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Flow Visualization
Team Assignment #1
Ferrofluid
3/14/2013

In Collaboration With:
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Jeremy Parsons
Jonathan Fritts

Special Thanks To:
Jean Hertzberg
Nick Stites

The intent of this image was to demonstrate the incredible and phenomenal shapes that are created when ferromagnetic fluid becomes magnetized within the presence of a magnetic field. In collaboration with Anna Gilgur, Jeremy Parsons, and Jonathan Fritts several different set ups were created using different magnets and magnetic pieces until a few ideal set ups were decided upon. From our experiences we determined that it would have been beneficial to have access to an electro magnet so that the strength of the magnetic field could have been changed. We feel as though this would have greatly increased the variety of images we would have been able to capture.

Ferromagnetic fluid is a liquid that contains very small particles, on the order of 10 nanometers in diameter, of magnetic solids lending it the ability to have "the fluid properties of a liquid and the magnetic properties of a solid"[1]. Ferromagnetic fluids are created by precipitating Fe_3O_4 from a combination of Fe(II) and Fe(III) in a basic solution as can be seen in equation 1[1]:

$$2FeCl_3 + FeCl_2 + 8NH_3 + 4H_2O \rightarrow Fe_3O_4 + 8NH_4Cl \quad \textit{Equation 1}$$

This photograph was taken on March 3rd in an indoor facility. It should be noted that proper precautions were taken to protect the surrounding environment from being stained by the difficult-to-remove ferrofluid. In figure 1, our experimental set up is shown. As can be seen a small tripod was used to elevate the camera and hold it steady, allowing for a sharp focus to be achieved. Additionally a small fish bowl was placed under a paper plate to provide the ferrofluid covered device with some elevation, moving it closer to the camera, and allowing a simple bar magnet to be attached on the other side of the paper plate.

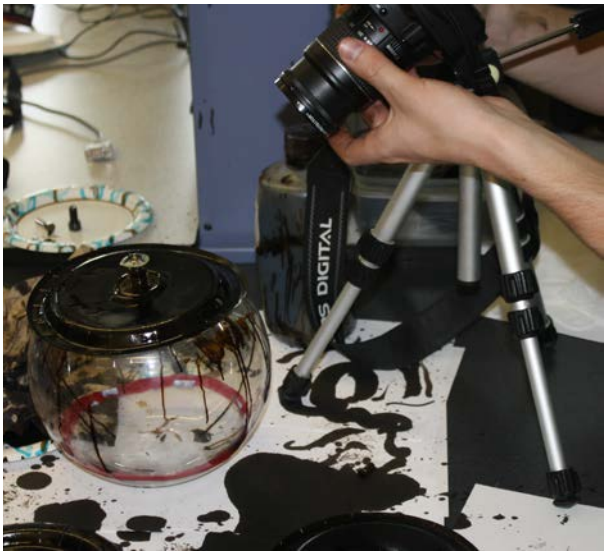

Figure 1: Experimental Setup

For this particular image, the device show in figure 2 was created out of two washers, buts, and a bolt with a convex head.

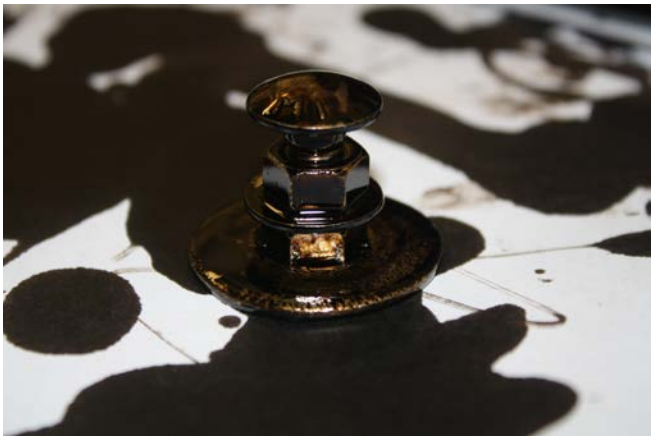

Figure 2: Device

The image was captured using a Canon EOS Digital Rebel XS with a 46mm focal length and no filter installed. The image was shot at a shutter speed of 1/64s with an aperture of f/5.0 at an ISO of 400 with the camera's built in flash discharging. It should be noted that while the flash discharged, it was partially covered up by the photographer's index finger. When the team was taking pictures, it was noticed that the built in flashes on the cameras created unwanted reflections in the ferrofluid. Instead of turning off the flash, it was merely covered with the photographer's hand. On one such occasion the photographer failed to completely cover the flash causing some of the discharged light to travel through his flesh creating a red reflection in the ferrofluid. This reflection was deemed to be attractive and desireable so the photographer continued to take pictures in this manner, covering the flash only partially with his index finger. The original image was 3888 x 2592 with the final image being cropped to 2488 x 1811. The orginal image was processed in Photoshop by increasing the overal contrast of the image by using the curves function available in Photoshop. Additionally, the opacity of the background was increased by using the stamp tool and the brightness of just the front of the ferrofluid was increased to create more detail. The original image was also rotated slightly clockwise to make the object appear square. The camera used saves image files with a .jpg extension and the edited image was saved as a .tif to avoid further compression. The before and after images can be seen below in figures 3 and 4 respectively.

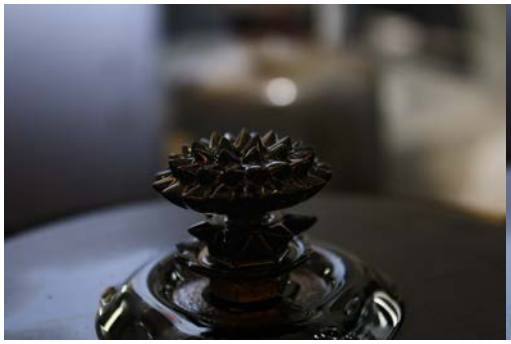

Figure 3: Original Image

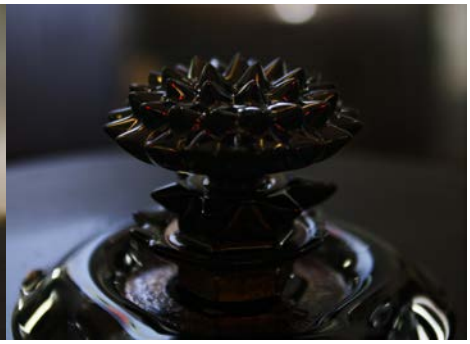

Figure 4: Edited Image

In hindsight it would have been beneficial to completely remove the background from this image to get rid of distracting particles such as the concentration of light in the top-middle of the image. Additionally the group would have enjoyed having a wider range in strength of magnets available to see the type of shapes achieveable out of the ferrofluid.

References

1. "Ferrofluids." *Ferrofluids*. University of Wisconsin-Madison Materials Research Science and Engineering Center Interdisciplinary Education Group, n.d. Web. 11 Mar. 2013. <http://education.mrsec.wisc.edu/background/ferrofluid/index.html>.