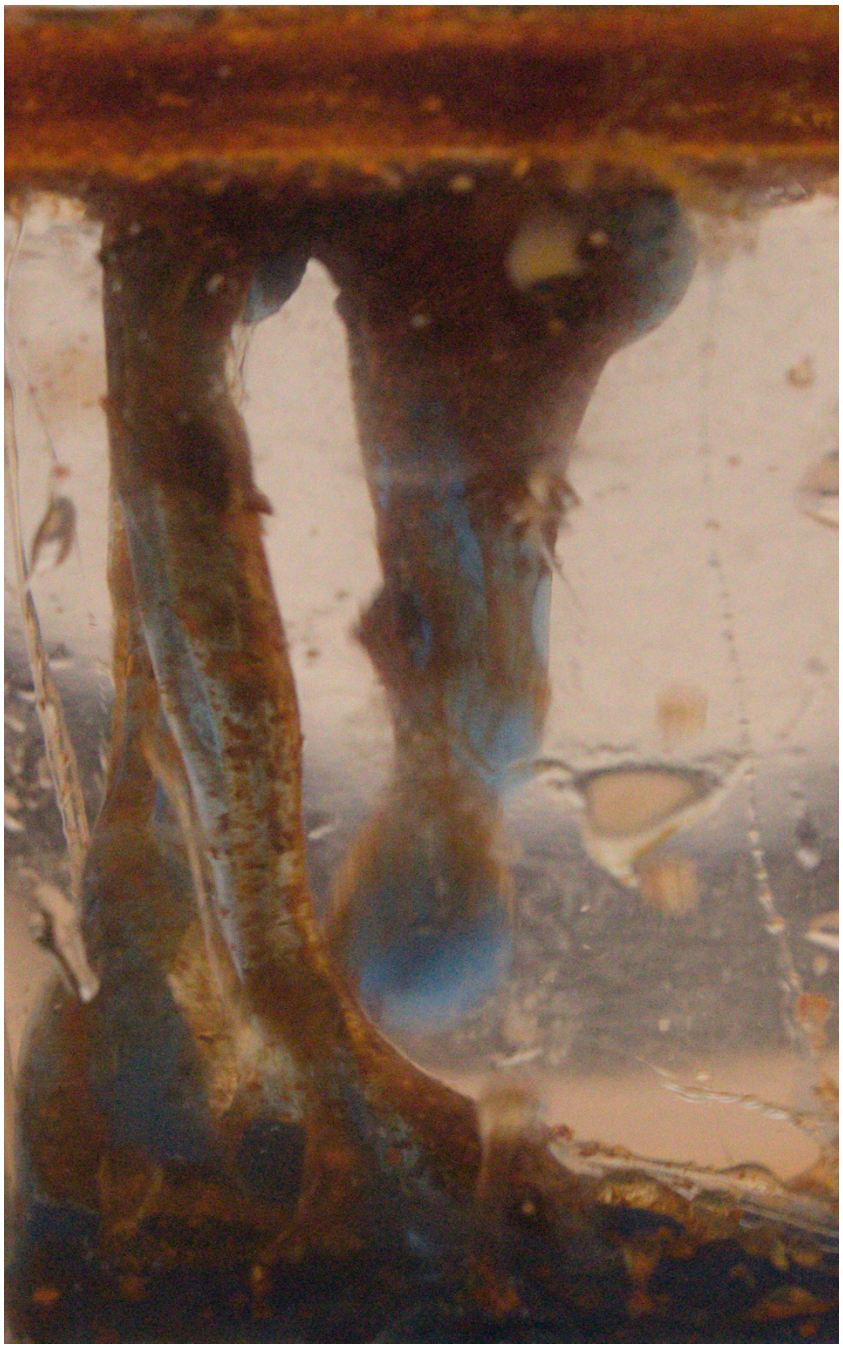

Figure 1: Image

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Flow Visualization
MCEN 5151

Context:

For this experiment I took an image by using the ingredients water, oil, chili powder and detergent. I filled a glass with water and poured some oil which floated on the top and sprinkled chili powder which formed a layer on top. I then poured detergent and due to the detergent being denser it goes down and during that process it interacts with the chili powder without mixing with it.

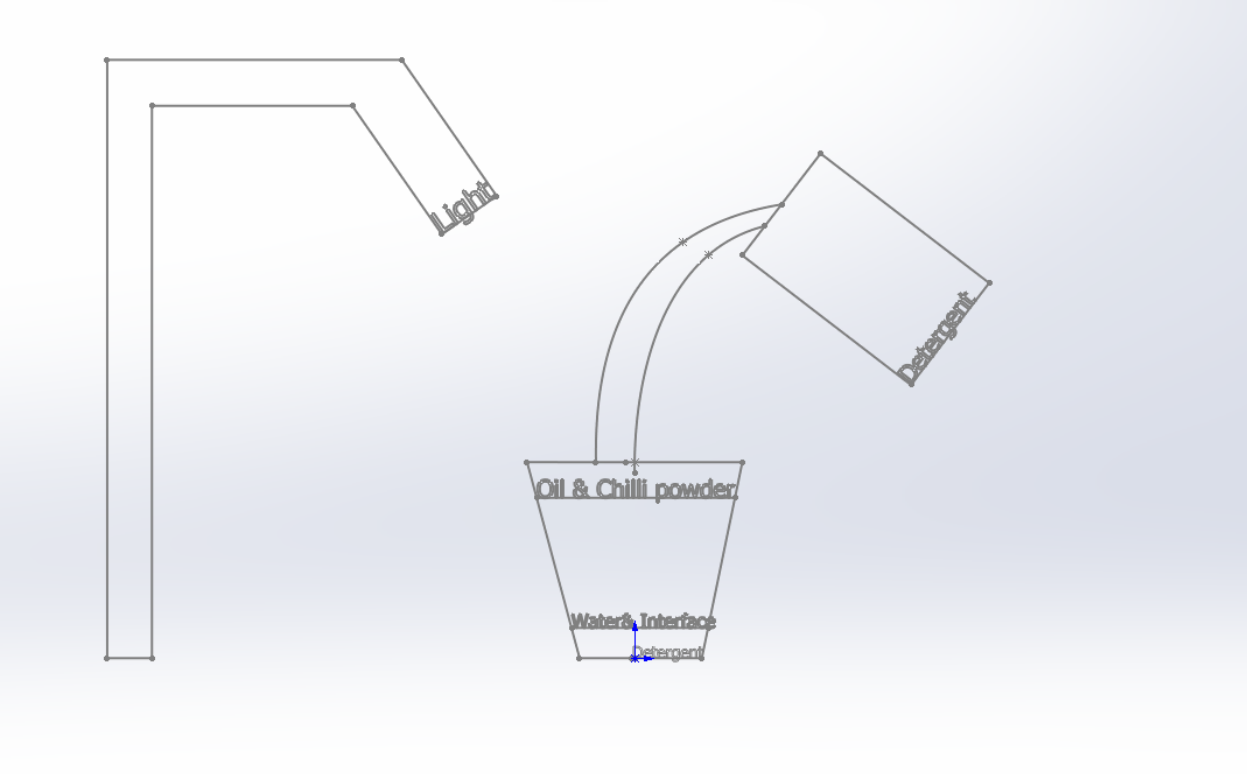

Figure 2: Setup

I used a light placed on the left of the glass as shown in the figure and had my roommate pour detergent into the glass and captured the image while the detergent was floating down.

Fluid Phenomena:

When oil was poured into water it floats onto the top as oil is less dese than water. When chili powder is poured on top it floats on top of water, which can be explained in two ways, due to density difference and surface tension. Since I only added a small amount of chili powder (1 tbsp) and even though on a per volume basis the density of chili powder is greater than that of oil, as the quantity of chili powder is relatively small the overall density of chili powder is less than that of oil and hence it floats on top It can also be explained by the phenomena of surface tension. Surface tension is the tendency of a liquid surface to minimize its area. In the case of oil and water, oil has

lower surface tension than water. When oil is added, the oil spreads out over the water surface to minimize the total surface area. When chili powder is added on top, the oil prevents the chili powder particles from immediately sinking. Instead, they are suspended on the surface due to cohesive forces acting at the oil water interface. In this experiment there are different interfaces, the interface between oil and powder, oil and chili powder, detergent and chili powder. In order to better understand the dynamic interactions between different substances within a fluid system, the calculation of Bond number emerges as a crucial parameter. Bond number explains the relation between gravitational forces and surface tension. If the Bond number is less than 1, surface tension forces dominate over gravitational forces. If the Bond number is greater than 1, gravitational forces dominate over surface tension forces. In this case Bond number is calculated for oil droplets and chili powder.

$$Bo=\rho g d^2/\gamma$$

Where: ρ: Density of the fluid (kg/m^3)
g: Acceleration due to gravity (m/s^2)
d: Characteristic length (m)
γ: Surface tension of the fluid (N/m)

By plugging the values for oil and chili powder the value of Bond number obtained for oil is 0.005444 and 0.0123 for chili powder. This indicated that surface tension dominates over gravitational forces, which explains why oil droplets are held by surface which is why they initially float on water. It also explains why chili powder forms a layer on the surface of the detergent.

Photography and Post Processing:

To capture this image, I used a Canon Eos Rebel T3i camera. The camera settings are as follows:

Shutter speed: 1/15
Aperture: f/8
ISO: 3200
Focus: 46 mm

The quantities of the substances added are:

1. Water: 75% volume of glass
2. Oil: 2 tbsp
3. Chili powder: 1 tbsp

Post processing was done using darktable. I cropped the image, enhanced it using RGB curve and temperature settings to add a more reddish tone to it. The original image is shown below.

Figure 3: Original unedited image

Conclusion:

Overall, I am satisfied with the image. To my eyes it looks similar to the “pillars of creation” image taken by image by NASA’s Hubble Telescope. Like gas clouds floating in space, this image looks like detergent pillars floating in water. I wish I had more to experiment with more fluids to generate patterns and add more color and use a different light setting to make the image more interesting.

References:

1. Willi H. Hager, “Wilfrid Noel Bond and the Bond number, Journal of Hydraulic Research Volume 50-Issue 1. (2012).