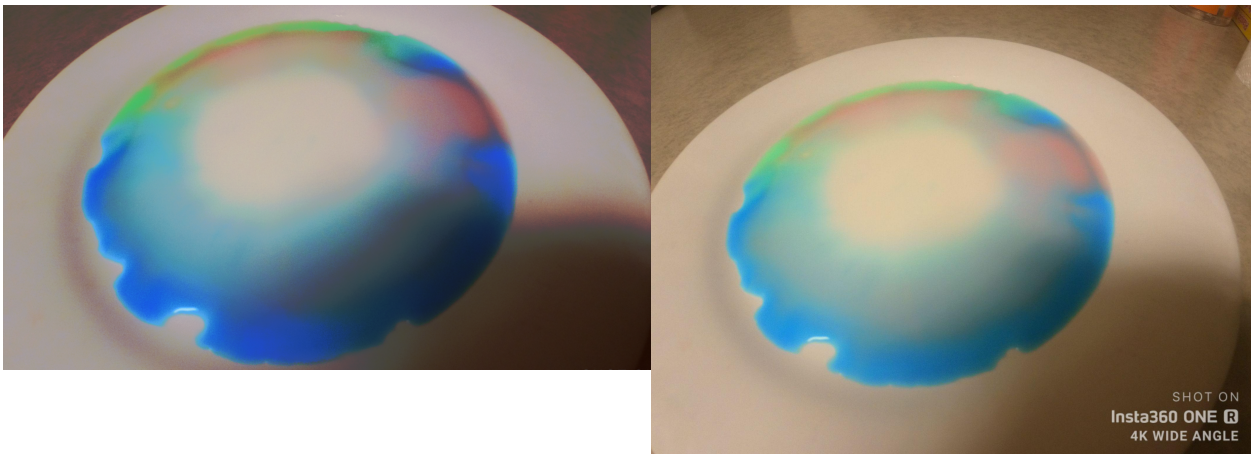



**Figure 2:** Post processed image on left, Original on right

After reviewing the picture, I think it does encapsulate a visual example of the Marangoni effect because of the gradient of color between the center of the milk and the edges. I made this more apparent in post by adjusting the white levels to exaggerate the contrast between the gradients depending on the location of the plate. I am a bit disappointed with the shadow in the corner, because while it seems like it could provide a further contrast point for the color

gradients, it is just more distracting to the whole image. There is a cool rainbow stripe at the top of the shadow if you look for it, but I will work harder to light my scenes in the future in a way that there will not be as pronounced a shadow on the subject. To develop the experiment further, I wonder what it would be like to add a bit of alcohol to the dye instead of water, which would theoretically increase its hydrophilic tendencies.

## References


Meggs, Lori. "The Marangoni Effect: A Fluid Phenom." *NASA*, 10 Mar. 2011, https://www.nasa.gov/mission_pages/station/research/news/marangoni.html.