Luminescent Fluid Visualization

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Image 3 Report

1 Introduction

The purpose of this image was to capture a fluid flow phenomenon of our choosing for the third project in our Flow Visualization course. I was interested in capturing fluorescence and decided to experiment with glow stick fluid. My inspiration came from many of the photos on the Flow Visualization website which successfully captured this phenomenon using similar techniques. This particular phenomenon also gave me the chance to try my hand at low light photography which I hadn't explored much in previous projects. The concept I had in mind was a pure black background with fluorescent fluid at the center. This kind of contrast is an aesthetic I enjoy quite a bit. It evokes a text editor in dark mode with candy colored syntax highlighting, or a carnival, or runway lights. As with my previous projects, I believe that compelling photos can be captured with a simple setup. With only a glass mason jar, some easily available glow sticks, construction paper, and water I was able to capture this mesmerizing fluid in action.

2 Discussion of Fluid Phenomenon

The flow apparatus used for the image is a simple, tear drop shaped mason jar filled with water. A spoon was introduced to move the water in a circular direction inside the jar and create a vortex. In the setup show above, the masor jar has a rim diameter of $xxinches$ and a diameter of $xxinches$at its widest point. The height of the jar was $xxinches$ and the height of the water was $xxinches$.

The first phenomenon to discuss is that of chemiluminescence (CL). The basic definition of CL is the emission of light as a result of a chemical reaction rather than the addition of heat. Although the reaction itself may emit heat, the light emitted is not a result of this. The reaction occurs between two compounds initially separated by a glass barrier. The two compounds are a diphenyl oxalate mixed with some kind of dye and hydrogen peroxide. When the glass is broken the chemical reaction kicks off and occurs in a couple stages.

The hydrogen peroxide oxidizes the diphenyl oxalate which creates several byproducts. The most important byproduct for phenomenon seen in my image is dioxetanedione. This compound is unstable and decomposes into carbon dioxide, releasing energy in the process. The compound being used as a dye then absorbs this energy, causing its electrons to reach an excited state. As these electrons return to their ground state, they lose energy that is emitted in the form of a photon.

The second phenomenon to discuss is the the interaction between the CL fluid and the cold water. We can see that the compounds in the glow stick fluid are immiscible and do not dissolve in water to create a solution. Instead, because the intermolecular bonds in the glow stick fluid cannot be broken, we get the phenomenon captured in the image. The CL fluid forms globs or beads inside the water and these units of the glow stick fluid can be moved around inside the water. Additionally the temperature of the water has an impact on the luminescence. Colder water will decrease the luminescence by slowing the rate of the chemical reaction previously described and hot water will increase the luminescence.

3 Producing the Phenomenon

Producing the phenomenon captured in my image submission required several steps and careful consideration. First I wanted to capture the image in low light. This was easier after Daylight Savings Time ended because it gets dark earlier in the evening and removes a lot of light from the apartment environment I was shooting in. Next I cleared the coffee table in the center of the living room and laid white construction paper on the table to create a plain, distraction free background. Finally, I slowly filled the mason jar with cold tap water.

I attempted this photo several times with two different glow sticks. The final submission came from the second attempt because it was challenging to capture the fluorescent fluid as it was being poured. I wanted to do something interesting instead of simply capturing it falling through the water so I had my friend stir the water. This created a vortex that persisted just long enough for her to pour the glow stick fluid into the water.

During my numerous attempts at capturing this image I tried a few other techniques. One involved agitating the water after the glow stick fluid had fallen to the bottom of the mason jar. Another involved capturing the immersed fluid from several different angles and with closer "macro" shots. I tried to capture directly overhead and also get the camera closer to the mason jar. I also took some shots without the flash and some with. Ultimately I decided that the best images were the ones shot from a little further away and with the flash on. Capturing this shot primarily came down to taking lots of photos as the water was being swirled, and the glow stick fluid was being poured.

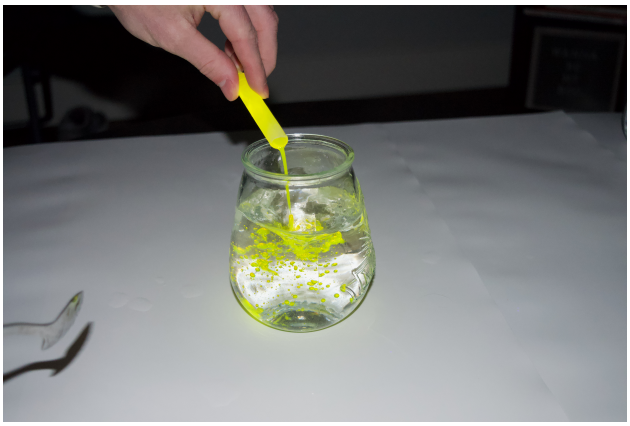
4 Visualization Technique & Equipment

The photographic equipment used to capture this photo was a Nikon D3300 Digital Single Lens Reflex (DSLR) camera equipped with an optical viewfinder. The specific lens I employed was the the Nikkor $18 - 55mm$ lens. To capture the image I submitted, I set the lens focal length to $32mm$ which gives the photo a slight wider field of view than what might be considered a "standard" field of view. The full list of exposure settings can be seen in the table below:

Focal Length	32mm
ISO	3200
Aperture	$f/7.1$
Shutter Speed	$1/100s$

For this image, I wanted to dive deeper into post-processing by pushing myself further than I had in previous submissions. I used Adobe Photoshop for the post-processing and envisioned a black background to contrast with the color of the glow stick fluid. The first step was to crop the image so that the mason jar could fill the space. Next I needed to select the mason jar as an object in order to make it into a layer. Once I did this I had two layers to manipulate: the mason jar and the background. I made the entire background pure black. After creating the black background I manipulated the color settings.

After cropping and post-processing the final resolution of the edited image was 2616x2494 pixels. The original raw image taken off the Nikon sensor was 6000x4000 pixels and the two photos can be seen side by side below:



(a) Before post-processing

(b) After post-processing

Figure 1: Before and after post-processing

5 Conclusions

In the case of this image submission, I measured success with two different parameters. The first was how well the image showcased the chemical reaction occurring within the glow stick fluid itself. The second was the proximity of the final image to the aesthetic I envisioned when I started the project. I believe I can declare success by both metrics, but more so the former than the latter. The image does really showcase the chemicals in the glow stick - and their interface with cold water - for the viewer. The image also has an aesthetic that is appealing, however it isn't exactly what I had in mind.To achieve the exact aesthetic I had envisioned, I believe I would have to make adjustments to the setup and perhaps throw out the idea of immersing the fluid in water altogether. Throwing out the water would likely make it simpler to achieve the background I wanted in post. Perhaps even letting the glow stick fluid flow down a vertical or inclined surface may have been just as interesting. This would be one of many directions I could take the idea of working with chemiluminescent fluid. With the image in its current form, however, I do really enjoy how I captured the fluid as it was being poured. The way it separates as it swirls in the vortex does look very interesting and the post processing I was able to do really highlights the color and motion.

References

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