

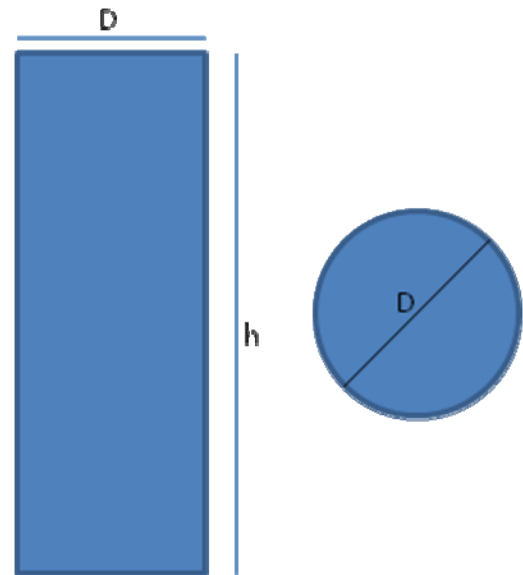
Get Wet: Soap Bubbles on Top of Milk in a Glass

Initially I was trying to see what a stream of blue dish soap falling through milk looked like but was unable to observe this phenomenon since milk is opaque. I noticed that the soap initially mixed with the milk a little bit before settling out on top. I thought that stirring the soap into the milk and allowing it to settle back out and that this might demonstrate some interesting physics. The soap never settled back out though which then lead me to use a straw to blow bubbles in the glass. I photographed the bubbles in the glass several times from various angles and with different lighting. I was trying to capture the interaction between the bubbles themselves, the sort of crystalline structure they form together, and how light interacts with the bubbles providing a good depth of field.

For this experiment I used a standard water glass. A side and top view are shown to the right. The glass had a diameter of 2.5in and a height of 8in.

Bubbles are impossible to create in pure water because the surface tension is too high and they evaporate much too quickly. Essentially they are too unstable in water. Soap acts as a surfactant by decreasing the surface tension to about one third its original value. It also provides a protective barrier to avoid evaporation. The soap helps stabilize the bubbles in water allowing them to exist for an extended period of time (1).

Bubbles try and minimize energy making them extremely efficient. Because of this bubbles are spherical in shape since a sphere has the smallest surface area for a fixed volume. Often you will not see spherical bubbles because they are distorted by air currents and gravity (2). Another example of how bubbles try and minimize energy is how they interact with each other. Since they are trying to minimize surface area they will share a common wall when they merge. If the bubbles are of the same size they will share a flat wall and if they are of different sizes the smaller one will bulge into the large one because it has a higher internal pressure



Sketch of testing apparatus (water glass)

(1). Bubble walls always come together in groups of threes, and since the surface tension in each wall is the same the angle between the walls is always 120 deg. Again this is another example of minimization of energy and maximum efficiency (2).

As seen in some of the bubbles in my Image there is a kind of colorful reflection on the surface of some bubbles. This is known as iridescence and is caused by interfering light waves. This is the same phenomenon that causes oil slicks and grease spots to appear shiny and multicolored. The interference between waves is a combination of reflection and refraction along with the fact that the bubble has an inner and outer surface with a varying wall thickness. The incident light reflects off the outer surface, while some is refracted through the outer surface before reflecting off the inner surface. The light rays may bounce around between the two surfaces several times before being reflected back out. Wall thickness affects which colors will be visible since it will cause certain color light to cancel out leaving other colors. When the wall thickness becomes much smaller than the wavelength of the incident light no reflection is observed (2).

To obtain the bubbles seen in the picture the glass was filled three inches high with milk 2% vitamin D milk and one inch high with standard blue King Soopers brand dish soap. The glass contained 19.6 cubic inches of liquid, of which 14.7 cubic inches were milk and 4.9 cubic inches were dish soap. To create the bubbles I inserted a straw into the glass and blew through it until the glass was full of bubbles. The experiment was conducted inside so as to have a controlled stable environment for the bubbles.

As you can see in the image the glass was side lit. I used a desk reading lamp with a 100 W light bulb. No camera flash was used to avoid.

To obtain my image I lit it from the side to help capture depth of field, add perspective and avoid distracting reflections as much as possible. I used a colored piece of construction paper to add color and contrast to the image. The picture is taken from the front left hand side looking slightly up and through the glass to give depth of field and capture the light going through the bubbles. I focused on the upper half of the glass containing the bubbles leaving the glass visible with some of the milk to help add contrast and perspective to the image. The distance from the glass to the lens was very small, somewhere around 1 inch; the image was shot in supermacro mode with a focal length of 5mm.

I used a digital point and shoot camera with maximum resolution and compression settings. The image was 4045 x 3045 pixels and the final image was not cropped at all. The resolution was 180 pixels/in and was unaltered for the final image. The camera used was a Cannon PowerShot sx200 IS. An aperture value of f/4.0 was used along with a shutter speed of 1/80s and 80 ISO rating.

In Photoshop I used the highlights/shadow tool to brighten up some of the darker parts of the image. Then I increased the contrast using the curves tool and changed altered the master color scheme to -120 giving it the blue and purple hues it has. I then tweaked the contrast using the curves tool again and sharpened the image slightly by 175% with a radius of three pixels accounting for lens blur.

I like my final image a lot. I feel it clearly shows and interesting network of bubbles of various sizes and illustrates the interaction between them. I think the lighting is great and accentuates the bubbles while demonstrating some iridescence on the surface of various bubbles. I feel it also provides nice depth of field. I find the reflection on the side of the glass slightly distracting and I wish the slight reflection of the camera lens could have been avoided. I think changing the color scheme really made the picture more interesting and much added artistic value. One of the main suggestions I received was to have cropped the image so only bubbles were visible. I was resistant to do this because I felt it made the image too one dimensional and limited the perspective and depth of field along with losing some artistic value.

References

- 1- The Exploratorium: <http://www.exploratorium.edu/ronh/bubbles/bubbles.html>
- 2- Wikipedia: http://en.wikipedia.org/wiki/Soap_bubble