Team 3 Project Ferrofluid

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Introduction

In this project, I decided to do a ferrofluid experiment. Basically, ferrofluid is the liquid that becomes very magentized when the magnetic field occurs. Ferrofluids are made up of tiny magnetic fragments of iron suspended in oil (often kerosene) with a surfactant to prevent clumping (usually oleic acid). There are many arts that comes from ferrofluid. The shape of ferrofluid can be formed into a lot of unique features. For those reasons,I decide to make my own ferrofluid this time.

Materials

Material	Amount
Rust-Oleum Specialty magnetic paint	35 ml
Vegetable oil	1.5 tsps to 1tsp ferrofluid
Earth magnet	1

Table 1. Materials list

Procedure

The whole experiment can be divided into two different parts. One is making the own ferrofluid. And the other is doing the ferrofluid experiment.

Making ferrofluid is straight-forward. The rule of thumb is that you add 1.5 tsps vegetable oil to 1 tsp magnetic paint. And then you mix them together and get your own ferrofluid.

When you have your own ferrofluid. The experiment can be performed. First of all, you pour the ferrofluid on a specific spot on a surface, where you place the earth magnets underneath. By the way, earth magnet is a better choice to do this experiment because neodymium magnets aren’t as good at stripping ferric oxide off

of the ferrofluid. After that, you move around the magnets under the table and you will see the interesting ‘needles’ that comes out of the ferrofluid, which is resulted from magnetic field.

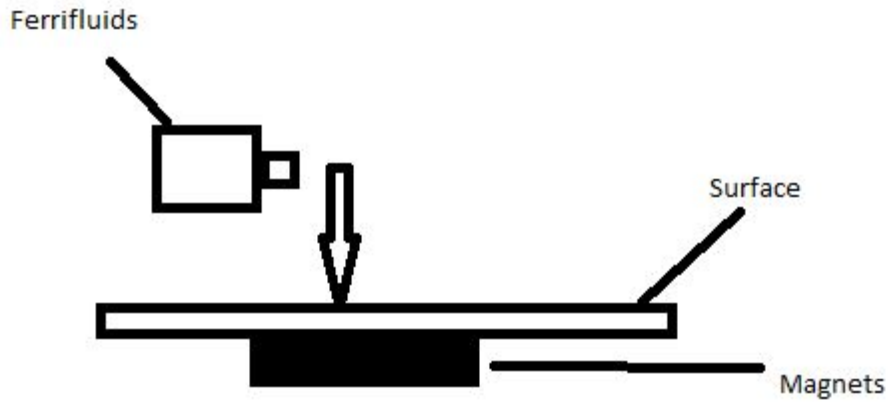

Fig.1 Experiment Set-up

Fluid Dynamics

The magnetic material in a ferrofluid isn't actually a liquid - it's a bunch of nano-sized particles suspended in a liquid. The particles aren't magnetic on their own. For example,they wouldn't stick to your refrigerator if you put them next to it. The particles are paramagnetic. This means that if we place a magnet next to them, the magnetic field will cause the particles to become polarized.[1] The magnetic field turns the particles into little tiny magnets that will then move around within the magnetic field, much like iron filings on a sheet of paper.They won't stick to metal like a normal magnet, but they will react with already made magnets. More technically, in a gradient field the whole fluid responds as a homogeneous magnetic liquid which moves to the region of highest flux. This means that ferrofluids can be precisely positioned and controlled by an external magnetic field. The forces holding the

magnetic fluid in place are proportional to the gradient of the external field and the magnetization value of the fluid. This means that the retention force of a ferrofluid can be adjusted by changing either the magnetization of the fluid or the magnetic field in the region.[2]

However, there are some factors that can influence the performance of ferrofluid. The thermal stability of a ferrofluid is related to particle density. The particles appear to behave like a catalyst and produce free radicals. Then the radicals will create cross linking of molecular chains and eventually congeal the fluid. Catalytic activity is higher at elevated temperatures and, therefore, ferrofluids congeal more rapidly at these temperatures.[3]

Camera settings

The ISO is very critical, since the contrast can be largely affected by ISO settings. In order to capture the clear feature of the ferrofluid, the focal length also need to manually adjusted.

Camera	Canon EOS Rebel T2i
Shutter Speed	1/160 sec
ISO	3200
Focal length	42mm
Lens	EF-S18-55mm f/3.5-5.6 IS
Resolution	72 Pixel per Inch
Image Size	3456x2304 (pixels)

Table 2. Camera settings

Post-processing

In this project, I only did a little post-processing. Firstly, I used lasso tool to get rid of the dark spot of picture. And I adjuted the contrast and brightness of the picture by using curve tool in Photoshop. In conclusion, I am pretty comfortable with the final effect of the picture. By comparing the photo before and after post-processing, the edited photo looks more aesthetically pleased.

Fig.2 Original picture

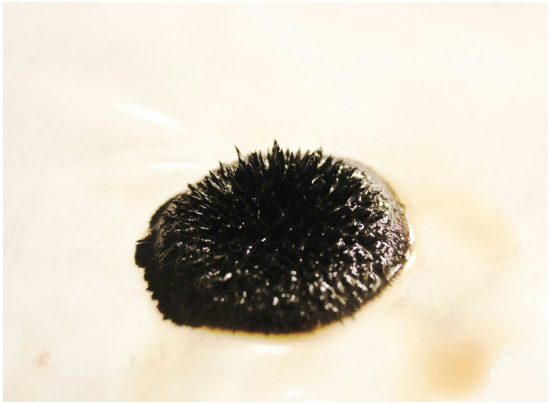

Fig.3 Edited picture

Reference

[1]K. Raj, B. Moskowitz, R. Casciari,Advances in ferrofluid technology,Journal of Magnetism and Magnetic Materials,Volume 149, Issues 1–2, August 1995, Pages 174–180

[2]http://www.howtomagnet.com/learn-more.html

[3]M. Strömberg, K. Gunnarsson, S. Valizadeh, P. Svedlindh, and M. Strømme ,Aging phenomena in ferrofluids suitable for magnetic biosensor applications,Journal of Applied Physics 101, 023911 (2007); doi: 10.1063/1.2424522