FERROFLUIDS

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Abstract: In this report, preparation of ferrofluid by using laser printer toner powder and oil is reported. And one of the applications of ferrofluid, cymatics is briefly explained and by this we can easily understand how ferrofluids are useful for understanding study of sound. The observations suggest that ferrofluids are better replacement for water and sand. At the end we have included the future implementations and new technologies in which ferrofluids take major part.

Keywords- ferrofluids, cymatics, laser printer toner powder, precautions, future implementations

i. Introduction

A Ferrofluid (portmanteau of ferromagnetic and fluid) is a liquid that becomes strongly magnetized in the presence of a magnetic field. Ferrofluid was Invented in 1963 by NASA's Steve Papell as a liquid rocket fuel that could be drawn toward a pump inlet in a weightless environment by applying a magnetic field.

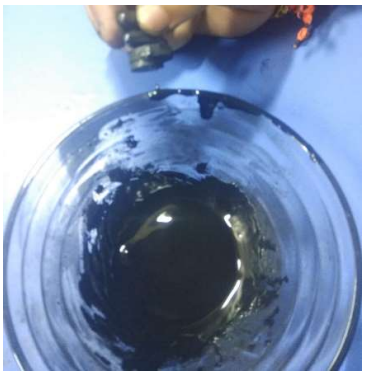
Ferrofluids are colloidal liquids made of nanoscale ferromagnetic, or ferrimagnetic, particles suspended in a carrier fluid(usually an organic solvent or water). Each tiny particle is thoroughly coated with a surfactant to inhibit clumping. These operate quite differently than normal liquid when they interact with a magnetic field. Ferrofluids, placed in water, looks like pools of heavy oil Large ferromagnetic particles can be ripped out of the homogeneous colloidal mixture, forming a separate clump of magnetic dust when exposed to strong magnetic fields. The magnetic attraction of nanoparticles is weak enough that the surfactant's Van der Waals force is sufficient to prevent magnetic clumping or agglomeration. Ferrofluids usually do not retain magnetization in the absence of an externally applied field and thus are often classified as "super paramagnets" rather than ferromagnets. The difference between ferrofluids and magnetorheological fluids (MR fluids) is the size of the particles. The particles in a ferrofluid primarily consist of nanoparticles which are suspended by Brownian motion and will not settle under normal conditions[1].

MR fluid particles primarily consist of micrometre-scale particles which are too heavy for Brownian motion to keep them suspended, and thus will settle over time because of the inherent density difference between the particle and its carrier fluid. These two fluids have very different applications as a result. [1]

ii. Composition of ferrofluid

Ferrofluid are composed of nanoscale particles (diameter usually 10 nanometer or less)of magnetite, hematite or some other compound containing iron, and a liquid. This is small enough for thermal agitation to disperse them evenly within a carrier fluid, and for them to contribute to the overall magnetic response of the fluid. This is similar to the way that the ions in an aqueous paramagnetic salt solution (such as an aqueous solution of copper(II) sulfate or manganese(II) chloride) make the solution paramagnetic. The composition of a typical ferrofluid is about 5% magnetic solids, 10% surfactant and 85% carrier, by volume[2].

iii. Procedure

- *Components required :* Laser printer toner powder, oil, bowl and magnets for testing
- Take some amount of Laser Printer Toner Powder in a tumbler.
- Add some oil to this powder.
- Mix both carefully with a glass rod. Pour the mixture on a plain surface like
  glass plate.
- Place the magnet under the glass plate.
- Observe the magnet is pulled towards the plate and stuck to the surface.
- 

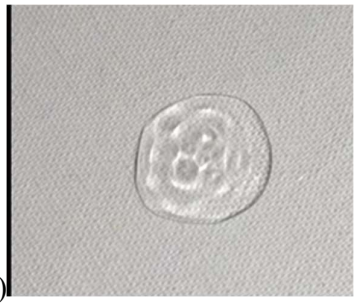
iv. Problems faced during synthesis

In order to work with ferrofluids, two things need to happen. First, the particles need to be small enough (diameter usually 10 nanometre or less). If the iron particles are too large, they act independently with the magnetic field. If, however, the particles are small enough to reach the nanoscale (between 1 to 100 nanometres), they react with one another in tandem with the magnetic field

In order to create a Ferrofluid, the nanoparticles must be coated with surfactant. Without this coating, magnetic field would simply pull the particle out of the Ferrofluid.

v. APPLICATION

- The underlying principle of cymatics is that the geometry of sound can be imprinted onto membranes and made visible with special techniques.
- The membrane can be a flexible material, such as latex or your skin, while other surfaces, such as brass or glass plates, may appear rigid yet they can still be minutely imprinted by sound.
- Simply by sprinkling on a little powder or sand, provided the membrane is horizontal, the imprint of sound can be revealed. The particulate matter gathers in the areas that are not vibrating, leaving the vibrating areas clear of particulate.
- Ferrofluids are extensively being used as a replacement for sand or powder. Below are the pic of our experiment on cymatics
- OBSERVATIONS:

a) 

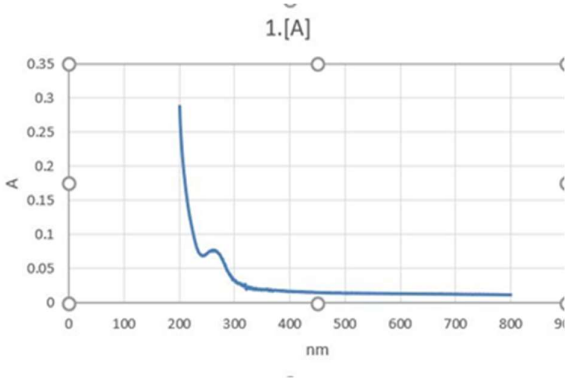
b) 

Fig.a. observation of cymatics through water. Fig.b. observation of cymatics through ferrofluid.

We have observed small spikes of ferrofluids when the sound is between the frequency

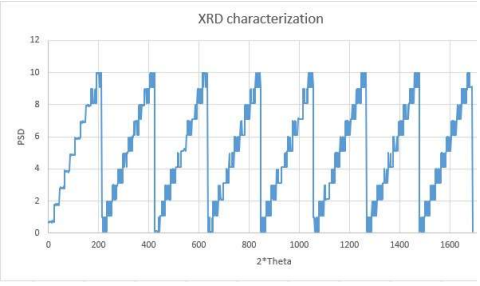
vi. UV characterisation:

Laser printer tonner powder was mixed with ethanal. we have used 1nm slit, lamp change was 320nm, meas. mode : spectral scan, Range[nm]: 200-800 nm, delta lambda:1. After passing uv rays we have plotted the graph vs Absorbance and wavelength



vii. XRD characterization

We have given laser printer tonner powder for XRD, in which they have taken goniometer radius=217.5, fixed divslit=0.6 started from 2theta=10 ,the graph below is the graph between 2theta and PSD



viii. Future implementations and new technologies[5]

1.Rocket fuel

Ferrofluid is used as a liquid rocket fuel that could be drawn toward a pump inlet in a weightless environment by applying a magnetic field.

2. Bio-Medical

Ferrofluid's magnetic nanoparticles may be incorporated into polymer microspheres (which are coated with antibodies and/or therapeutic /chemotherapy drugs), injected into tissues and then drawn to the site of a lesion using a strong magnetic field. They may also be used alone, as a medium for site-specific thermal ablation of malignant or necrotic tissue. Current research in the area of diagnostic tests and experimental therapies for malignant masses (plus an assortment of other lesions) often requires magnetic nanoparticles for success. For some applications, one approach for using Ferromagnetic materials is to combine the particles with a liquid monomer to create a polymer with magnetic properties This polymer can then be shaped and/or treated in some other way to make it useful in these applications. The other area of use for magnetic nanoparticles is their site-specific delivery to the site of concern for hyperthermia therapy.

3. Sensors, Switches and Solenoids

Ferrofluids can be used to improve performance in applications that include inclinometers, accelerometers and flow meters, tilt, vibration, pressure and level sensors, and various switches. The unique properties of magnetic fluid make it a feasible technology for some sensor and switch applications. The use of ferrofluid may enhance the motion sensitivity in some sensing applications. The introduction of a ferrofluid into a solenoid dramatically reduces the noise level of certain equipment, such as home care

kidney dialysis machines. Ferrofluids have been shown to provide both thermal and dielectric benefits to transformers.

4. Education

Educational Ferrofluids are specifically designed for use in classrooms, schools and museums. Ferrofluids feature magnetic properties that make it easier to visualize the magnetic patterns and provide an instructional, engaging experience. Ferrofluid is an amazing material that can be used to visually explain magnetism in unique, exciting ways. It can be a very effective educational tool. It can be used to visualize magnetic patterns while performing several thought provoking experiments.

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ix. References

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