Team First

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ATLS 4151 - Flow Visualization

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Introduction

For the Team First Assignment, Pablo and I decided to examine the reaction that happens when a bath bomb interacts with water. To begin the project, we were unaware of what caused the reaction between bath bombs and water. However, each of us has had the experience of seeing a bath bomb being dropped into water, releasing bubbles and colors. For the project, we wanted to capture the violent flows we had memories of. However, the bath bombs we used created very gentle flows, which creates an interesting image that shows a soft gradient of purple and pink dyes surrounding a decaying bath bomb, which resembles the smoke and ash produced by a volcano or explosion.

Flow Chemistry

The chemistry of bath bombs is surprisingly simple and interesting. Two ingredients create the fizzing reaction when a bath bomb is mixed with water. The first ingredient is citric acid ($C_6H_8O_7$), a common organic compound naturally produced by citrus fruits. The second ingredient is sodium bicarbonate ($NaHCO_3$), also known as baking soda. The effect of bath bombs results from two different reactions happening nearly simultaneously. First, when a bath bomb is dropped into water, the sodium within the sodium bicarbonate splits away. All the while, hydrogen is released from the citric acid. When the hydrogen from the citric acid encounters the bicarbonate, another reaction is set off, which releases carbon dioxide. The release of carbon dioxide is visualized through the formation of bubbles emanating from the bath bomb and creating motion on the surface of the water. The chemical equation describing this reaction is shown below.

Figure 1: Dissociation of sodium bicarbonate:

$$NaHCO_3 -> Na^+ + HCO_3^-$$

Figure 2: Hydrogen reaction with bicarbonate:

$$H^+ + HCO_3^- -> CO_2 + H_2O$$

Figure 3: Overall reaction equation:

$$C_6H_8O_7 + 3NaHCO_3 -> 3CO_2 + 3H_2O + Na_3C_6H_5O_7$$

The reaction produced when a bath bomb is mixed with water results in buoyant forces because of the release of carbon dioxide gas. The upward motion creates flows within the water as the bubbles rise to the surface due to the buoyancy. These flows can then be visualized by the diffusion of the dyes held within the bath bomb. As it dissolves, the dyes are released and spread out by the motion created by the convective flows from the bubbles rising to the surface. This is seen by the plume of dye directly above the bath bomb. The dye also displays density differences and low diffusion rate as the dye is seen in a more significant amount collecting at the bottom of the tank with more clear water on the top. This shows that the dye solution is denser than water as the dye sinks to the bottom of the tank.

Photographing Method

To photograph this reaction, a clear storage bin 8.8 inches in height, 12.2 inches in width, and 12.6 inches in length was filled with 7 inches of water. It was the setup in my kitchen in front of a white backsplash on a stovetop with a white towel behind. A camera was then set up on a tripod to 40 inches high. The camera was then set back 28 inches from the tank and aimed directly at the center. A kitchen utensil was placed in the middle of the tank to set the camera's focus, and the lens was then manually focused. After finding the correct focus, the kitchen utensil was removed, and the lens was zoomed into 150mm. To light the scene, I used an external flash on the camera and the overhead stove light in addition to natural light coming in through the windows in the kitchen. After the scene was prepared, the bath bomb was dropped gently into the tank. Using a remote shutter, I captured multiple images throughout the bath bomb decay using various apertures and iso settings. A picture of the setup is shown below.

Chart 1: Final image settings:

Contrast	**Normal + S-curve**

FOV	**13.7° horizontal, 9.1° vertical**
Distance from object	**28 inches**
Lens specs	**35-150mm F2.0-2.8**
Camera type	**Sony A7R3 (mirrorless)**
Image dimensions	**7952 x 5304 (orignal)** **3611 x 5414 (cropped)**
Focal length	**150 mm**
Aperature	**f4**
Shutter speed	**1/60s**
ISO	**1600**
Flash	**Off**

Figure 4: Image of experiment setup:

Figure 5: Image before and after:

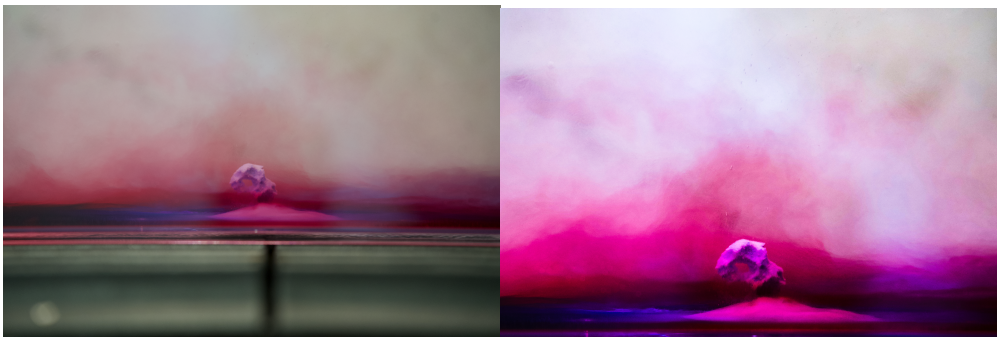

Image Analysis

After capturing the original image, I wanted to highlight the drama of the flow. To achieve this, I brought the image into Lightroom for editing. I feel like in the original image, the colors appear inaccurate and washed out. In Lightroom, I readjusted the white balance by selecting a neutral area in the upper right of the image. Additionally, I increased the temp by two and the tint by 58 to make the image warmer and bring out the pinks and purples. Although I feel like the original image is under-exposed, in editing, I turned the exposure down half a stop so that I could turn up the contrast and shadows. Increasing the shadows and contrast adds more color to the darker regions of the photo, which helps show more of the flow with greater color accuracy. To go along with increasing the contrast, I added a slight s-curve to the tone map to create a greater separation between the light and dark colors. This made the faint colors more prominent, increasing the visibility of the dye flow above and to the sides of the bath bomb. Lastly, I added a crop to the image. The crop intended to bring the viewer closer to the subject and remove unnecessary distractions.

Works Cited

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