Soap and Dyed Milk

Flow Visualization

Professor Hertzberg

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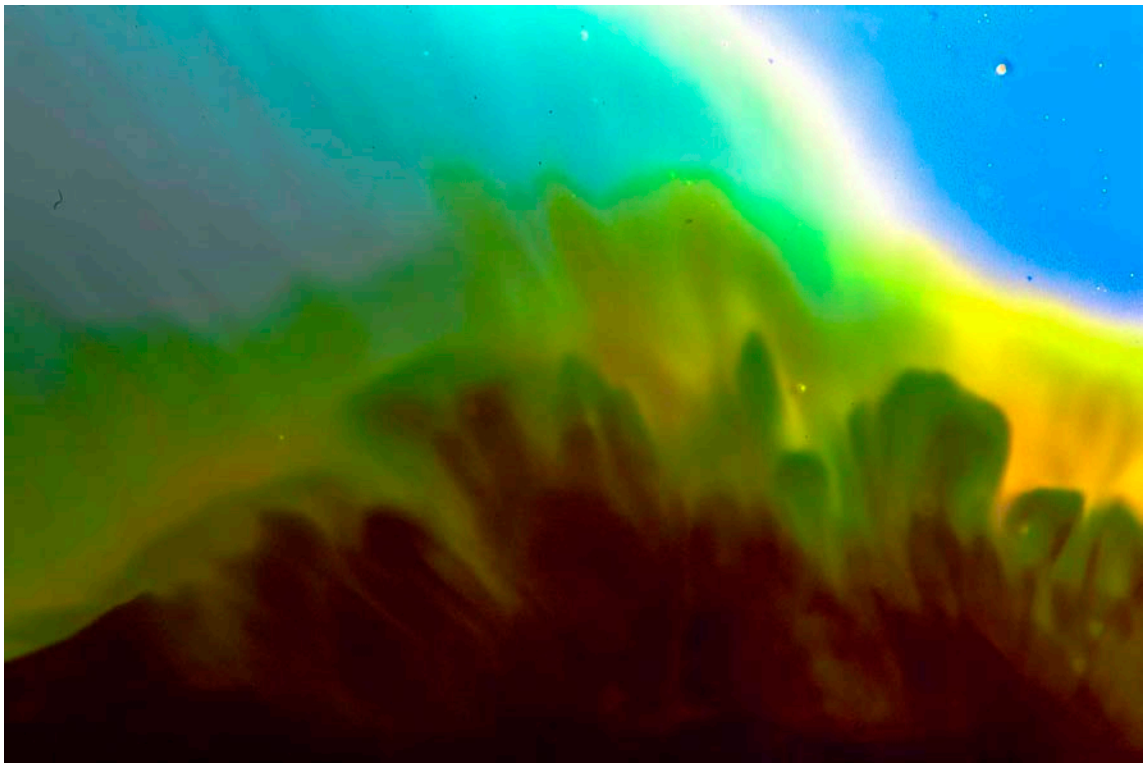

By

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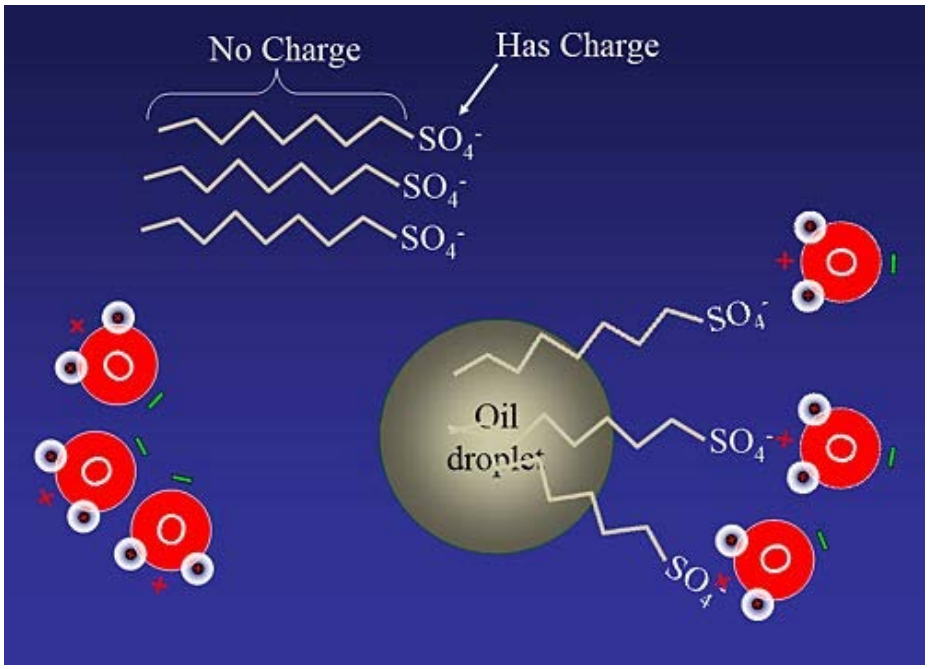
One topic I wanted to explore for the second group project was the classic reaction of soap in milk. For the most part we have all seen this reaction before, but I wanted to revisit the topic so I could understand and visualize the physics going on in the reaction. It was my intent to use dye to visualize the milk streaming from the source of the soap, and then be able to explain in layman's term what is going on.

In the image attached one can see a multicolored wave front of milk moving across the field of view. The colored milk is laced with food dye and soap, the surrounding white milk is without any soap or dye. I know from previous experience that milk is a colloid suspension of fat and protein particles. The fats globules reside in the milk in spherical shapes, where the hydrophobic ends of the fatty molecules populate the outside of the sphere. Similarly, soaps are long chained molecules of fatty acids, but are water soluble. The fatty acids of soap are bipolar like milk fats, so the hydrophobic ends of the soaps are attracted to the fat molecules in milk. When the soap molecules and the milk fats come together, the fat is said to emulsify, dissolving in the soaps. The soaps can emulsify with oils and fats because the hydrogen bond formed is actually stronger than soaps hydrogen bond with water [1]. It is the attraction of soaps to the fat molecules that causes the rapid reaction visualized within the milk. This transportation mechanism is in addition to the Marangoni effect, which describes the transport of molecules along the surface tension gradient. When a drop of soap is deposited in milk, there is a localized area of low surface tension and high concentration. These Marangoni forces re-homogenize the milk surface with respect to surface tension over time[3].

Even though there are a whole spectrum of colors seen in the picture, there were only two colors of dye used for the experiment, blue and yellow. Undiluted food grade dye was used in whole milk, with ajax dishwashing soap. The milk was still cold when



#2: Soap is made from a chain of carbon and hydrogen atoms (zig-zag line) connected to a charged group of atoms like SO4. The chains of carbons have no charge so they are ignored by water as they migrate through the water [2].

used for the experiment, but I'm sure it was being warmed quickly by

the bright halogen light that was focused on the milk. This halogen light source of 55 Watts was positioned about 2 feet from the milk, at an angle of 60 degrees to the milk. Even though we were using extension tubes which darken the image, I would not recommend using such a bright light for this type of shot. It was extremely difficult getting the image into focus with the end of the lens practically touching the milk whilst being blinded periodically by the bright lights.

This soap and milk cosmos seen in the image is approximately three inches in diameter. The whole plate of milk was about ten inches in diameter, but we tried to focus in on the detail in the stratifications. The lens had to be extremely close to the surface of the milk because of the macro tubes, so close even that the edge of the lens would touch the milk; this distance is approximately two centimeters. With the macro tubes that I have the lens has to be operated manually, and the aperture must be set to f/22, I'm not sure why. I also used an exposure time of 1/15th of a second, and an ISO sensitivity of 200. I chose such a low ISO, even with the bright lighting, to keep the noise down in the deep colors. In photoshop I did not crop the image, so it remains the original 3000x2000 pixels. I did, however, modify the colors extensively. By adjusting the exposure value and the luster of individual colors I was able to bring out the contrast of the image. The blue area in the upper right is entirely manufactured with photoshop. I prefer this method for exploring the astral nature of this visualization.

I love this image for how it reveals the nature of the flowing plumes of milk fat, driven to disperse by the soap deposited in the middle of the dish. The wave front seen here is a prime example of this type of phenomena. Despite what I have here, I would like to have seen what different types of soaps and dyes do when unleashed in milk. I would have spent some more time in photoshop cleaning it up too. In all, it is a solid shot to describe the physics of soap dispersion in milk.

Appendix

Sources

1) http://homepages.ius.edu/Dspurloc/c122/soap.htm. Indiana University Southeast

2) http://www.chemistryland.com/CHM107/Water/WaterQuiz.html

3) http://en.wikipedia.org/wiki/Soap_film