

# Watercolor on a Ferrofluid



**Team First**  
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Flow Visualization  
A Course in the Physics and Art of Fluid Flow  
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## Background

The objective of the Team First assignment was to develop an idea for a flow visualization experiment, to creatively gather materials and design the experiment, and to photograph the results. The image contains essence of the art of flow visualization with a balance between demonstrating the physics of the flow and showing any aesthetic photograph.

### Experimental Setup, Physics, and Chemistry

A ferrofluid is a liquid, which becomes highly magnetized in the presence of a magnetic field. The distinctive 'spikey' shape of a magnetized ferrofluid is caused by the need to find the most stable shape in order to minimize the total energy of the system, an effect known as the normal-field instability.

The most well used ferrofluid is manufactured by Ferrotec ferrofluid EFH1. It is a suspension of magnetite particles in a light mineral oil (carrier fluid) with an oil soluble surfactant. The property table is down below.

Ferrofluid EFH1	
Appearance	Black-brown fluid
Carrier Liquid	Light Hydrocarbon
Saturation Magnetization	440 Gauss(44mT)
Viscosity at 27 degrees Celsius	6 cp(6 mPa*s)
Pour Point	-94 degrees Celsius
Density at 25 degrees Celsius	1.21 g/ml
Surface Tension	29 dynes/cm
Volatility (1hr at 50 degrees Celsius)	9%

Table 1. Property of Ferrofluid EFH1

### Visualization Technique

Ferrofluid is a unique fluid, which is stable colloidal dispersion of nano-scale ferromagnetic particles in a carrier liquid, which is light hydrocarbon. When the liquid is exposed to a magnetic field, the particles inside the carrier liquid react to the magnetic forces and the carrier fluid acts as a proxy where the direction and amplitude of the magnetic fields are visualized.



Figure 1. The image of the watercolor on a ferrofluid

#### Equipment and photographic technique

The Samsung Galaxy S8 was used to take the photo shown in Figure 1. The camera on the Samsung Galaxy S8 is Samsung SM-G950U, which the focal distance was 4.25 mm, Aperture of F1.7, exposure time of 1/554 seconds, and ISO of 50. The pixel of the image was 4032x3024 with a manual flash.

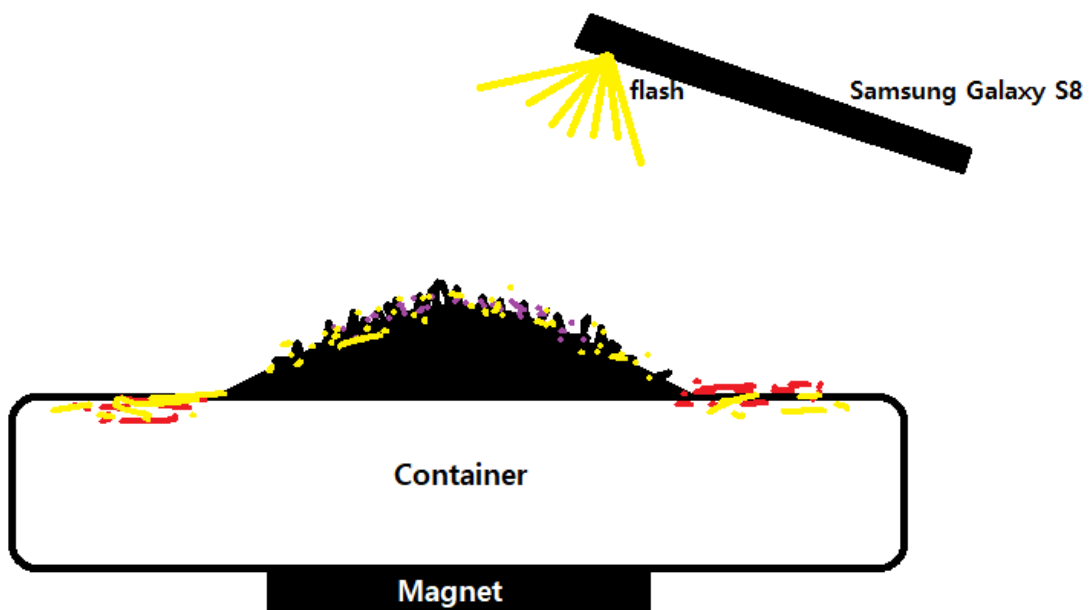


Figure 2. Experimental Setup

The Figure 2 shows how the image was taken with the Samsung Galaxy S8 with the flash. The magnet was below the container to center the ferrofluid. The online editing tool was used to adjust the contrast ratio to darken the ferrofluid and expose more colors for the watercolors.

### **Conclusion**

The ferrofluid was a great idea to show both physics and aesthetic vision of the flow visualization. The magnetic field was strong enough to produce spikes in the ferrofluid where the spikes were able to maintain watercolors on top of them. The watercolors were perfect for the image, where the artistic intent of the experiment was fully achieved.

## Citation

- MAGCRAFT Brand Rare Earth Magnets. (2018). What is a ferrofluid?. [online] Available at: <https://www.magcraft.com/blog/what-is-a-ferrofluid> [Accessed 8 Mar. 2018].
- Ferrofluid. (2018). ferrofluids - Ferrofluid. [online] Available at: <https://ferrofluid.ferrotec.com/products/ferrofluid-educational-fluid/efh/efh1/> [Accessed 8 Mar. 2018].