Elephant's Toothpaste- An Explosion of Gas-Driven Foam

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Introduction: As our team-first project, our purpose was to develop an elephant toothpaste using dish soap, hydrogen peroxide, yeast and food colors. We were trying to see how these components were reacting exothermally to give rise to a foamy eruption and analyze the flow physics behind this as well. To get the shot, one of my teammates, Alex helped me by arranging the deliverable dilute chemicals needed to perform our experiment, Jessica prepared the warm solution of yeast necessary for the explosion of the elephant toothpaste, me and Alex, we prepared our solution with dish soap and hydrogen peroxide using safety goggles, and for the reaction to kick in, we were needed to pour warm yeast solution in the hydrogen peroxide mixture and Jessica was pouring the yeast solution, I was clicking still pictures and Alex was capturing the video. I was having trouble in focusing my camera, and my team mates helped me in getting a better focus.

Flow Physics: For this experiment, hydrogen peroxide, dish soap, food colours, yeast mixture in warm water were used. We poured half a cup of hydrogen peroxide (3 %) in a bottle, added a squirt of dish soap and swirled gently to mix the chemicals, then we added two different colours of food dye (pink and purple) by dripping them down into the bottle. In a measuring cup, we mixed 1 tablespoon of yeast in 3 table spoon of warm water and stirred it for 30 seconds. Finally, elephant toothpaste was formed as soon as we poured that yeast mixture into the bottle with hydrogen peroxide and dish soap. The production of elephant toothpaste was a result of a series of chemical reaction and flow physics phenomena. If the exothermic reaction is considered here, it was found out that hydrogen peroxide decomposed into water and oxygen after adding the warm mixture of yeast. Since, there was a rapid production of oxygen gas molecules, bubbles were being formed in liquid soap and the expansion of these bubbles gave rise to a foamy eruption which is known here as an elephant's toothpaste. If flow physics is considered here, it can be said that the foam from our experiment is a buoyancy driven flow. Oxygen bubbles inside the vessel has lower density than the surrounding liquid inside the bottle and such difference in density causes the bubbles to flow upwards and this upward force is a buoyant force. The primary driving force of the foam is the rapid generation of oxygen gas inside the vessel which creates a high pressure environment, forcing foam to flow upwards outside, however buoyancy does play a role in driving the flow physics of foam eruption as well. Dish soap used in this experiment works as a surfactant to lower the surface tension of water formed by the decomposition of hydrogen peroxide, and this helps bubbles to form easily, maintain their shape and make the foam last longer [1], [2].

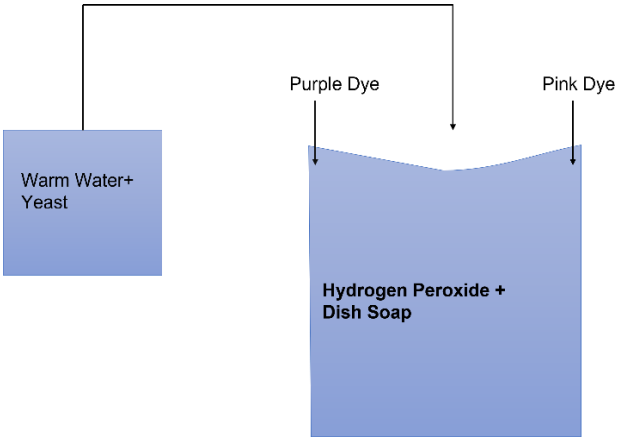

Figure 1: Experimental Setup

Figure: Original Image

Visualization Technique Used: To visualize the foamy eruption of elephant's toothpaste, pink and purple food colour dyes, 3% USP hydrogen peroxide, yeast and dish soap was used. The experiment was conducted outdoor, all of the team members wore safety goggles. Since oxygen gas produced would be pushed out during the experiment, to avoid fire hazard we removed all flammable hazardous materials and all of the team members were 5ft apart from the table while

the reaction was taking place and this safety protocols were adopted from previous literature [3]. To safely dispose elephant toothpaste mixture, we used plenty of water to first dilute the mixture as we rinsed it down to the drain. The picture was taken outdoor under bright sunshine to get good lighting and to avoid chemical hazard.

Photographic Technique Used: Our approximate field of view was 5.5 inches. Sony alpha 7 was used to capture this image. This digital camera has a focal length of 28-70 mm, ISO range from 100 to 51200, a 24.2MP full-frame Exmor R CMOS sensor. The original image had a width and height of 1616 and 1080. The final edited image had an image width and height of 535 and 547 respectively. The picture was taking with an aperture of f/2.8, ISO of 100 and a shutter speed of 1/1000 s with manual focusing. The original image was 1616*1080 pixels and the edited image was 535*547 pixels. For image processing, I processed by image with a black background in windows photos app, and then in dark table I tried to increase the sharpness of the image, because it seemed that the picture was out of focus and was looking blurry to me. Other than that, to zoom in into the swirling pattern of foam, I cropped out the picture, which might have resulted in the loss of resolution in the final edited image.

Conclusion:

The image reveals the flow physics of elephant toothpaste. The eruption of foam from the elephant toothpaste looked visually appealing to me and the purple, pink colour popped out in a very appealing way in the black background. However, I am not convinced with the image resolution, the picture looked a bit blurry and out of focus to me. I should use macro imaging techniques to improve my image's resolution from now on. I think our experiment on elephant toothpaste is a decent example to show buoyancy and high pressure driven flow, and effects of surface tension. I would like to improve the resolution of my image by using macro imaging techniques. To further develop this idea, I would like to see how change in concentration of hydrogen peroxide and change in temperature effects the foam behaviour.

References:

[1] I. Sri Hardyanti, I. S. Hardyanti, I. Nurani, and D. S. Hardjono HP, "Elephant's toothpaste: review of exciting chemistry learning in senior high school," *Universitas Pendidikan Indonesia*, vol. 3, 2018, [Online]. Available: http://science.conference.upi.edu/proceeding/index.php/ICMScE/issue/view/3|ICMScE2018

[2] "Elephant Toothpaste: A Fun and Foamy Science Experiment for Kids."Available: Elephant Toothpaste Experiment (suchscience.net)

[3] "Elephant's Toothpaste" (PDF). *University of Utah Chemistry Demonstrations*. University of Utah. Archived (PDF) from the original on 23 December 2014. Retrieved 21 March 2014.