Bath Bomb - Flower

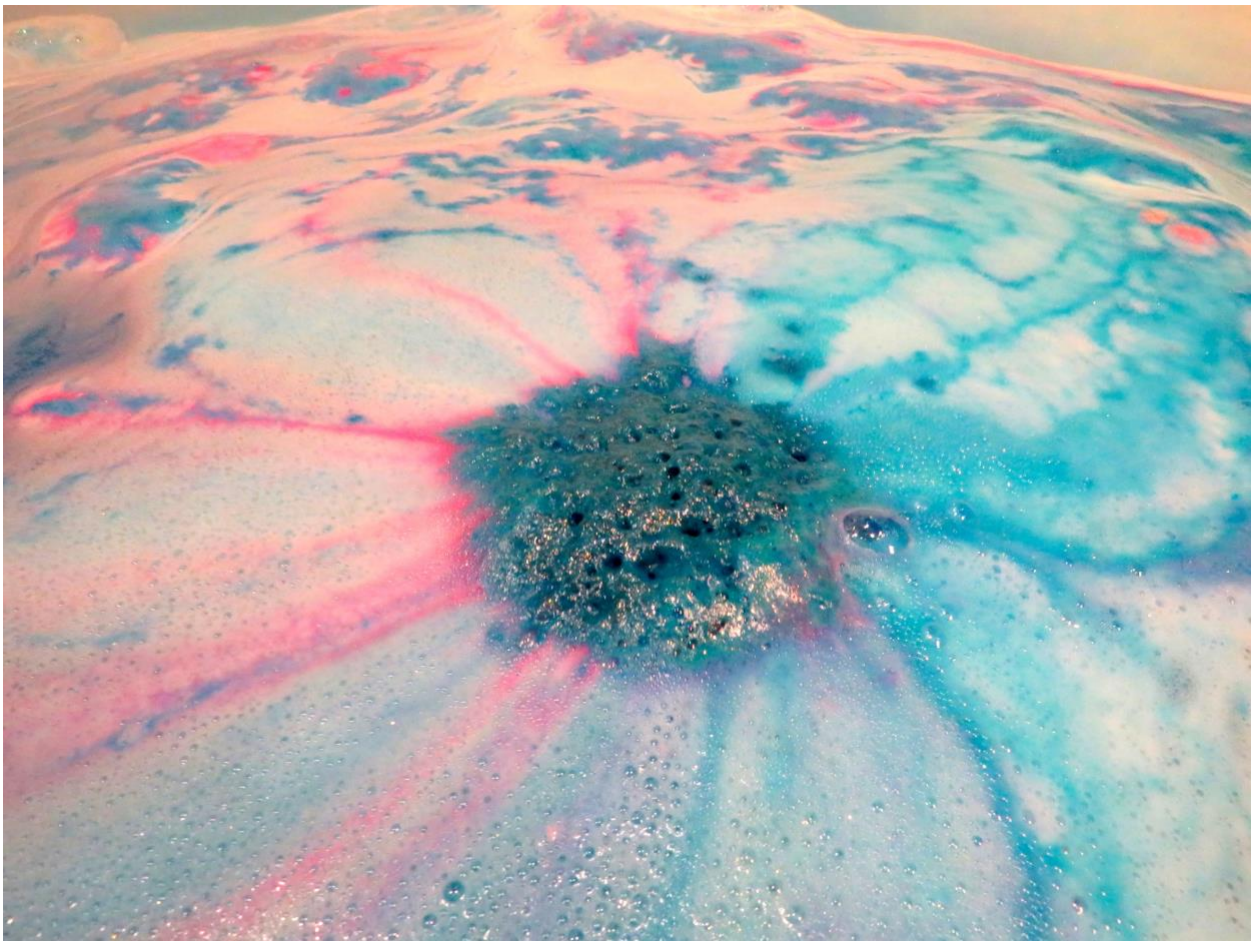

Image-Video 2

MCEN 5151: Flow Visualization

University of Colorado Boulder

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Introduction

The report will discuss the flow phenomenon, experimental setup, photographic technique, and conclusions about the flow image. This report is for Image-Video 2 assignment in MCEN 5151 Flow Visualization, and the purpose is to allow students to explore and capture a fluid flow phenomenon. The image needs to be appealing and interesting, while being able to explain the phenomenon with physics. The intent for this photo is to visualize an interesting pattern from the flow of a dissolving bath bomb in a tub of water. The motivation comes from my previous observations of bath bombs, and I was intrigued by the color and reaction it had on water.

Flow Phenomena

The two key ingredients of a bath bomb are solid citric acid and chemical sodium bicarbonate [1]. The final pH of the bath bomb should be neutral, and no reaction should happen until it's dissolved in water [1]. The acid + base reaction with sodium carbonate results in tiny bubbles of carbon dioxide gas, which is the fizzing that you see [1]. The fizzing and the heat of the water helps disperse the bath bomb faster, so that the bath would be ready in no time [1]. Here is the chemical balance equation for a bath bomb:

Citric acid + sodium bicarbonate → sodium citrate + water + carbon dioxide

$$\mathbf{C_6H_8O_{7(s)} + 2NaHCO_{3(s)} \rightarrow Na_2C_6H_6O_{7(aq)} + 2H_2O_{(l)} + 2CO_{2(g)}}$$ [1]

Next, I want to talk about the buoyancy force of the bath bomb. Since the bath bomb floats, the buoyancy force should be equal to the force of gravity. The buoyancy force equation is:

$$F_B = V\rho g \text{ [2]}$$

$$1.315\ \frac{kg * m}{s^2} = (0.000134\ m^3)(1000\ \frac{kg}{m^3})(9.81\ \frac{m}{s^2})$$

Here, V is the volume of the bath bomb that is submerged, ρ is the density of the water, and g is the gravity. The volume of a sphere is $V = \frac{4}{3}\pi r^3$ [3]. So, with a radius of approximately 1.25 inches, the volume of the submerged bath bomb is approximated to

be 8.18 cubic inches or 0.000134 cubic meter. Using the buoyancy equation, you get $1.315\ \frac{kg*m}{s^2}$.

Now, to calculate the force of gravity, it is just the mass of the bath bomb times the gravity. So, $F_g = (0.133\ kg) * \left(9.81\ \frac{m}{s^2}\right) = 1.305\ \frac{kg*m}{s^2}$, assuming that the bath bomb weighs around 4.7 ounces or $0.133\ kg$. As you can see, the force of gravity and force of buoyancy is about the same, which results in the flotation of the bath bomb on water.

Experimental Setup

The objective is to capture an interesting pattern created by the bath bomb's reaction with water. The setup is shown in figure 1. The equipment list includes bath bomb, water, tub, DSLR camera, and bathroom lighting. The bath bomb was purchased from Lush, and I asked for their brightest colored one. The water, tub, and bathroom lighting were all sourced in-house. The DSLR camera is a Canon PowerShot SX540 HS purchased from Best Buy and was also used for the previous assignment.

The tub was first filled with lukewarm/hot water. This took approximately 15-20 minutes. Before putting in the bath bomb, I made sure that the settings and exposure on the camera were good. This means getting the right focus on the water, and lighting. Then, I dropped the bath bomb onto the water and took photos rapidly. As the bath bomb moved around the tub, I had to move my camera as well. This is the tricky part because I did not want to lose focus. I even tried moving around for different angles but was restricted to only 180 degrees because the tub was enclosed with three walls. I took many photos until the bath bomb's reaction was finished. Luckily, I was able to capture a flower-like image of the bath bomb as shown in figure 2.

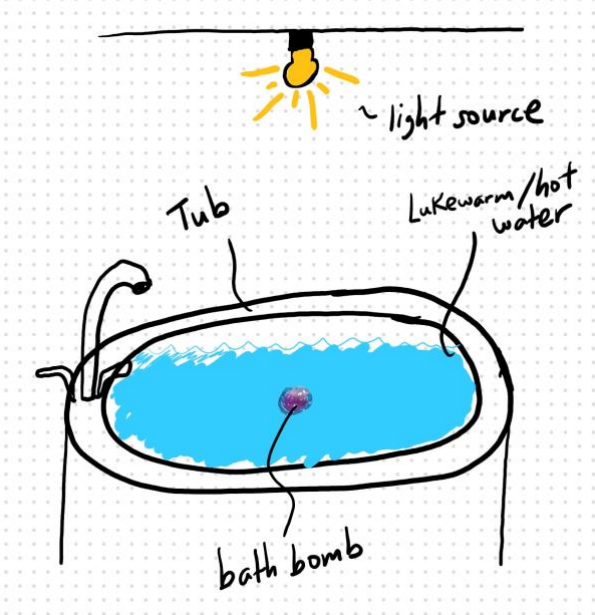

Figure 1. Bath bomb photo setup

Photographic Technique

As the bath bomb moved around the tub, I kept about 4 inches of distance from the camera to the bath bomb. The aperture, focus, shutter speed, and ISO were manually adjusted before the experiment to get the best quality image. I used to bathroom lighting as the light source. Fortunately, the light was right above the tub, and I was able to get adequate lighting. Table 1. shows the camera used and the exposure levels.

Camera	Canon PowerShot SX540 HS (DSLR)
Aperture	F4.0
Focal Length	35mm Equivalent
ISO	800
Shutter Speed	1/30
Height	3888 pixels
Width	5184 pixels
Photo Size	4.92 MB

Table 1. Photo Specifications

The photo was uploaded and edited on Gimp. My goal was to brighten up the image and increase the contrast to make the colors more appealing. Surprisingly, I did

not need to crop the image at all. The photo was right in the frame that I wanted it to be. The color overall is good, so I did not mess with the color balance. The exposure and brightness were increased slightly to brighten up the image. I also adjusted the black level slightly to make the dark spot in the middle more defined. The contrast was increased to make the bath bomb's color more enhanced, which made it more appealing. Lastly, I adjusted the RGB curve by randomly pulling the curves around to make it just right. Figure 2. shows side by side comparison of before and after edits.

Figure 2. Before and after photo edit on Gimp

Conclusion

The image shows a bath bomb reacting to the water, and it created a flower-like design. This was very lucky, and the design only lasted for three seconds before it blended in with the water. I love the frame that I captured it in because you can see the flower and wavy water in the back. However, the water is not actually wavy, and the effect is created by the bubbles and foam from the bath bomb. A weakness of the photo is that it will be hard to replicate because the bath bomb created the flower image by chance. The chemical reaction equation is important to examine why the bath bomb fizzes. I also did a buoyancy force and gravity force calculation to show that the bath bomb floats on water. I fulfilled my intent by capturing an interesting pattern that the bath bomb created, which in this case is a flower with red/pinkish pedals on the left and blueish pedals on the right. I could further develop this idea by mixing multiple bath bombs together. This would be interesting to visualize because there will be a lot more colors and more bubbles from the reaction.

Reference

[1]: Michelle, et al. “How Do Bath Bombs Work? the Science (with Video).” *Lab Muffin Beauty Science*, 30 Aug. 2019, labmuffin.com/how-do-bath-bombs-work/.

[2]: Boundless. “Boundless Physics.” *Lumen*, courses.lumenlearning.com/boundless-physics/chapter/archimedes-principle/.

[3]: “Volume of Sphere - Formula, Derivation, Examples.” *Cuemath*, www.cuemath.com/measurement/volume-of-sphere/.