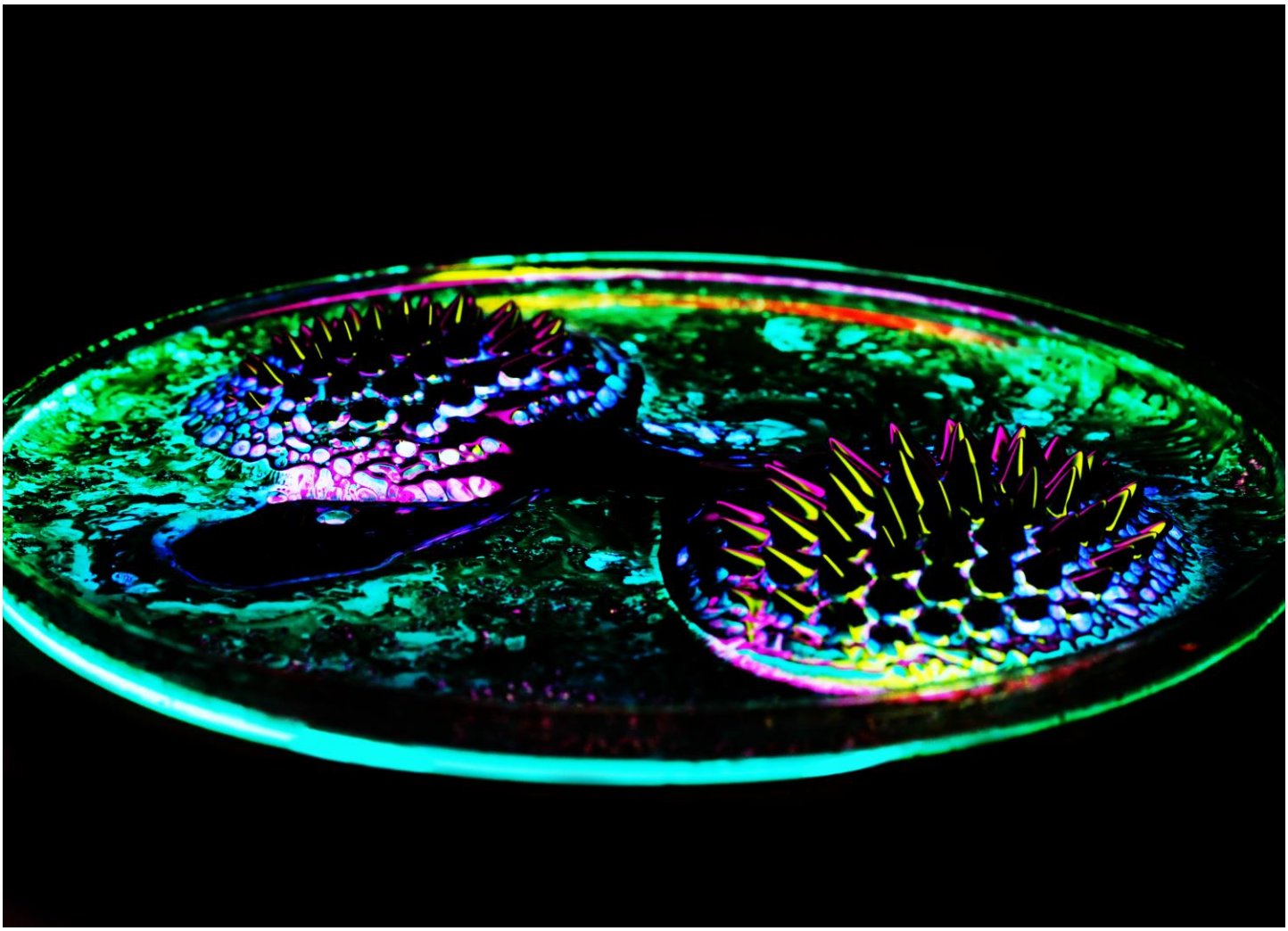
Thing One and Thing Two Ferrofluid

MCEN 4151; TEAM 3 IMAGE

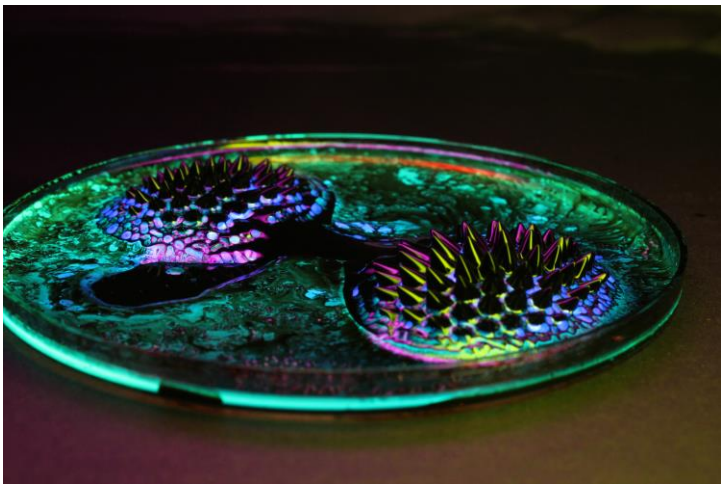


Erick S Pena | Flow Visualization | December 17, 2015

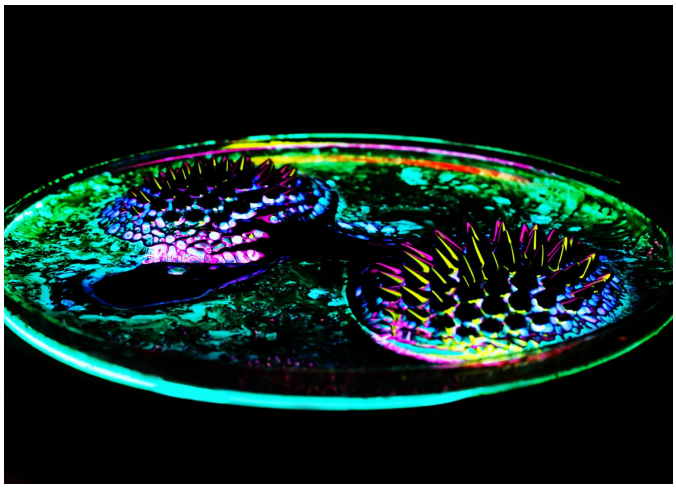
Goal

The goal of this Flow Visualization is to capture the fluid phenomenon of ferrofluid. This Idea came from looking at videos from Physics Girl on YouTube[1]. She used glow sticks fluid to aluminate and create patterns on the ferrofluid. My teammates and I decided to do a still photograph of the unique phenomenon that happens when a magnet gets in close contact with the ferrofluid by applying similar techniques as Physics Girl.

In figure 1 we see a comparison between the raw image on the left and the edited image on the right. To produce the edited image I used curves in gimp image editing software, and increased the contrast. I also got a paint brush to make the background completely black. There was a little processing with colors as you can see in figure 1a there is an area where the blue line in not continues and so I applied some color to make it flow smoother. Finally I cropped the image to make it more symmetrical and reduce distractions.



(a) Original Dimensions: 5184 X 3456



(b) Cropped Dimensions: 4803 X 3456

Figure 1: (a) on the right is the raw image. (b) On the left is the edited image using curves in Gimp.

Team

For this assignment, I was assigned to a group of two other members, consisting of the following members

1. Erick Pena
2. Daniel Patrick Maguire
3. Stefan Schultz

[1] AMAZING! Ferrofluid + Glow Sticks: https://www.youtube.com/watch?v=RtBtD0_KZ9o

Materials

This is a list of materials that will be needed to produce a similar photograph as seen on the cover.

1. Gloves
2. Safety Glasses
3. 8 rectangular Neodymium Magnets 1” x 1/4” x 1/4”
4. Ferrofluid from FerroTec (container information)
    a. Catalog No. EFH1
    b. Lot No. J102210A
    c. Quantity 1000 cc
5. Different diameter and heights petri dish
6. Regular 35 mL Syringe
7. 2 in long glow sticks (4 pack, bot in Dollar Three)
    a. Yellow, Blue, Pink, Green
8. 14 inch long glow sticks (one in each container, got from Dollar Three)
    a. Yellow, Blue, Pink, Green
9. 10 Droppers
10. Black cardboard for background.
11. Painters cloth to reduce mess
12. Box with a hole
13. Table to elevate
14. Canon EOS Rebel T2i

Figure 2: Glow sticks got from Dollar three

All of the photos that were shown are taken inside a garage, and placed a black cardboard for background to direct the focus to the flow. The settings for the camera were as fallows.

- No flash
- Distance from lens to object: about 50-60 mm
- Aperture Value (AV)
- Exposure Compensation: 0
- Focal length 43 mm
- Aperture f/14
- Exposure 5 sec
- ISO: 1250
- Original Dimensions: 5184 X 3456
- Cropped Dimensions: 4803 X 3456

Procedure and set up

Producing a sustainable set up to conduct the photographs was very time consuming. As you can see in figure 3 we carved out a hole in which we could easily place the magnets right underneath the ferrofluid. The black cardboard was bent in a 90 degree angle to create a continues background. Then we placed a petri dish with a height of ¼ inch in the center of the cardboard part that was parallel to the ground. The tripod was placed a little higher and as close to the edge of the black cardboard as possible; this allowed us to capture the ferrofluid phenomenon from the side. Once everything was set up we took safety precautions by putting on latex gloves and safety glasses. A syringe was used to extract the ferrofluid from its container to avoid any unnecessary spills. Eight rectangular magnets where then placed under the petri dish and slowly released the ferrofluid out from the syringe and onto the petri dish. Once we put sufficient fluid we then completed the focus on the camera. The glow stick fluid was then also placed with the ferrofluid using droppers one for every different color. We put a maximum of two different colors of glow sticks on top of ferrofluid because it was easier to photograph. Lastly we got two other glow sticks and placed them above the fluid moving it back and forth while the camera was exposed for 5 sec. The glow sticks that were being moved back and forth wore necessary because it allowed us to see the spikes on the ferrofluid.

Figure 3: In the image above is the setup of where the fluid and the camera with the tripod were placed. Using the material listed above allowed us to take pictures more efficiently.

Fluid Physics

The behavior of a ferrofluid is influenced by the size distribution of the nanoparticles and rheological properties of the fluid[2], and also by the nature of the surfactant used to suspend the particles. A surfactant adheres (sticks quickly) to the surface of particles and mediates the interactions between the particles and the solution.[3] In ferrofluids the surfactant causes a net repulsion between the particles that keeps them from sticking together and precipitates out of the solution. The key components of a good ferrofluid are a combination of the right type of mix combination of magnetic partials, liquid medium, and surfactant.

The ferrofluid contains tiny particles that are about ~10 nm in diameter of a magnetic solid that is suspended in a liquid medium[4]. When the ferrofluid is next to a magnetic field, the fluid forms sharp peaks that point in the direction of the magnetic field lines. At the Nano scale the particles experience the Van Der Waals force that makes the particles want to clump together[5]. By adding a surfactant which is a type of molecule that has a polar and non-polar end to the liquid medium, this reduces the surface tension of the liquid in where it is dissolved[6]. One end of the surfactant is attracted to the dirt and oil being the neon particles that form a coating around the particle, the other ends is suspended in the liquid. The spikes in the ferrofluid form do to the balance between the gravitational pull keeping the fluid down flat, the surface tension that wants to minimize the area of the fluid, and the magnetic field that wants to make the ferrofluid alien with the field line that cause the spikes to form.

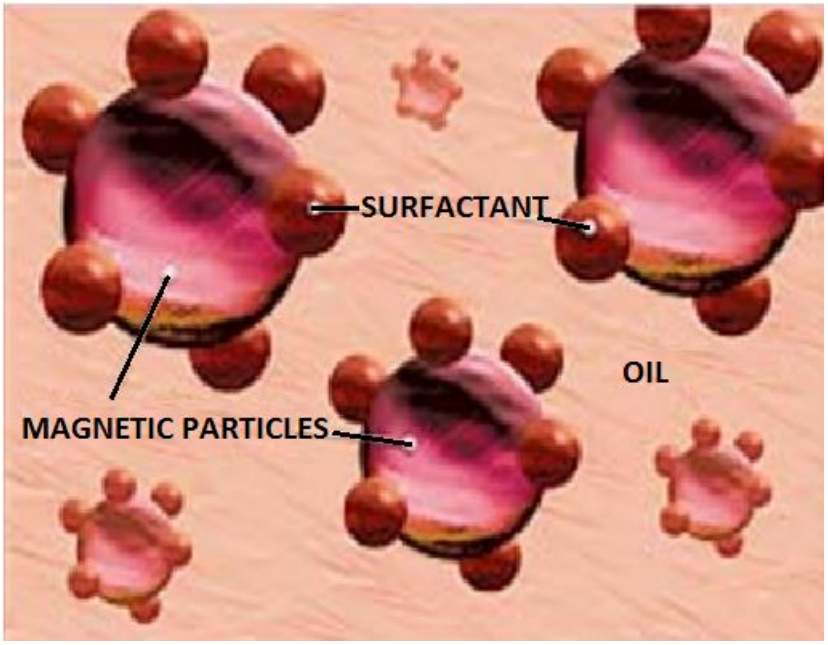


Figure 4: Magnetic particles, with surfactant molecules attached, suspended in a oil fluid to form a ferrofluid. The surfactant prevents clumping of the magnetic particles. (Drawing from Ferrotec Corporation [USA])[7].

[2] http://addis.caltech.edu/teaching/MS90/lab4-prt1.htm
[3] http://addis.caltech.edu/teaching/MS90/lab4-prt1.htm
[4] http://education.mrsec.wisc.edu/background/ferrofluid/#howto
[5] http://www.physicscentral.com/explore/action/ferrofluids.cfm
[6] http://education.mrsec.wisc.edu/background/ferrofluid/#howto
[7] http://www.physicscentral.com/explore/action/ferrofluids.cfm

Conclusion

This experiment was very fun and messy. I would say that this is my second favorite image that I have taken in Flow Visualization class. I had not seen such an interesting fluid like ferrofluid. The interaction between this fluid and a magnet is very noticeable. If I were to do this experiment again I would do it with poster paint, and try to develop an image such as photographer Fabian Oefner did. The reason I would use poster paint is because glow sticks are very difficult to focus and take pictures in the dark. Over all, this was very fun and we obtained very good pictures.