Colton Oglesbee
Flow Visualization
MCEN 4151-001

Graphene Coating and Water - Rayleigh-Taylor Instability

Fall 2020 IV 1 Report

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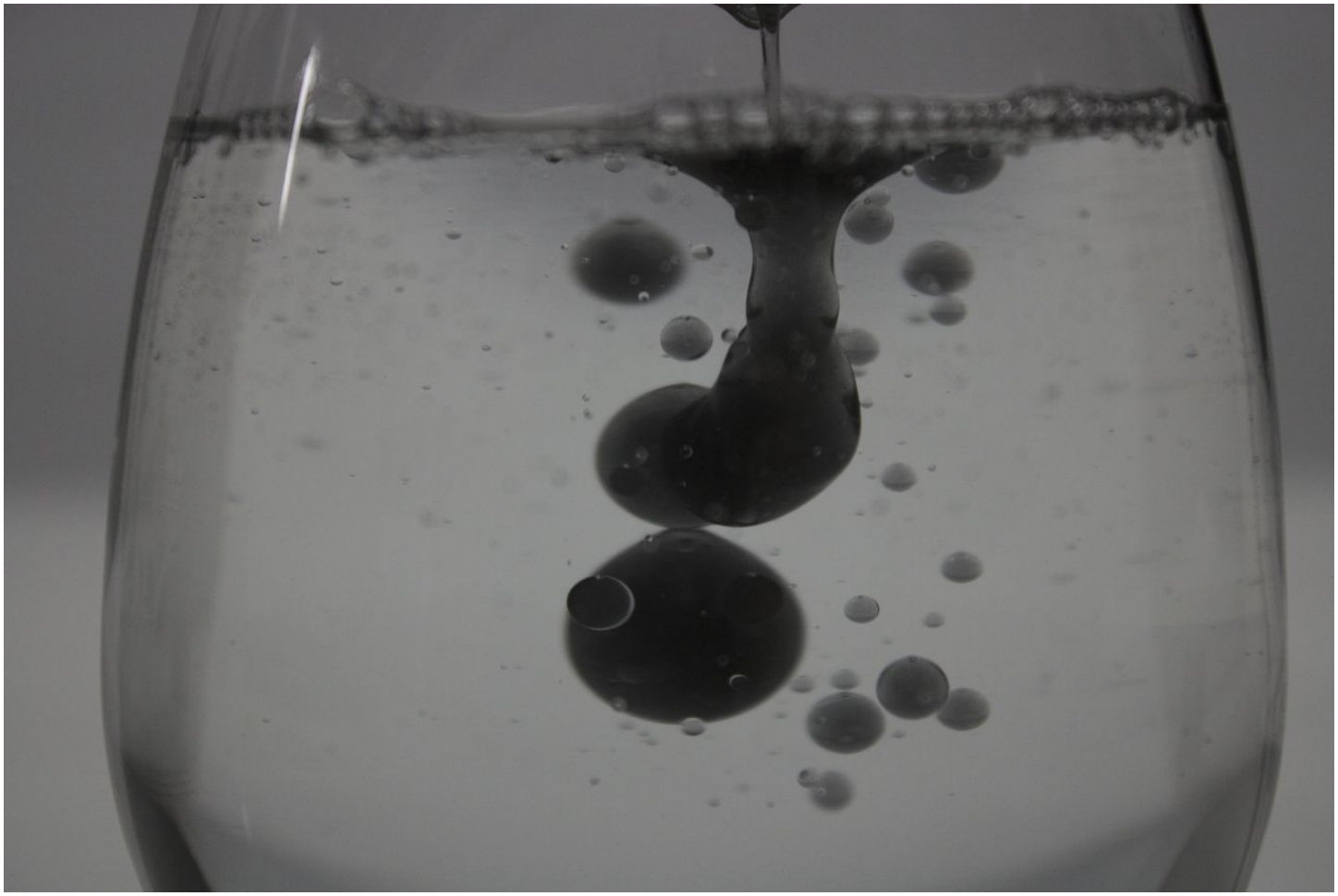
Assisted by Hannah Moller



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Background

For this first image assignment I wanted to focus mostly on the image and working on my photography skills. With that in mind, mixing two liquids with varying densities came to mind due to the ease of repetition and set up. Having access to a chemical lab through my job allowed me to use some different liquids than others may have access to. I chose to use a black, graphene, oil based liquid and dropped it into a wine glass full of water with a white background. Hannah Moller aided in the production of this shot by dropping the liquid into the wine glass while I managed the camera.

Setup and Engineering

As mentioned this shot captures different density fluids interacting together. The graphene coating is an oil based liquid and is less dense than water. When the coating is given some initial velocity prior to entering the water, the Rayleigh-Taylor Instability can be observed. Since the graphene is lighter than water, it rises to the top of the glass quickly and doesn't diffuse with water. Gravity acts on both liquids downward, the more dense or heavier fluid naturally will sit under a lighter fluid, while the less dense fluid will rise to the top. However, giving an initial velocity to the graphene, pushes into the more dense fluid. The flow of the graphene into the water shows the Rayleigh-Taylor Instability. This instability is the interface between a lighter fluid being pushed into a heavier fluid.

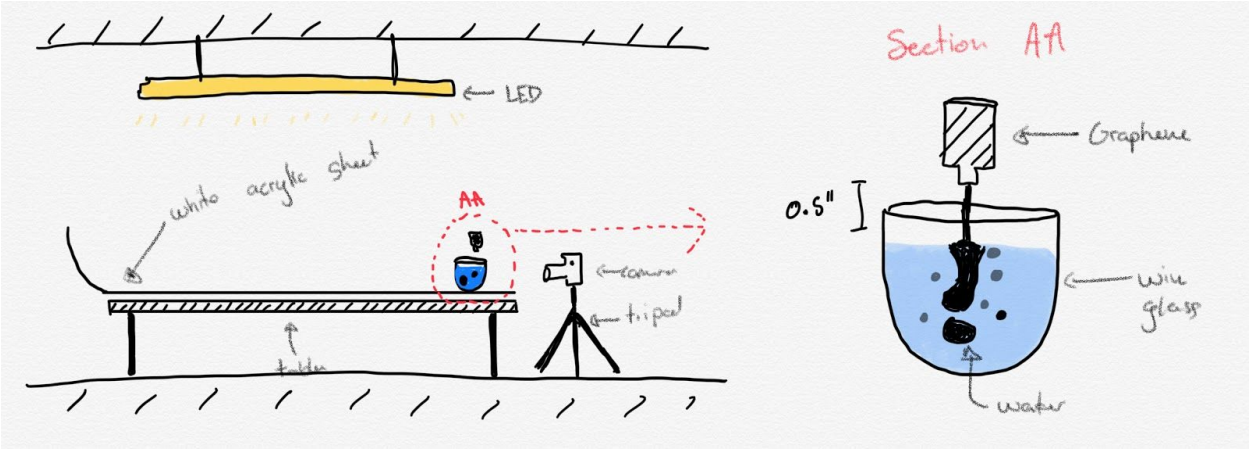

Figure 1- Sketch of how the image was taken.

As seen from the image the flow is not as complex as some other experiments around the Rayleigh-Taylor instability, such as creamer in coffee. In my photo spherical balls formed in all sizes as the graphene was dumped into the water. This leads me to believe the Atwood number is close to 1. The Atwood number can be calculated using Eqn. 1

$$\textbf{(1)} \quad A = \frac{p_1 - p_2}{p_1 + p_2}$$

Where, p_1 is the density of the heavier fluid and p_2 is the density of the lighter fluid.

Assuming this is true we can conclude the graphene coating is much lighter than the water. If the Atwood number were to approach zero we would see 'fingers' or more disruption than the bubble like spheres.

The graphene coating produced by B&B blending was selected due to its darker color. I chose to use a large sheet of white acrylic plastic measuring 3 ft by 6ft on a table and sloping up at the end to create an infinite background. Again the white background was purposely chosen to contrast the black graphene liquid. The image was taken in a small room with led lights and a led flood light was used to help light the background. I did attempt to use the camera flash and supplemental lighting on the wine glass but was not happy with the reflection off the wine glass.

Photography

Using a Canon Rebel T7 with a standard 18-55mm zoom lens at the max focal length of 55mm I was able to get this close up shot with no cropping. The camera was about 18 inches away from the wine glass, allowing for the whole wine glass to be seen in a very tight frame. Due to my inexperience with photography I did let the camera select an appropriate shutter speed and ISO, while I focused on getting the best focus and framing. In my option the image came out sharp enough with a 1/160 shutter speed. The auto mode used an ISO of 1000, but since I did not crop the image it does not appear to be grainy. The aperture was in the most closed position of 5.6, and ideally I would like to play around with this number more to get more light in the image. Since the image was framed to be all black and white I wanted to keep that look and just made small adjustments in Darktable to the exposure and contrast.

Conclusion

This image really shows the initial time frame of the Rayleigh-Taylor Instability prior to the spherical balls breaking up and shows some very interesting surface tension between the water and the liquid graphene. The size of the spheres captured in the image were satisfying and unique to this liquid combination. However I would like to capture the image varying some more settings on the camera. Dropping the ISO and adding more light, as well as playing with the post production editing to really bring out the whites and darken blacks to create even more contrast. The blacks seem to fade into grey and white, so that is a big improvement that could be made on this image.