MAGNETIC HILLS

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ABSTRACT

A small amount of a ferrofluid placed in an inhomogeneous magnetic field forms hill-like structures. Magnetic Ferrofluids (MFFs) are colloidal suspensions made up of tiny ferromagnetic particles, about 10nm in diameter, suspended in a carrier liquid and have magnetic and liquid properties simultaneously. Ferrofluid surface is exposed to a heterogeneous magnetic field which instead of being flat or curved, it is a convex surface or nails-like protrusion. In this research we are going to investigate how the properties of these structures depend on relevant parameters.

Keywords : *Ferrofluids- colloidal solution - heterogeneous magnetic field- Magnetic Peaks*

1. Introduction

Magnetic Ferrofluids (MFFs) are colloidal suspensions made up of tiny ferromagnetic particles, about 10nm in diameter, suspended in a carrier liquid and have magnetic and liquid properties simultaneously. Ferrofluid surface is exposed to a heterogeneous magnetic field which instead of being flat or curved, it is a convex surface or nails-like protrusion. Its reason is applying of too much magnetic forces which causes the interaction between surface forces. It should be noted that ferrofluids are liquid in normal states but solid when approaching a magnet (http://nanoclub.ir).

2. Definitions Regarding Different Parameters

Magnetic field: is the medium of the influence of two charges and is generated by moving electrical charges. When there is a moving charged particle, a magnetic field is generated in its surrounding.

Every magnetic field has the lines called magnetic field lines (David Halliday, Robert Resnick, Kenneth Crane, 2002, page 199). The direction of moving of the lines are in clockwise direction, "coming out" of the North Pole of a magnet and "going into" the South Pole of a magnet.

When you pour some iron powder on a paper near a magnet , the iron powder immediately form the magnetic field lines. This shows the magnetic field around the magnet .

Ferrofluids : Ferromagnetics are the materials which are attracted and form in the same direction if placed against a magnetic field. In other words, its magnetic dipoles are aligned.

Ferromagnetics are divided into two categories: hard ferromagnetics and soft ferromagnetics. Soft ferromagnetics are the materials that are easily converted to magnet and easily lose their magnetism characteristic. Hard ferromagnetics are the materials that are hardly converted to magnet and hardly lose their magnetism characteristic (http://edu.nano.ir).

Ferrofluid is a liquid that is attracted to the poles of a magnet. It is a colloidal liquid made of nanoscale ferromagnetic or ferromagnetic particles in a carrier fluid.

Pole and pole density: Magnetic poles that are the two ends of the magnet, which have more magnetism rather than other parts of the magnet. If you divide a magnet into smaller pieces, again there will be the two N and S poles calling them the magnetic dipole. The density of magnetic field lines are more in magnet ends wherever the density of magnetic field lines are more, the attraction and repulsion is stronger (www.chap.sch.i).

The more the number of magnetic field lines per unit area, the more the density of the pole. Pole density can be the power of attraction and magnetic field. The more closer to the poles, the more the pole density will be and the more closer to the middle ground between the two poles, the less pole density will be.

Magnetism is a phenomenon that is occurred on the surface; therefore magnetism is a surface phenomenon, not a volumetric one. It should be noted that the densification of poles occurs on magnet surfaces.

Surfactant: The particles dispersed in ferrofluid are Colloidal, but after a short time they get together and form larger particles. The smaller the particles are, the better the solution exhibits magnetic properties. That is why materials called surfactants are added to the solution which prevents the particles from joining together and particles lose their magnetism over the time (www.rasekhoon.net). It should be noted that the surfactants reduce the surface tension and the surface material is active. The surface active molecule should be partially hydrophilic and lipophilic (www.britannica.com).

3. Experimental Setup

Ferrofluid Recipe:

1) Prepare 10.77 grams of developer (Fig. 1)
2) Prepare 1/8 cup or 16 grams of toner (Fig. 2)
3) Prepare 19.84 grams of oil (Fig. 3)
4) Mix the ingredients and density of ferrofluid:1.86 (Fig. 4)

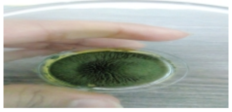


Fig. 1: Developer

Fig. 2: Toner

Fig. 3: Oil

Fig. 4: Mixing result

4. Determination of Ferrofluids Formation

1) A full Ferrofluid never precipitate.
2) Ferrofluids have hexagonal structure; because hexagons cause all the surface be involved and causes the clusters be formed. If the surface is in another form, all the surface will not be involved, leading to not creation of bulges.

Examined materials for Ferrofluid creation:

1) Developer + water
2) iron powder + castor oil
3) Developer + oil (preferably vegetable)
4) developer + Acetone
5) developer + Children's Body Oil
6) developer + oil
7) developer + Petrol
8) developer + Toner + Oil
9) Cassette + Acetone + oil

5. Reason of Magnetic Peaks Formation

The main reason for Formation of magnetic peaks, is magnetic field lines; the magnetic peaks are the magnetic field lines that are displayed in three dimensions. The more the magnetic field lines are, the more the peaks with higher altitudes will be generated.

In addition, the height and number of them depends on magnet strength, the magnetic field lines, and pole density. It should be noted that the bigger the magnet is, the more the number of generated peaks and the greater their height. Each of the generated clusters are small magnet themselves that if we approach a magnet, they will be attracted.

6. Surveyed parameters

1) Change in the container level

Small surface: 4 cm (about 50 clusters). (Approximate height of the highest cluster: 1.27 mm)

Vast surface: 9 cm (about 150 clusters). (Approximate height of the highest cluster: 1.55 mm)

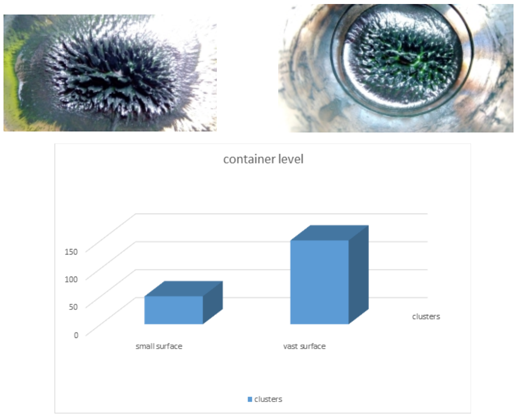
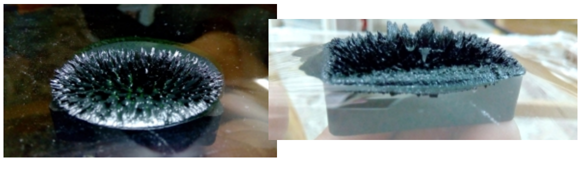


Fig. 5: The clusters in two different vessels

2. Change in thickness of Ferrofluid container

Cellophane thickness: 0.02 mm (almost 150 clusters). (Almost height of the highest cluster: 1.70 mm)

Glass thickness: 5.16 mm (almost 300 clusters). (Almost height of the highest cluster: 1.38 mm)



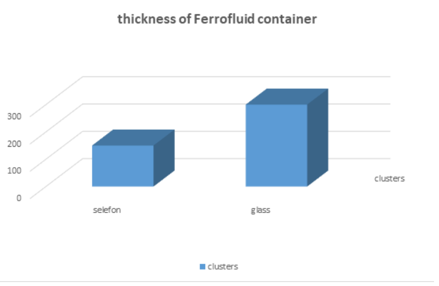


Fig. 6: The clusters in two different Ferrofluid container

3. Size of the magnet

Big magnet: 4 cm (almost 400 clusters). (Almost height of the highest cluster: 5.2 mm)

Small magnet: 1.5 cm (almost 20 clusters). (Almost height of the highest cluster: 2.3 mm)

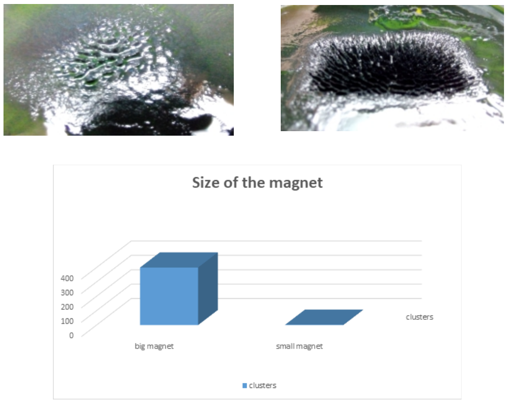


Fig. 7: The clusters with two different size of magnet

4. Change in Ferrofluid temperature

32°C : (almost 100 clusters). (Almost height of the highest cluster: 1.9 mm)

-4°C : (almost 300 clusters). (Almost height of the highest cluster: 2.1 mm)

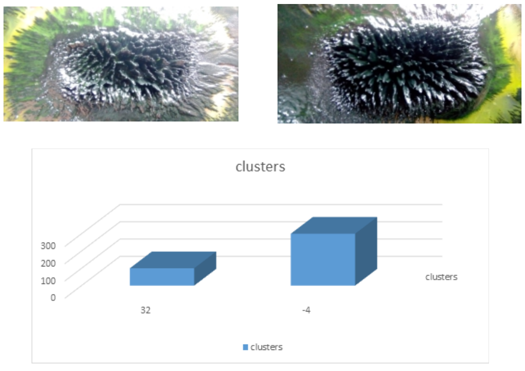
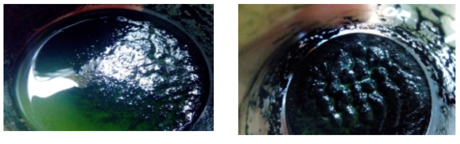


Fig. 8: The clusters in two different temperatures

5. Change in volume of Ferrofluid

High volume: 25 ml (Almost 10 clusters). (Height negligible)

Low volume: 12.5 ml (Almost 30 clusters). (Height of the highest cluster: 2.7 mm)



6) Type and size of the constituent particles

The more nanometer particles, the better magnetic properties the Ferrofluids will have.

7) Concentration of Ferrofluids

Ferrofluids concentration is very important, because if the concentration is too high, less peaks are generated and the less the concentration of Ferrofluid, the more peaks and the more their height.

8) Pole density and magnetic field lines

The more the density of the pole, the more the number of magnetic field lines; consequently the more the number of peaks and their heights.

9) Amount of surfactant

The amount and type of surfactant in Ferrofluids has great importance. Surveyed: soap, shampoo, dishwashing liquids, etc.

10) Ferrofluids Color Change

Ferrofluids color depends on the constitutive magnetic particles color; For example toner Ferrofluid is black; developer Ferrofluid color is green; cobalt Ferrofluid is blue, and copper Ferrofluid is red. It should be noted that particles change in Nano-scale.

7. Conclusion

The more the surface of Ferrofluids, the more peaks will be generated, but there will be not such change in their height and the more the thickness of the container, the more peaks with sharper tips and lower heights will be generated. The larger the magnet is, the more peaks with higher heights will be. As the temperature of Ferrofluid increases, with approaching a magnet to the Ferrofluid, peaks are generated easier and faster than the ones in low temperature but the number of peaks and their heights are lower than the ones in cold temperatures, and the peaks have sharp tips in negative temperatures. The larger the volume of the Ferrofluid, the less clusters with lower heights will be and the lower volume, the more clusters with higher heights will be.

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