Jeff Byrne

MCEN 4151: Flow Visualization

Professor Hertzberg

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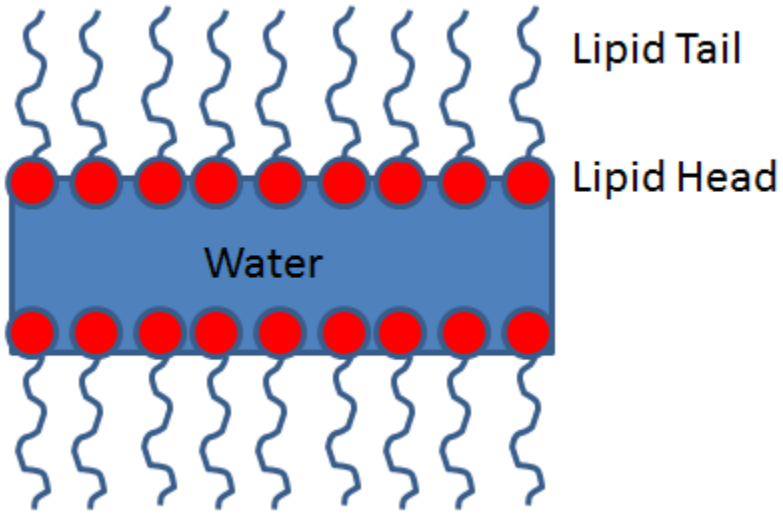
Team Project #1: The Soap Bubble

This image was created to fulfill the first team project requirements of an undergraduate flow visualization class. The raw photo was created in the flow visualization room in the basement of the ITLL with assistance of Aaron Coady from Group Alpha. The image was intended to display the effects of surface tension in creating a soap bubble, and to accomplish this task in an impactful, artistic manner.

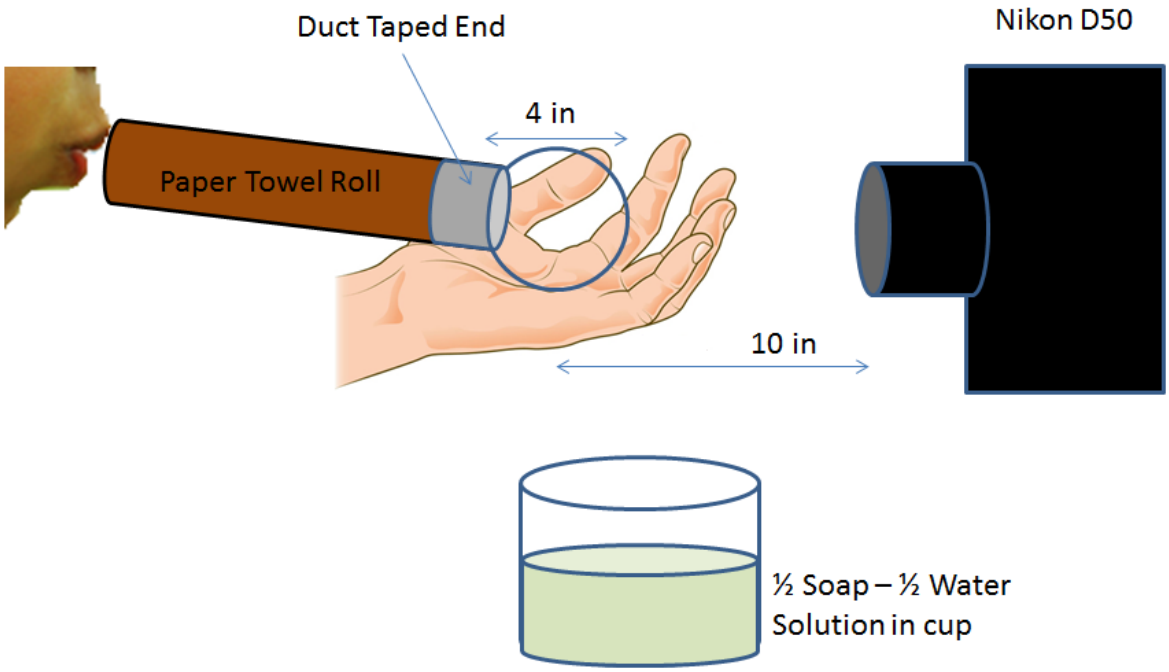
Soap bubbles are essentially lipid bilayers, as shown in the following image. The lipids from the soap have a hydrophilic head and hydrophobic tail, which causes them to orient their heads toward water. These tightly packed lipid molecules prevent the water molecules from escaping between them. Bubbles are essentially hollow water spheres that are trapped within a lipid bilayer that forms the inner and outer surface of the bubble. The bubbles are also stabilized by the Marangoni effect, which is a force on lipid molecules that causes them to move toward areas of the bubble where the surface concentration of lipids is thinnest. This effect results in a state where the bilayer is constantly attempting to keep the concentration of lipids on the surface constant, and can be seen as "streakiness" on the bubble's surface where the gradient is evident.[1]



In the image it can be seen that the bubbles assume nearly spherical shapes. This is because a sphere is the most energetically favorable shape due to the fact that it has the smallest surface area to volume ratio[2]. We also see a vivid interface between the largest and second largest bubble on the hand. At this interface it can be noted that the smaller bubble protrudes into the larger bubble. This is a

result of the smaller bubble having a higher internal pressure than the larger bubble, thus forcing the shared wall between the bubbles farther into the larger bubble[3].

To create the bubble, a standard sized paper towel roll was wrapped with a strip of duct tape on one end, and then dipped into a 50% water, 50% Dawn dish soap solution. The duct tape prevented the paper towel roll from deteriorating as a result of repeated wetting. Dipping into the solution created a soap film on the end of the paper towel roll. At this point I blew air lightly through the paper towel roll to create a bubble on my hand, and then the bubble was separated from the paper towel roll by wiping the end of the paper towel roll across my hand. The bubble then remained in my hand for a few seconds while Aaron Coady was able to snap the photo using the settings I had determined. The camera was approximately 10 inches away from the bubble at the time of the capture, and the largest bubble in the picture was approximately 4 inches in diameter. An incandescent flood light was also positioned about 2 feet above the bubble for lighting, and non-reflective black poster board was used as a backdrop.



The raw image was taken by a digital Nikon D50 DSLR camera. The focal length of the lens during the capture was recorded as 55.0 millimeters. An exposure time of 1/320 second with f/8 and an ISO of 800 were used to capture the image in the camera's manual setting. The image was originally 3008 by 2000 pixels and covered a 6 inch by 4 inch field of view. The lens was approximately 10 inches from the bubble at the time of the exposure.

Edits were made to the raw image in Photoshop CS5.1 to produce the final image. The image was first cropped to 2622 by 1550 pixels to remove the wrist as well as the black region at the bottom of the picture because these regions of the photo did not assist in focusing attention to the bubble. The color balance was then adjusted to emphasize the reds in the picture. Focus on the bubble was further

enhanced by adjusting color levels and increasing contrast. Finally, the curves plot was modified to increase the blacks for a dark and dramatic effect. This adjustment also made the boundary of the individual bubbles more apparent. The raw and final images are shown in the following figures.

Raw "Before" Image

Post-Photoshop "Final" Image

The image demonstrates the effects of surface tension caused by a soap film. I like that the final image turned out rather artistic looking with the ranges of bubble sizes on the hand, where the lines of the hand are also evident. I was hoping originally to capture the bubble popping, and was slightly dissatisfied when I was incapable of capturing that phenomenon with my camera. The image was artistic and showed the effects of surface tension, so it did fulfill the intent of the project. The visualization technique may have been more effective if I could have filled the bubble with stage fog instead of just air, as this would have created more contrast. I may also have benefitted from the use of a high speed camera to capture the bubble rupturing.

References

[1]*Soap Film*. (n.d.) Retrieved from http://en.wikipedia.org/wiki/Soap_film

[2] http://www.exploratorium.edu/ronh/bubbles/shape_of_bubbles.html

[3]http://www.exploratorium.edu/ronh/bubbles/bubble_meets_bubble.html