Bathing in Hues

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I Introduction

A series of chemical reactions are depicted in this image using reactions and compounds that are detailed in this report. Likewise, the photographic and visualization techniques are used to capture the science behind the flow. This image was taken for the Team First assignment for the Flow Visualization course at the University of Colorado Boulder. The experiment was conducted alongside Jonathon Gruener, Ari Matrajt Frid, and Patrick Watson.

The image shows the resulting reaction that occurs when a pink bath bomb is placed in a fish tank filled three fourths of the way with tap water. Upon placing the bath bomb in the water, the chemicals within the bomb instantly reacted with the water, with the entire reaction lasting around 10 minutes in total. This created the bubbles and colored liquid seen in the photograph.

II Flow Apparatus

This experiment can be done by filling a fish tank three fourths of the way with water and allowing it to sit on a steady surface to minimize movement. The bath bomb was then dropped into the fish tank from a few inches above the surface of the water. The bath bomb sat in the water until it completely dissolved which took around 10 minutes. The experiment setup to capture the image is shown in **Figure 1**.

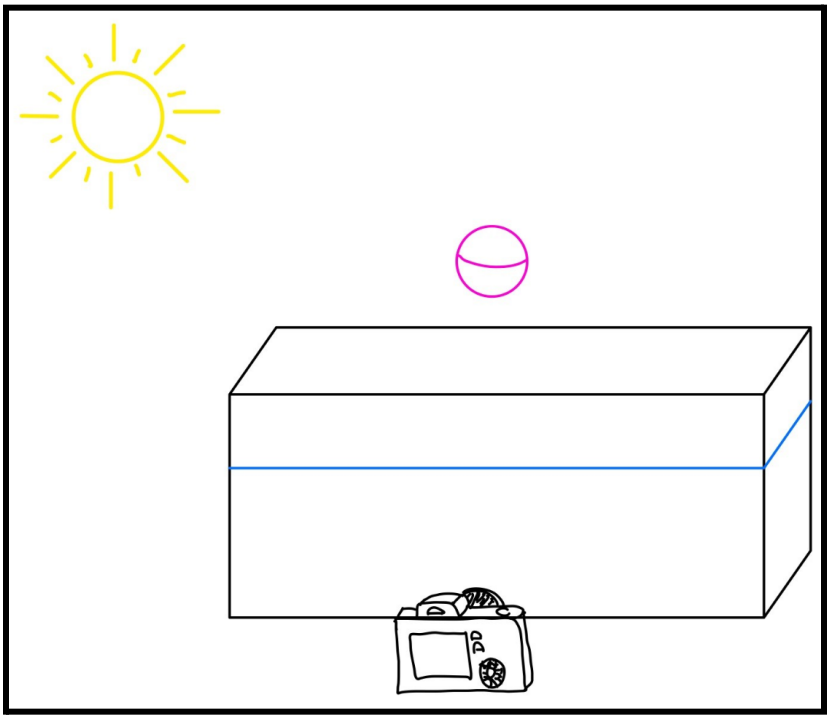

Figure 1: Diagram of experiment setup

The reaction is created by the sodium bicarbonate and citric acid that is contained in the bath bomb. This is known as an acid-base reaction, also known as a neutralization reaction. A neutralization reaction is when an acid and a base react resulting in salt and water. The citric acid is the acid and the sodium bicarbonate is the base. Once the bath bomb is placed in the water the sodium bicarbonate and citric acid react creating an aqueous solution, where the neutralization reaction actually takes place [1].

Sodium bicarbonate is commonly known as baking soda. The chemical formula for sodium bicarbonate is $NaHCO_3$. This means that it is comprised of one sodium atom, one hydrogen atom, one carbon atom, and three oxygen atoms. The bicarbonate is the HCO_3 section of the formula. The chemical formula for citric acid is $C_6H_8O_7$. This means that it is comprised of six carbon atoms, eight hydrogen atoms, and seven oxygen atoms. When the two compounds react they create a salt called sodium citrate, along with water and carbon dioxide. The chemical formula for sodium citrate is $Na_3C_6H_5O_7$. This means that it is comprised of three sodium atoms, six carbon atoms, five hydrogen atoms, and seven oxygen atoms. The chemical reaction is shown below in **equation 1**.[2]

$$NaHCO_3 + C_6H_8O_7 \rightarrow Na_3C_6H_5O_7 + CO_2 + H_2O$$ **Equation 1**

The sodium bicarbonate is what creates the carbon dioxide in the reaction. This is because sodium bicarbonate is a metal carbonate. When metal carbonates undergo a neutralization reaction they release carbon dioxide. The bubbles in the image are made up of carbon dioxide, which is what makes the bath bomb fizz.

There are other chemicals in bath bombs that add smell and color, like incense and dyes. These are noticeable before the bath bomb comes into contact with water, but are much more prominent once the bath bomb is dropped in the water. This is because the scents and color trapped within the bath bomb are released into the water.

III Visualization Technique

The visualization of this bath bomb was achieved by using a fish tank borrowed from Dr. Hertzberg. The fish tank was filled 75% of the way with tap water. The tank was brought outside. Then, we dropped a pink bath bomb in the tank. It took about 10 minutes to dissolve, and we took pictures throughout the entire dissolving process.

To attain the desired lighting, this experiment was conducted outside at roughly 6:00 pm. This allowed for the sun to be the light source without being directly above the experiment. That way the camera was able to be angled directly above the experiment without casting a shadow on the image.

IV Photographic Technique

The image was captured on a Canon EOS 5D camera with a 28-200 mm lens. This lens has an aperture range of f/3.5-5.6 and a filter thread diameter of 72 mm. The distance from the camera to the object was about 1 foot with a field of view of about 12 degrees. The exposure was 1/200 seconds ,the focal length was 200 mm, and the ISO was 640. The camera was set to max. I chose these settings to capture the motion of the image without compromising the vibrancy of the color. The original image was 5616 x 3744 px. My edited image was 2153 x 1540px. The original and edited pictures are shown below.

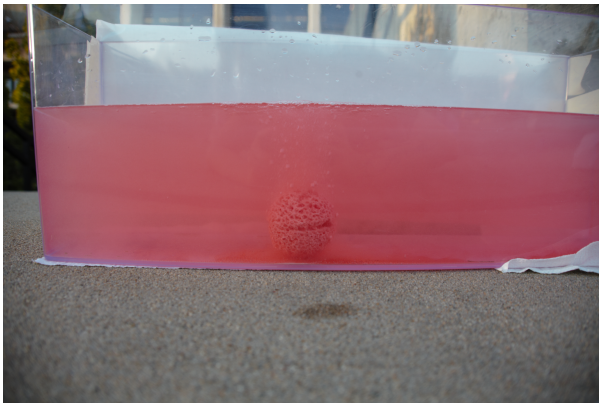

Figure 2: Original Image

Figure 3: Edited image

The photo editing software I used was darktable. I adjusted the tone curve, increased the saturation, increased the exposure, sharpened the image, and increased the color contrast. I also cropped the image to focus more on the reaction rather than the entire set up. The goal of these edits was to make the pink color pop as much as possible, as well as make the bubbles more apparent.

V Image Analysis

The image provides an example of an acid-base reaction. I really like how my image turned out. I think the pink color is very vibrant. I also really like the different textures within the image. The bubbling carbon dioxide adds a very interesting texture to the porous surface of the bath bomb. I think I could improve this image in post-processing. I could sharpen the image more and increase the contrast. This would help with the visualization of the smaller bubbles. I also think that the fluid physics are shown well. Bath bombs are an everyday item, but my group and I were able to show the physics and chemistry behind how they work. To develop this idea further, I could dye the water the bath bomb was dropped into. This would provided some color contrast between the bath bomb and the water it is submerged in.

VI References

[1] *Key stage 3 worksheet the science of bath bombs*. The Science of Bath Bombs. (n.d.). https://s4science.co.uk/wp-content/uploads/2020/10/F-KS3-The-Science-of-Bath-Bombs_answers.pdf

[2] *Reaction exposed: The big chill! - activity*. TeachEngineering.org. (2023, July 31). https://www.teachengineering.org/activities/view/wsu_big_chill_activity1#:~:text=In%20the%20presence%20of%20water%2C%20citric%20acid%20%5BC6H,pressure%20so%20no%20explosions%20occur.