Synthesis and Rheological Analysis of Ferro-Fluids

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Abstract: We report the rheological properties of ferro-fluid (FF) containing iron oxide nano-particles. At first, a FF was synthesized by using chemical co-precipitation. The microstructure study using SEM revealed that the FF contained nano-particles with the mean particle size of 35nm. The XRD study revealed that we have well crystallized structures of magnetite; they appeared to be approximately single crystalline structures. The rheological results proved that the FF has non Newtonian behavior, it is a shear thinning fluid in all magnetic fields, Moreover, the magnetic field increases the viscosity in a definite shear rate due to the nano-particles agglomerations and formation of chain-like clusters. It was concluded that the FF underwent the separation phase condensation at magnetic fields higher than about 100 kA/m. In this case that the instrument reveals negative viscosity in the low shear rates. Negative viscosity were also reported in some articles before, but for oscillating low magnetic fields.

1. INTRODUCTION

Several types of magnetic fluids have been developed. The most noteworthy and the subject of this body of work are colloidal ferro-fluids which are composed of coated single domain magnetic particles suspended in a liquid carrier fluid.[1] These materials remain suspended due to thermal energy and the surface coatings prevent aggregation[2]. In other words, they behave as super paramagnetic. Because of their high sensitivity to electromagnetic energy, ferro-fluids have been applied to such applications as seals, bearings, dampers, stepping motors, loudspeakers, sensors, and medicines[3].Magneto-rheological fluids have also been developed. These are composed of larger particles, typically on the order of microns or more[4].These fluids will solidify in the presence of magnetic materials/fields. In contrast, ferro-fluids will continue to flow in the presence of a magnetic field and they behave as super paramagnetic materials[5].

2. METHODS

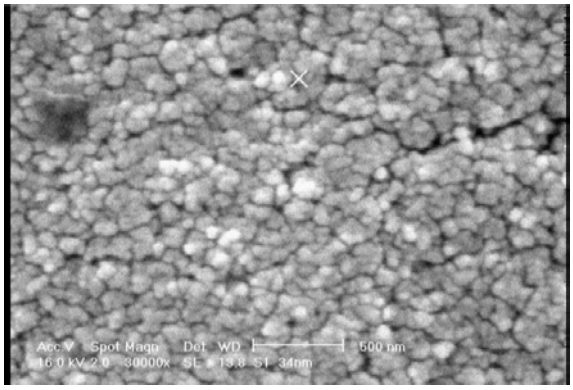
Ferro-fluid (FF) was synthesized by using chemical co-precipitation, in which Iron (II) and (III) chloride salts was added to ammonium hydroxide. Then we confirmed their magnetic property by observing their response to a magnet. After that we coated the nano particles with oleic acid as a surfactant in order to prevent their agglomeration.

3. ANALYSIS

We analysed the size of our samples with SEM, the texture of them by XRD, and the rheological properties by rheometer.

3.1 SEM Analysis

The SEM analysis showed that our samples are between14-80 nm



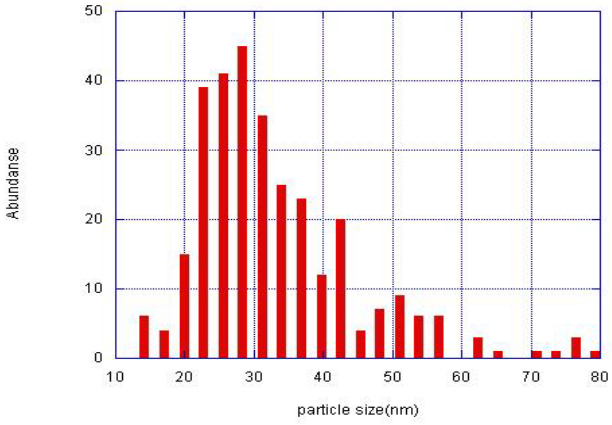


Fig-1: SEM Analysis & the size distribution

3.2 XRD Analysis

XRD analysis showed that our samples are Magnetite(figure2)

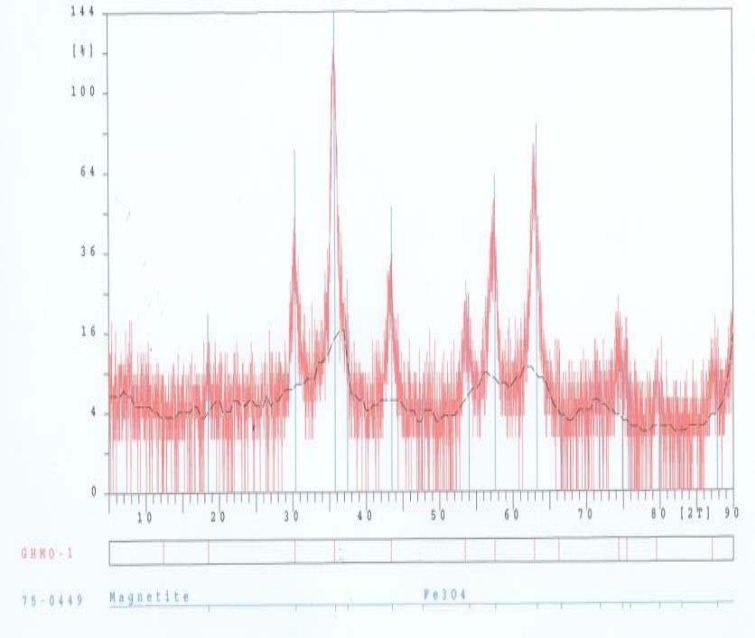


Fig-2:XRD Analysis reveals magnetite

3.3 Rheology Analysis

The rheology analysis revealed that our samples are shear thinning fluid and their viscosity grows with magnetic field but at very high magnetic fields under low shear rate we observed negative viscosity (fig5)

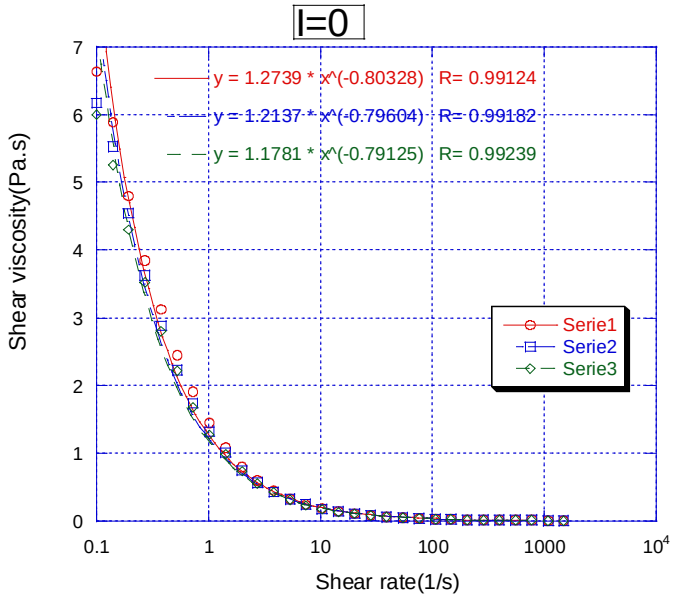


Figure 3- Rheological analysis, our samples are shear thinning fluids.

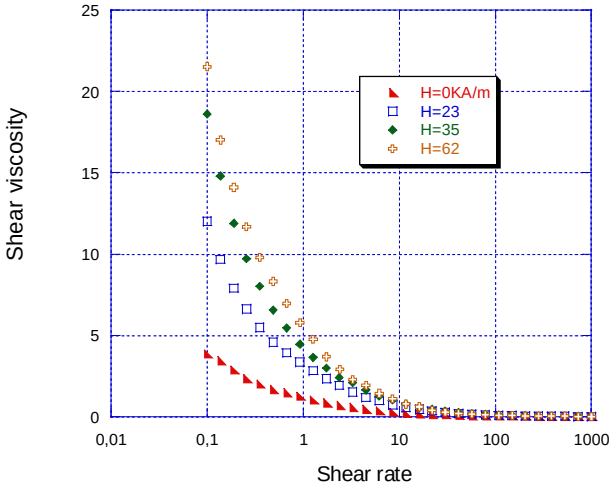


Figure 4- Rheological analysis, magnetic field increases the viscosity

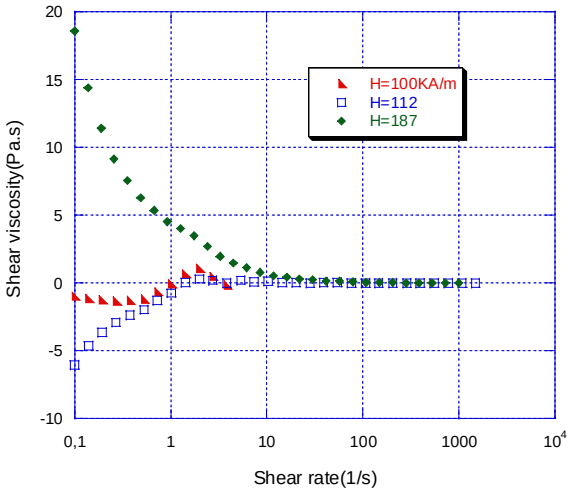


Fig 5- Rheology Analysis, in high magnetic fields and low shear rates negative viscosity have been observed

4. CONCLUSION

Ferro-fluid (FF) was synthesized successfully by using chemical co-precipitation. The Nano-magnetic particles made have average size of 35nm with a distribution between 14 and 80nm.The ferro-fluid made is a shear thinning fluid and its viscosity increases with magnetic field, at very high magnetic fields and under low shear rates we observed negative viscosity. In this case the instrument reveals negative viscosity in the low shear rates, a phenomenon reported in some articles previously under oscillating magnetic field[6,7,8], Perez Madrid 'calculations showed that in a range of frequencies larger than the local vorticity the negative viscosity arises[9] . In our case the magnetic field is constant but the ferro-fluid is under the rheology measurement, i.e, in rotation.

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