Floating Bubbles

Jon Severns
MCEN 4151
April 4, 2013

1 Introduction

For this concept, I wanted to explore the interaction between bubbles and CO2 formed from dry ice. An example of this online prompted my interested, because the way bubbles float on top of the dry ice vapor seemed to defy logic. The setup was fairly simple, but it ended up yielding an interesting image from both artistic and scientific points of view. To capture this image, I had the help of several collaborators: Andrew Locke, Ashlyn Norberg, and Zach Wehner. Multiple people were needed to control the various aspects of the setup, as well as take the photo, and it would be difficult to complete alone.

2 Flow Apparatus

The setup required to realize this concept was very simple. A 10-gallon fish tank was filled with approximately one inch of water, and several chunks of dry ice were placed inside. The tank filled with carbon dioxide vapor, which began to stabilize as the initial dry ice reaction slowed down. At this point, bubbles were blown with a small children's bubble wand. The fluid used to create the bubbles was a mixture of dish soap and water. The bubbles simply floated on the 'surface' of the dry ice vapor, allowing photographs to be taken. See Figure 1 below for a schematic of the setup.

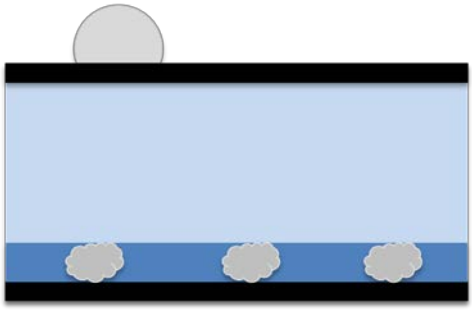

Figure 1: Experimental Setup

3 Flow Analysis

The science behind this phenomenon is quite simple. Carbon dioxide vapor formed by the sublimation of dry ice has a density of 1.977 kg/m^3 at 0^{oC} and 1atm, and air has a density of 1.293 at the same temperature and pressure. Because the air inside the bubble is less dense, it 'floats' on the interface between the carbon dioxide vapor and the air.

An interesting observation that was made during this experiment, and can be seen in the photo is the movement of the soap film on the bubble causing the dry ice vapor to move. Contrary to popular belief, the surface of a bubble is not motionless. The soap and water is constantly moving around in ever-changing patterns. Evidence of this can be seen in the colorful upper section of the bubble in the photo. In this setup, as the bubble sat on the surface of the vapor, it exerted a shear force on the vapor, causing it to travel along with the movement of the bubble surface. This can be seen in the right side of the bubble.

4 Visual Technique

The visualization technique used for this setup was the smoke from dry ice, and bubbles made from dish soap. The dry ice was purchased at a local grocery store, broken into smaller pieces, and placed in water. The dish soap was obtained in the lab, and mixed with tap water in a 1:4 ratio. To blow the bubbles, a toy bubble wand was used, which was designed to blow large bubbles.

5 Photographic Technique

To capture this image, a digital Canon Rebel EOS camera was used. I chose to take the photo with a macro lens (Canon EFS, f/2.8, 60mm) because it had the ability to capture more detail in the close up point of view. The bubble in this photo is approximately 4 inches in diameter, and the camera was about two feet from the subject. The original and final images can be seen in Figures 2 and 3, respectively.

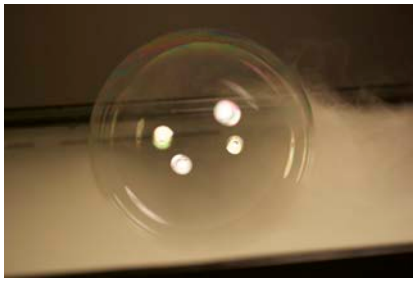

Figure 2: Original Image (2048x3072)

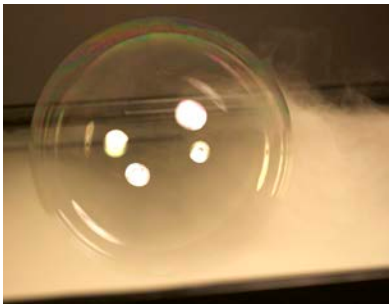

Figure 3: Edited (2490x1932)

To capture this image, I simply used the automatic setting on the camera. The bubble was well lit, not moving much, and depth of field was not a concern, so manual settings were not needed. The resulting settings were: ISO800, f/3.5, 1/320.

Not much editing was done to produce the final image. The frame was cropped so the bubble and smoke really fill the screen. Also, slight adjustments to the levels and contrast were made to enhance the bright colors at the top of the bubble.

6 Conclusion

In the end, I am happy that I was able to capture such an interesting interaction between these various materials. I would have liked to see some more color in the bubble, but it was difficult to achieve that, as the bubbles often popped before starting to become very colorful. The physics revealed in this image are quite interesting, between the density difference, as well as the interaction between the bubble surface and vapor.