**MCEN 4151: Team Third Report**

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In Team Third project, our team decided to study the imaging of the soap film under illumination. We used a TV display as a light source. When the light was projected onto the soap film, the uneven surface on the soap film disperses the incident light, resulting in beautiful and colorful images.

In this experiment, we used a flow vis report written by Dennis Can in 2015 as a reference. We first mixed a quarter cup of water with 2 tablespoons of dishwasher soap and 5 tablespoons of sugar to get a soap solution. Then we immersed an aluminum bottle slowly in the solution at an angle of 5° to the horizontal direction, and a soap film was formed on the surface of the container. We then kept the soap film perpendicular to the ground and its angle was slightly less than 90° to the display. The camera was situated between the TV display and thermos about 5 inches from the film.

The color bands observed in thin film interference is due to the varying thicknesses of the soap film and changes of index of refraction as the light ray passes through the soap film. The figure below shows the effect of index of refraction.

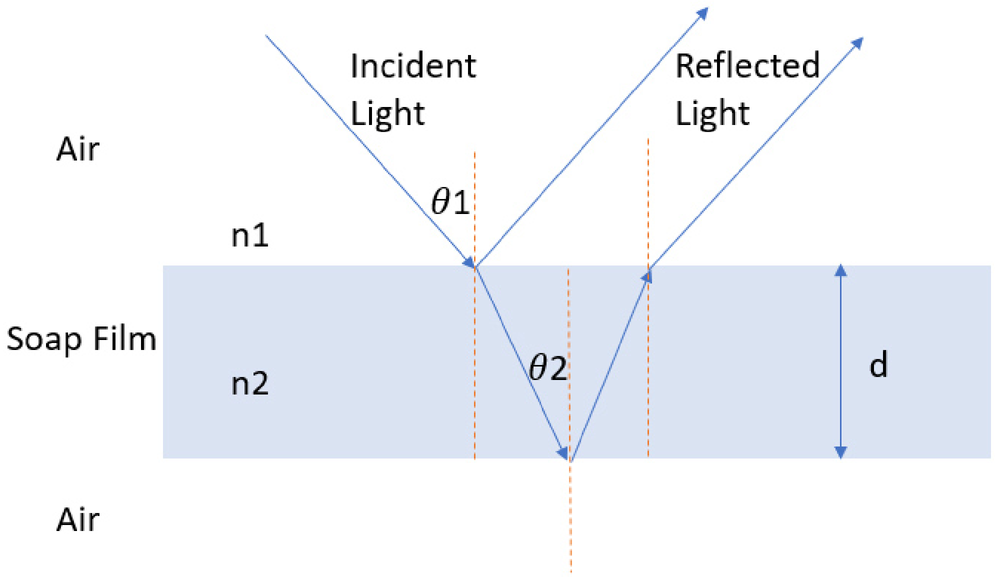


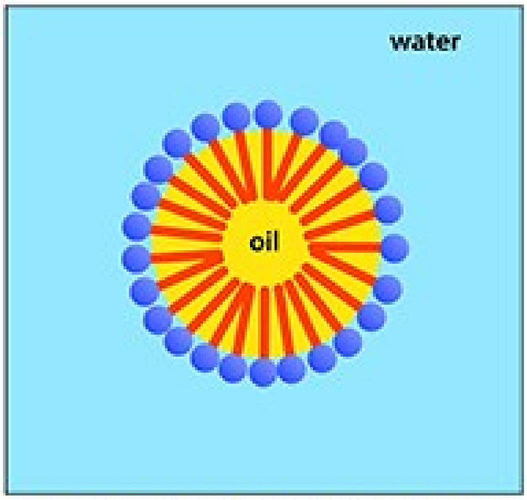

Figure 1: Effect of Index of Refraction

The relationship between light reflection and refraction is written in Snell's Law:

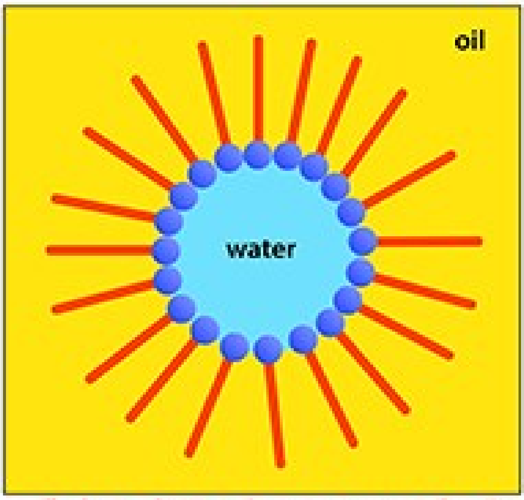
$$\frac{sin\theta_2}{sin\theta_1} = \frac{n_1}{n_2}$$

Since there is micron distance between reflecting surfaces of the film, the incoming light travels slightly different distances while reflecting, which provides different colors depending on the angle between the film surfaces and the thickness of the film.

Most of the soap ingredients are stearates, which are organic macromolecules. The soap molecule has a paradoxical property of having both a "hydrophilic group" and a "lipophilic group" which causes the soap film consists of soap molecules on the surface and water molecules inside. Uneven distribution of water molecules results in surfaces of different thicknesses of the soap film. Since the sugar molecules are also organic macromolecules, the sugared soap solution has greater surface tension.



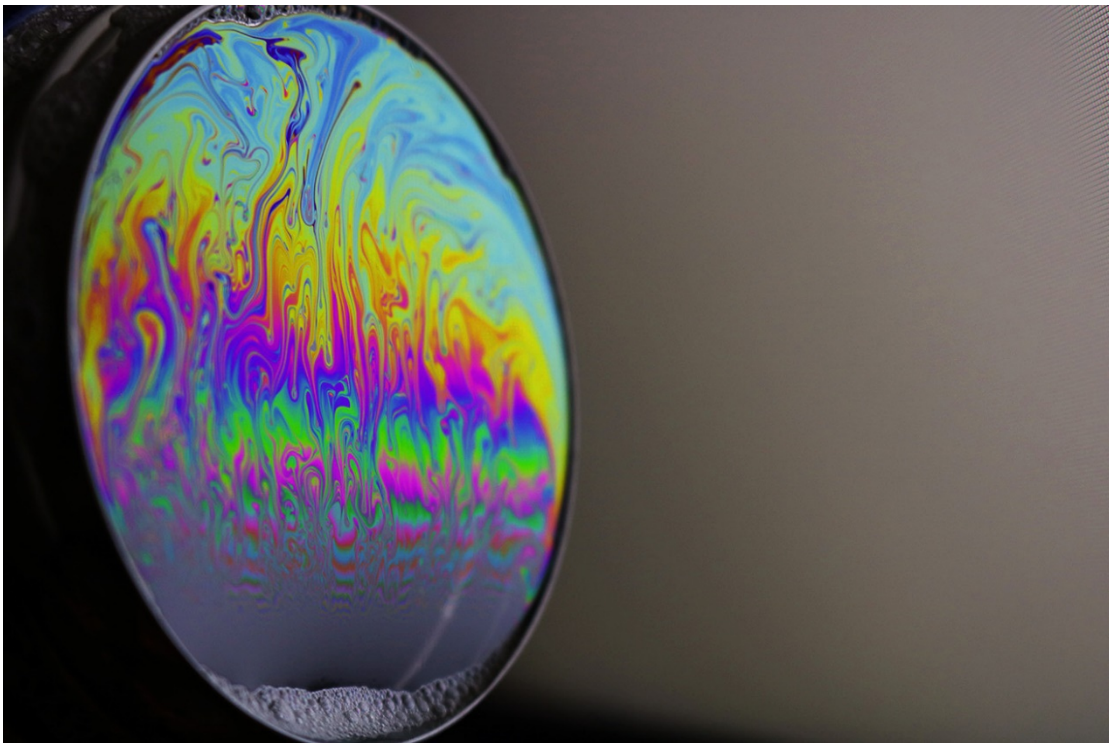

The hydrophillic head moves toward the water




The hydrophobic tails moves toward the oil

Due to the physics of light reflection and refraction, the pixel light of the TV display is scattered to form the pigment color primaries on the soap film, which is Cyan, Magenta and Yellow.

Our team used a Canon T6i DSLR to take the photo. The lens was held at about five inches from the film and the focal length of the lens was $f = 35mm$. We used an aperture of f/5.6, a shutter speed of 1/80 sec and ISO of 400. I used Photoshop to edit the image. I adjusted the tone curve to increase the saturation and contrast of the image and improve the brightness of the image. I kept the soap film at the one third location of the image to improve the composition and balance. At the top right of the image, the display pixels are faintly visible



In this experiment, I was amazed at such a bright colorful soap film we formed and was very satisfied with the results. If I were to recreate this photo, I will try to avoid the interfering small bubbles that appear in the bottom of the image. I am also willing to try to take a video about the color change on the soap film.

**Reference:**


"A horizontal soap bubble film drains towards its center, while nonuniformities from undissolved sugar crystals create colored patterns as the film thickness varies" Dennis Can: http://www.flowvis.org/wp-content/uploads/2018/12/Cleveland_TeamThird-_2018_Report.pdf

Snell's Law – Wikipedia: https://en.wikipedia.org/wiki/Snell%27s_law

How Does Soap Work: https://www.chagrinvalleysoapandsalve.com/blog/posts/how-does-soap-work/

Primary Colors of Light and Pigment: http://learn.leighcotnoir.com/artspeak/elements-color/primary-colors/