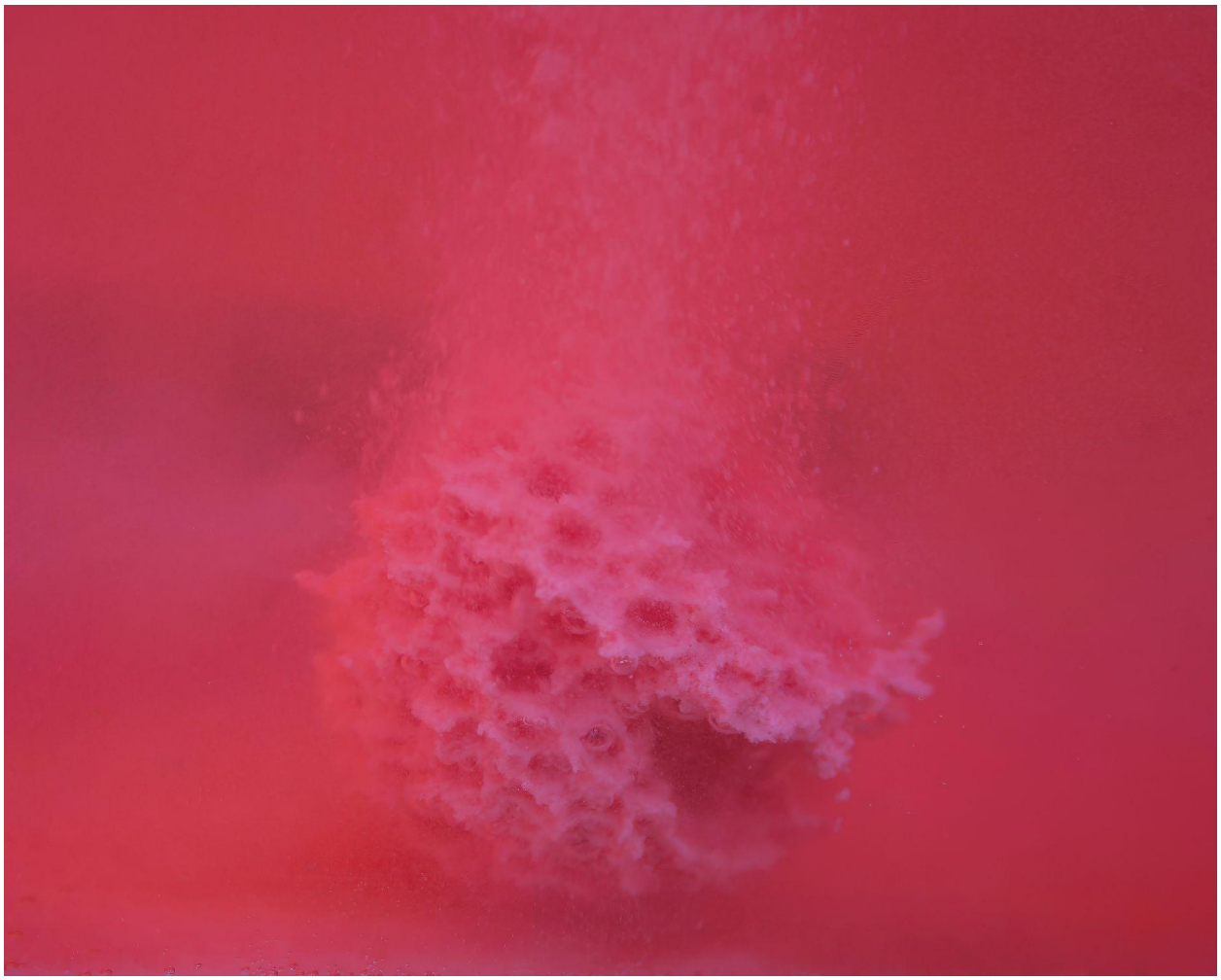

Figure 1: Depiction of bath bomb being dissolved in water through acids and bases interactions, releasing CO_2 bubbles

Ari Matrajt
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Introduction

The image presented in Figure 1 corresponds to the Team First assignment for the course MCEN 5151, Flow Visualization. The picture shows a bath bomb dissolving in lukewarm water in a fish tank. The bath bomb consists of several chemical compounds, including acids and bases that react with the water [1]. These reactions dissolve the bath bomb and unleash CO2 [1]. A further analysis of this process will be explained in the next section. The experiment, as well as capturing the images was made possible by the help and support of Sierra Greeley, Jonathan Gruener, and Patrick Watson, as well as Professor Hertzberg, who provided the tank in which the experiment took place.

Fluid Dynamics

Bath bombs consist of many compounds, most of which aim to create aesthetically pleasing colors and nice odors. However, the most important compounds needed to create a bath bomb are citric acid and baking soda [1]. Citric acid, as its name claims, it is an acid, while baking soda is a base. Acids and bases are classified as such depending on their pH. A low pH corresponds to an acid, while a high pH corresponds to a base. A compound's pH dictates some of its behavior and how it interacts with other compounds. When a base and an acid are mixed together in an aqueous solution (i.e. water), these undergo a neutralization process, releasing carbon dioxide in the process.

Citric acid is composed of carbon, hydrogen, and oxygen ($C_6H_8O_7$), while baking soda comprises hydrogen, sodium, carbon, and oxygen ($3NaHCO_3$). Baking soda is the common name for the chemical compound called sodium bicarbonate. When these two compounds interact with water (H_2O), they form carbon dioxide (CO_2) and sodium citrate ($Na_3C_6H_5O_7$). The complete reaction is as follows:

$$C_6H_8O_7 + 3NaHCO_3 \rightarrow 3H_2O + 3CO_2 + Na_3C_6H_5O_7$$ [2]

Figure 1 shows many bubbles coming from the bath bomb, leaving the orifices created by it being dissolved. These bubbles are CO_2 bubbles. The reason why they rise is because they have a lower density than water, so when they come into contact with water they weigh less and as a result, are propelled upwards.

Visualization Method

The visualization techniques used in this experiment to take the photograph in Figure 1 were the following. First, a container was borrowed from Professor Hertzberg to conduct the experiment. The container was a fish tank that could hold around 10 liters of water. This tank was then filled up to around 75% maximum capacity with lukewarm water. A bath bomb was acquired by Sierra Greeley. It was around 3 inches in diameter and had a red/pink hue. The tank was set up outside on a concrete floor. The tank's side was covered with white sheets of paper with the goal of making the bath bomb stand out more. The experiment was performed at sunset to get a better lighting source which would be parallel to the tank. The bath bomb was dropped in the tank and the chemical reaction was allowed to take place. Overall, the bath bomb dissolved for 10 minutes in the water until it was no longer visible. The image in Figure 1 was taken around 7 minutes after the bath bomb was dropped.

Photographic Method

The image was taken using a Canon EOS 5D camera with a Canon EF 28-200mm lens. This lens has an aperture range of f/3.5-5.6, a focal length of 28-200mm, and a filter thread diameter of 72 mm. The distance from the object to the lens was around 6 inches with a field of view of around 3 inches. The digital camera had the following settings when the image was taken: 1/80 exposure, the camera aperture was f/5.6, a focal length of 90.0 mm, and 200 ISO. The original image had a pixel size of 5616px width x 3744px height, which was then cropped to 3000px width x 2400px height. The reason for this crop was to reduce some unnecessary background. Other post-processing procedures were to increase contrast, increase color saturation, slightly change the RGB curve, and increase the sharpness of the image. All of these steps were done in order to make the bath bomb stand out from the background, as well as to highlight small details like bubbles. The original image can be seen in Figure 2.

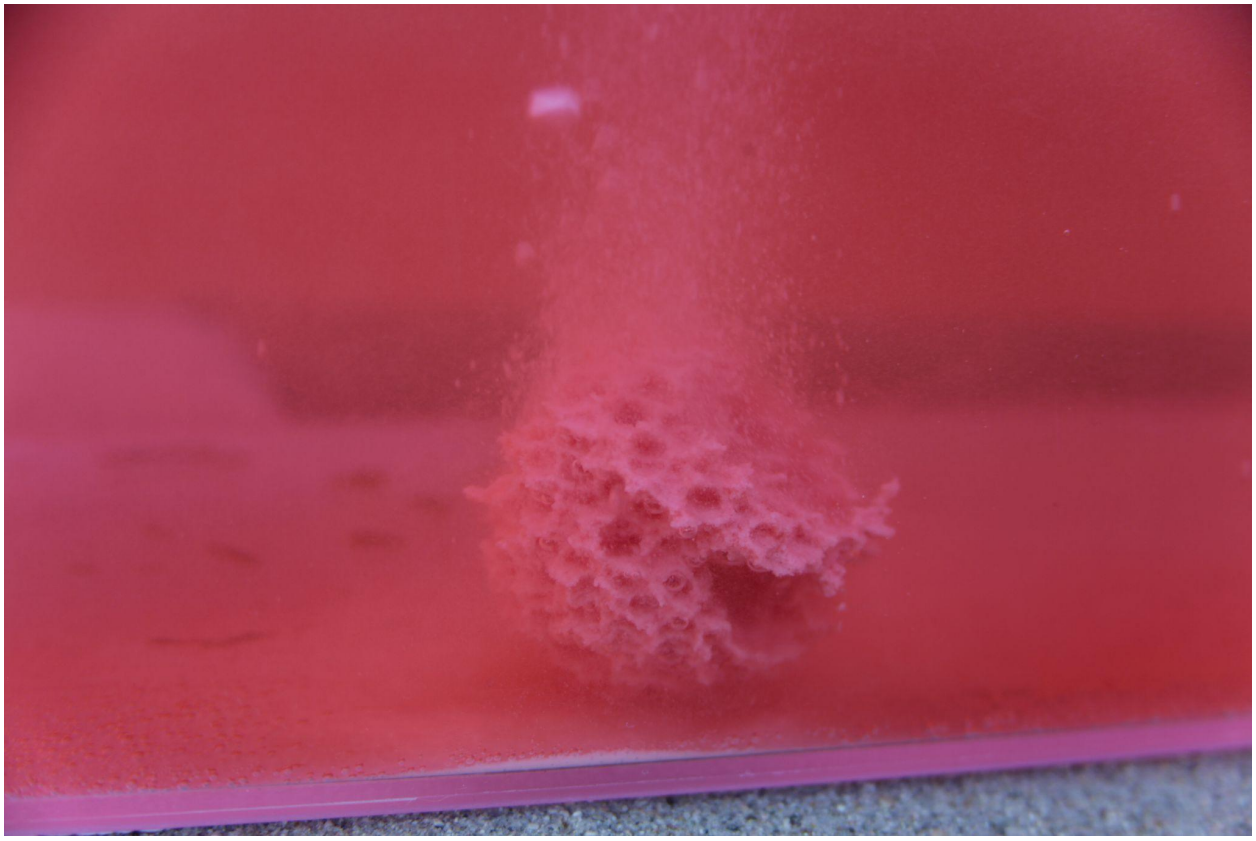

Figure 2: Original image before post-processing depicting a bath bomb dissolving in water

Conclusion

The image taken in this experiment, shown in Figure 1, is a dynamic representation of the chemical reactions between acids and bases, resulting in a release of gasses and the subsequent dissolving of the bath bomb. It was a simple experiment to perform, making it a highly reproducible task. The setup was straightforward and fast. Several things could be improved if the experiment was reproduced. Firstly, using a tripod would enable the photographer to produce by reducing unnecessary blurriness induced by shakiness. Another possible improvement could be dyeing the water with a different color before introducing the bath bomb. This would allow for a higher contrast between the bath bomb and the water, allowing more details to show. Overall, the experiment was a success and the identified fluid physics were captured as intended.

References

[1] Rowland, Teisha. "Bath Bomb Science." Science Buddies, 29 July 2023, https://www.sciencebuddies.org/science-fair-projects/project-ideas/Chem_p105/chemistry/bath-bomb-science. Accessed 6 Oct. 2023

[2] “Key Stage 3 Worksheet the Science of Bath Bombs.” The Science of Bath Bombs, Swansea University, s4science.co.uk/wp-content/uploads/2020/10/F-KS3-The-Science-of-Bath-Bombs_answers.pdf. Accessed 6 Oct. 2023.