Get Wet Report
MCEN 4151-001: Flow Visualization

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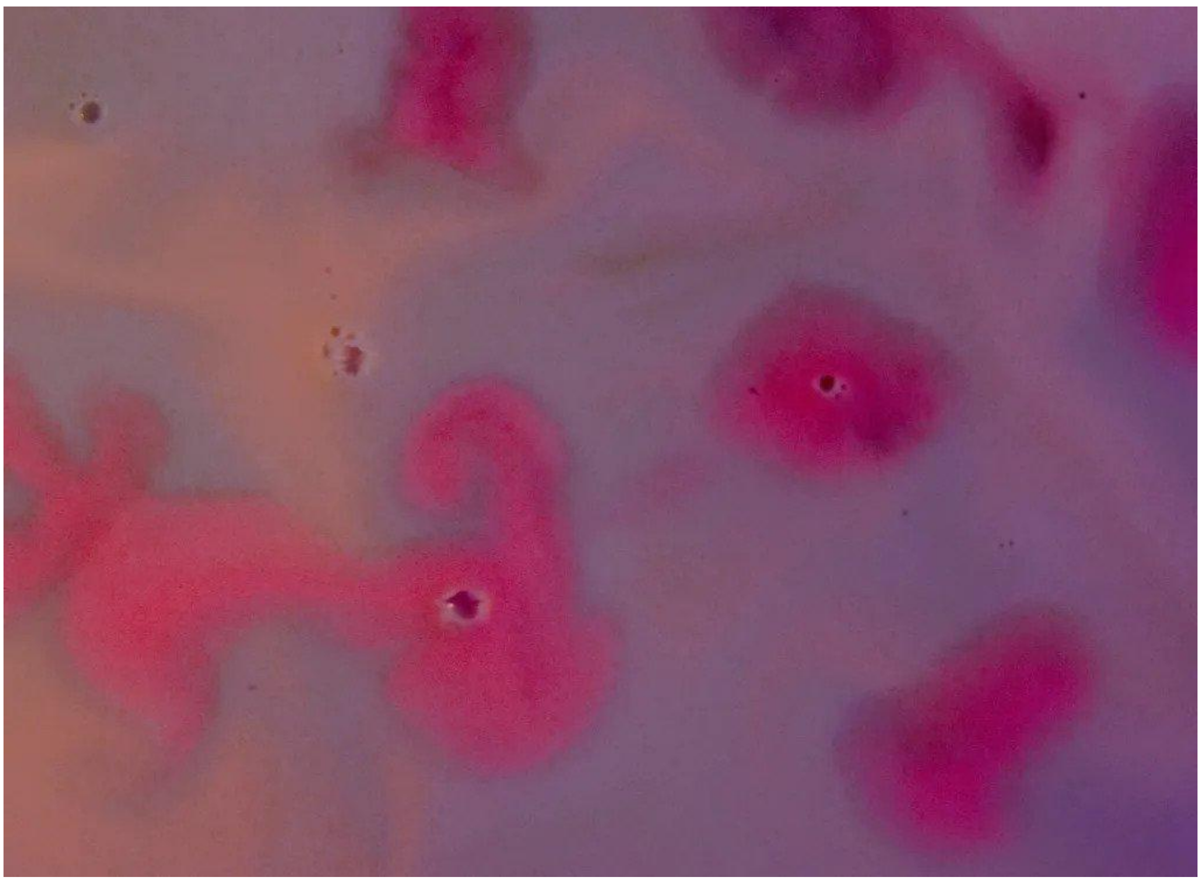

Introduction

I chose this image strategy to pursue an understanding of fluid dynamics and intermolecular interactions, with this strategy I was able to look at the interaction between food dye, milk, and dish soap. With this interaction I observed that when the dish soap made contact with the food dye, the food dye would move around the milk. The image was taken on September 21, 2023, at 815 32nd Street. The intent of this image was to showcase the complex mathematical expressions between a simple experiment performed by most middle school students.

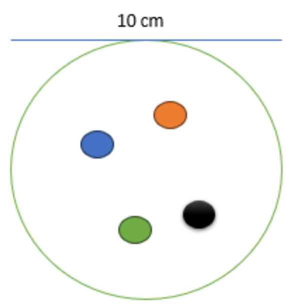

Figure 1: Bowl setup with food dye.

Flow Apparatus

The experiment was conducted in a bowl with a diameter of 12 cm. The camera was positioned vertically above the bowl, as depicted in Figure 2. The camera was also placed a distance of 12 cm away from the bowl, in order to ensure the quality of the image was high enough to be able to visualize the mixing of the food dye. The food dye mixes due to the molecular bonds of the dish soap interacting with the food dye particles. The particles are able to spread out due to the density of milk being greater than the density of the food coloring dye. Also, the food coloring dye droplets do not break the surface tension of the milk. Breaking the system down, the only force acting on the food dye droplets is a repelling force from the intermolecular bonds in the dish soap and food dye. This force drives the motion of the food dye across the milk surface. This flow pictured above is random, because I cannot control how the molecules interact with each other.

$$Re = \frac{\rho v L}{\eta} = \frac{VL}{\upsilon}$$

$$\rho = The\ density\ of\ the\ fluid = 1022.5\ kilogram/meter\hat{}3$$

$$L = The\ characteristic\ length = 0.1\ meter$$

$$\eta = The\ dynamic\ viscosity = 0.001\ NewtonSecond/meter\hat{}2$$

$$V = The\ velocity\ of\ the\ fluid = 0.00447\ meter/second$$

$$\upsilon = The\ kinematic\ viscosity\ of\ the\ fluid = 0.000001\ Meter^2/second$$

$$Re = \frac{\rho v L}{\eta} = \frac{(0.00447)(0.1)}{(0.000001)} = 447$$

Figure 2:Calculation of Reynolds Number with all the assumptions listed out

With a Reynolds number around 447, it can be stated that the flow is likely in the transitional phase and not laminar or turbulent. The Reynolds number is also affected by the fluid which in this case is whole milk.

Visualization Technique

To set up this experiment I created a metal stand that held my camera at the specified height provided earlier in the report. The picture was taken inside in order for any sort of wind to not affect the surface profile of the bowl. The milk was left to sit at room temperature in order to make sure the viscosity of the fluid followed the assumption used in the calculator. After the camera was set up, I then placed four different food coloring dyes, this allowed for the mixture between all the colors to be visualized [2]. I used a desk lamp to light up the surface of the milk, allowing for the contrast between the colors to be better visualized. To ensure a complete representation of the experiment, I captured three sets of burst photographs, each representing a distinct phase of the experiment: initial mixing stage, the half-way point of mixing, and the state of complete mixture.

Photographic Technique

The set up of the experiment is provided in Figure 1 and Figure 2. The field of view is about 12 cm from the top surface of the milk. As seen, in the set up figure the camera was at a fixed position and multiple images were taken to ensure the best result was chosen. The lamp was also at a fixed position about two feet above the milk surface, and placed at a 45 degree angle to get the best contrast between the colors. I experimented with different light setups, (natural light, and flashlight), but found that the desk lamp provided the best outcome. Only one manipulation was added to the image and that was increasing the contrast a little bit. The camera used below was an iPhone 12 with the following settings:

Lens Focal Length	26mm
ISO	32
Shutter Speed	1/1162 s
Aperture	f/6
Image Size	4032 x 3024 pixels

Table 1: List of all settings for camera setup

Figure 3: Camera Setup with bowl configuration below

Conclusion

The image provided reveals the mixing of different colors, and all shows the intermolecular forces between chemical bonds of different compounds. I really like how the image has a focus point on one of the colors mixing, I also like the lighting provided in the image. I dislike how all of the colors are mixed together, I wish I got a picture between the phases of mixing. I also wish I had better lighting for the photo so the contrast between the colors would be more defined. With the addition of more contrast it would allow for the audience to have a better visual about the forces acting upon each other. Furthermore, it would display the vectors acting on each of the droplets of food dye. To further analyze this setup I would like to take numerous compounds and observe the interaction between the intermolecular forces. I might look at the interaction of oil and water, and use slow motion to visualize the forces acting on each fluid. However, for immediate enhancement of the setup, I would have incorporated better lighting and selected alternative colors for the mixing process.

References

[1] Hertzberg, Jean. "Flow Vis Guidebook." Flow Visualization, 13 July 2023, www.flowvis.org/Flow%20Vis%20Guide/overview-3-lighting/

[2] Danielle. "Magic Milk Science Experiment - Amazing Explosion of Color!" *Cool Science Experiments Headquarters*, 18 Apr. 2023, coolscienceexperimentshq.com/magic-milk-science-experiment/

[3] "Reynolds Number." *NASA*, NASA, www.grc.nasa.gov/www/k-12/airplane/reynolds.html. Accessed 17 Oct. 2023.