Get Wet: Fluorescent Emulsion

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1 Introduction

For first project for the Flow Visualization course, students were asked to simply provide an introductory image that fit the context of the class. It has to demonstrate both the physics and properties of fluids, but also have significant artistic qualities. The final product was to be visually appealing, while providing a glimpse into a fluid phenomena. To achieve this, I knew I wanted to photograph the intense vibrant colors produced by the combination of ultraviolet (UV) light and the fluid contained in glow sticks. I initially planned to simply photograph the flow of the fluid as a moving droplet, but developed a different plan after attempting to dilute the fluid in water. The liquid contained in the glow stick did not mix with the water as expected, but instead created an emulsion. Not only did this provide a much more interesting fluid phenomena to document, but it enhanced the colors and contrast of the images that were taken.

2 Flow Apparatus

Because an emulsion is a simple and natural occurrence, a very simple apparatus was used to achieve the desired effects. See Figure 1 for a simple sketch of the system used to contain the emulsion.

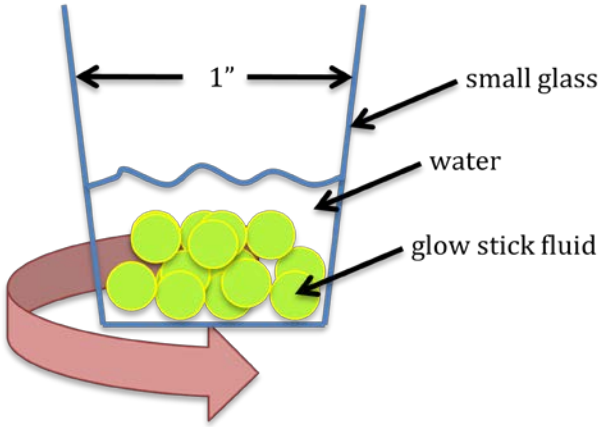

Figure 1: Fluid Apparatus

As shown, a small glass was used to contain the fluids. Because the glow stick fluid would accumulate into one mass if left stationary for an extended period of time, the glass was rotated by hand shortly before photographs were taken, as indicated by the red arrow. This would cause the fluid to break up and create smaller bubble-like individual masses.

3 Flow Analysis

At the time the photograph was taken, the fluid was moving rather slowly. The effect of fluid flow is not the most interesting property that was observed, but the emulsion of the two fluids. An emulsion is defined as "any colloidal suspension of a liquid in another liquid" [1]. More simply, an emulsion is the combination of two unmixable liquids such that one liquid is separated from the other. This is commonly observed when oil and water are combined.

In this case, the glow stick fluid was denser than the water. Although there are many different types of chemicals in glow sticks, the most prominent one is phenol. The density of phenol at 25^{oC} is 1.07 g/mL [2], which is greater than water at the same temperature, 1.00 g/mL [3]. This resulted in the glow stick fluid pooling at the bottom of the glass, with the water above it.

As stated previously, the glow stick fluid would combine into one mass if left to sit for more an extended period of time. This is the result of the inherent instability of emulsions [4]. To create the emulsion, the glass was swirled in a

circular motion, adding energy to the fluids, and breaking up the glow stick fluid into smaller spherical masses. This was likely because the violent and fast movement of the fluid created turbulent flow within the glass, separating the glow stick fluid into smaller and smaller parts. After swirling, the fluids stopped moving and the fluid slowly pooled at the bottom of the glass again. The photograph was taken right as the fluid stopped moving in order to minimize movement lines, so the Reynolds and Grashof numbers equal zero.

Assuming the height of the photo incorporates approximately one inch, the spatial resolution would be approximately 1in/1730pix = .0006 inches/pixel.

4 Visual Technique

To set up this experiment, the first step was to extract the glowing fluid from the plastic tubes in which they were contained. Although the chemicals in glow sticks are non-toxic and non-flammable, proper safety procedures were still followed. Several glow sticks were broken carefully, and then cut open to allow the fluid to drain. The chemical reaction that causes glowing took place before water was added. Although the exact volumes do not affect the outcome of the emulsion, water was added to the glow stick fluid in an approximately 2:1 ratio.

To achieve the colors and lighting in the final photo, four two-foot long UV tube lights were placed in a square pattern around the glass. Because the photo was taken in an otherwise dark room, this provided adequate light from all directions.

5 Photographic Technique

To capture this image, a digital Canon Rebel EOS camera was used. I chose to take the photo with a macro lens (Canon EFS, f/2.8, 60mm) because it had the ability to capture a close-up image, providing more detail. The glass containing the fluid was approximately one inch in diameter, and the camera lens was only 8-9” away from the fluid. The original and final images can be seen in Figures 2 and 3, respectively.

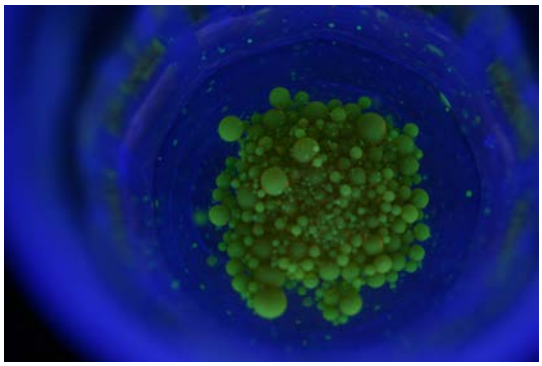

Figure 3: Original Image (3072x2048)

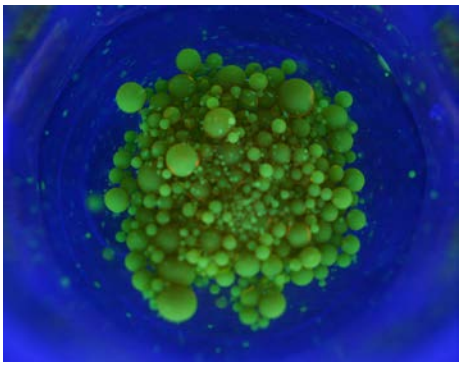

Figure 2: Edited (2214x1730)

Because of the unique lighting and subject matter, several different aperture and shutter speed settings were tested. I discovered that the lowest f-stop number provided the best images, and an automatic shutter speed worked fine. The final image had the following exposure specs: ISO800, f/2.8, 1/125.

Very little post-processing was done in Photoshop to alter the image. The first task was to crop the photo. I chose to center the glow stick fluid, but leave some of the glass along the outside. This brings more depth and perspective, and leaves more colors from the bright blue appearance of the glass. Next, I made a slight adjustment to the Levels in order to lighten the image and provide more contrast. Finally, I used the Dodge tool to brighten the middle of the photo to make the glow fluid stand out from the glass a bit more.

6 Conclusion

I believe the final image fits the specifications of the assignment very well. It clearly demonstrates the presence of an emulsion, and it is also very visually appealing. I was able to achieve my goal of producing a brightly colored image that is different from many of those I have found online. My favorite part of the image is how vibrant the colors turned out. The unexpected blue in the glass really brings out the fluorescent effect of the glow stick fluid. If I were to repeat this technique, I would give more care to bringing more of the photo into focus. I may also attempt to expand on this idea by using different colors of glow stick fluid to bring even more variation to the final product.

7 Appendix

[1] "emulsion." *Dictionary.com Unabridged*. Random House, Inc. 13 Feb. 2013. <Dictionary.com http://dictionary.reference.com/browse/emulsion>.

[2] *Phenol BioUltra, for Molecular Biology, ≥99.5%*. Sigma-Aldrich. Web. 13 Feb. 2013. <http://www.sigmaaldrich.com/catalog/product/fluka/77608 >.

[3] *Water, 99.99 atom %16o*. Sigma-Aldrich. Web. 13 Feb. 2013.

<http://www.sigmaaldrich.com/catalog/product/aldrich/329886 >.

[4] "Emulsion." *Wikipedia*. Wikimedia Foundation, 11 Feb. 2013. Web. 13 Feb. 2013.

<http://en.wikipedia.org/wiki/Emulsion>.