IOSR Journal of Applied Physics (IOSR-JAP)
e-ISSN: 2278-4861.Volume 8, Issue 1 Ver. II (Jan. - Feb. 2016), PP 52-55
www.iosrjournals

Affected magnetic properties of ultrafine Iron Oxide nanoparticles in anionic SDS aqueous dispersion

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Abstract: *The wet chemical route of co-precipitation method synthesized Iron oxide nanoparticles (IONs) dispersed in anionic dispersion was used in this study. XRD confirmed Fe_3O_4 phase and estimated nano size by Williamson Hall plot method. The M-H loop from SQUID showing very low coercivity, linearity for a very small applied field and good saturation magnetization in an anionic aqueous dispersion. In the dispersion, IONs are tending to aligned more with its easy axis than in powder form. The effect on magnetic properties has been explored in the study.*

Keywords: *Magnetic Nanoparticles; Iron oxide; SPION; Fe_3O_4, SDS dispersion, magnetite*

I. Introduction

The use of magnetic nanoparticles (MNP) in sensors, medicine and therapy has recently gained importance. The Iron Oxide nanoparticles (IONs) are found to be very promising in these in nanotechnology and nanomedicine area. The drastic change in physico-chemical properties of the materials in "nano" regime is manifested in the magnetic nanoparticles as "single domain behavior". They show relatively large magnetization saturation at low fields with very low (near zero) coercivity.

Amit Sharma and his team have studied on MNP for cancer treatment and showed IONs are non toxic [1]. MNP can be used for drug delivery after coating and attaching drug to it [2]. Thus this requires the MNP with less coercivity Hc, high saturation magnetization (M) and probably low remanence ratio [1, 3, 4]. The particles with size 20 – 30 nm are considered as single domain structure. As size decreases super paramagnetic iron oxide nanoparticles (SPION) are obtained which can play crucial role in drug delivery. For very small size, above which the relaxation in Hc occurs, the magnetic behavior is tending to be vanished. The wet chemical route of co-precipitation method is employed to synthesize such MNP SPION. It is suitable for colloids nanoparticles [5] and due to the advantage over others methods. Hypothesis is that Iron Oxide nanoparticles tend to change their aggregation, remove agglomerates due to surfactant as an anionic SDS medium and therefore their magnetic properties get affected.

II. Experimental

By the wet chemical route of co-precipitation method the IONs were synthesized at room temperature 300 K using precursors like Ferric Chloride Hexahydrated, $FeCl_{3.6}H_2O$ and Ferrous Sulphate Hydrated $FeSO_4.7H_2O$ (in the molar proportion of 2:1); Ammonia solution and deionize water (free of dissolved oxygen). The reaction temperature was varied at different stages i.e. for nucleation, growth and restricting the growth. By decantation and centrifugation the IONs were separated and washed in the Acetone and Hexane mixture and dried for 24 hours. We get IONs in black powder form. The 30.3 mg IONs in powder form were mixed in 2ml of Sodium Dedocyle Sulphate (SDS) anionic solution prepared in deionized distilled water, well shaked and kept in ultrasonicater chamber in water bath for 45 minute. The suspended particles were observed (for 30 minutes).

The X-ray diffraction (XRD) was carried out on a Philips X-Ray Diffractometer using Cu-Kα radiation of wavelength (λ) approximately 1.54 Å. XRD Sample were prepared on glass substrate. SQUID (QUANTUM) MPMS is used with the range of field between -20 KOe to 20 KOe was used for magnetic study at 300 Kelvin. SQUID sample were prepared in cut pipet tip closed using Araldite

III. Result And Discussion:

Black lustrous IONs were observed which turned black-brown in color when suspended in SDS. After ~40 minutes all IONs settled down due to the effect of gravity. Fig.1 illustrates the highly intense peaks of the SDS which is used for the preparation of dispersion medium. For analysis, it has been taken SDS XRD shown in Fig.1. These indicates that sharp peak of high intensity is matched with the peaks of lower intensity and shows formation of crystals of SDS dispersion medium.

Broad peaks with low intensity matched with inversed spinal Iron Oxide. This is observed from the comparison with the reported work in literature and the JCPDS-PDF card 19-629. The peaks are close to those reported by D. Maity, D.C. Agrawal [6] for ratio 2:1 of Fe^{3+} to Fe^{2+}. Their relative Intensity matched with a Phase Magnetite i.e. Fe_3O_4. The presence of shoulder peak just right side to (331) has confirmed that only a magnetite phase is present and not a maghemite. XRD data reveal the cubic inverse spinal structure of space group Fd-3m. Presences of the broadened peaks indicate the presence of nanograins.

Broadening of peaks measured by β (Full Width of Half Maxima) increases with the angle of diffraction. Average size of the Particles estimated using calculated by Williamson Hall analysis as mention in paper by VD Mote et. al. [6] is found 21 nm with mean deviation 7nm. In the plots β* and d* are the factors related to the terms βcosθ and 4sinθ/λ respectively, where as θ is Bragg's reflection angles. For calculation the unit of β is taken in radian. The estimated average size for Iron Oxide is suggested the formation of structure below single domain. The analysis carried for all data obtained from all peaks except Fe_3O_4. From this the SDS particles, which are form a cluster with Fe_3O_4 after drying, show 173nm of size with deviation of 57nm. These are anionic large grain particles have coated the Fe_3O_4 nanoparticles. The plane of (311) of Fe_3O_4 is very close and likely merged with (220) peak of SDS. Due to this the stain in Fe_3O_4 was possibly changed. But in a aqueous medium the dispersion of anionic particle is form. These causes' equal molecular forces acted on Fe_3O_4. This may decrease the aggregation and agglomerization and make molecules non-interacting with each other or less interacting. This has been studied using magnetic properties.

From Fig.3 for the dispersion of Fe_3O_4 in SDS coercivety (Hc) is found near to zero in Oe with the magnetization saturation (Ms) of 0.043 emu is found. However saturation slope is present and very small implies for the scanned field the sample were not fully saturated. In order to know M in emu/g, we have estimated the weight of the magnetite in the given volume of liquid dispersion. As per our estimate Ms turn out to be 65emu/gm. this shows magnetite retain their magnetic behavior. It is aspected from Fig.3 the remanence ratio Mr/Ms is very very small compare to that of the value of single-domain particles i.e. 0.5 expected for non-interacting, randomly oriented particles [4]. Thus the super paramagnetic nature is observed and suggests the formation of SPION. These features render these IONs in the area of biomedical for various applications, particularly for the drug delivery and for the hyperthermia treatment to cure cancer [1, 2, 3]. And also in the area of sensors for low magnetic field but less data points below 100Oe does not provided here the exact nature except superparamagnetic nature at 300K in anionic dispersion. The M-H curved studied on M-H loop trace for maximum of 332G of field for the undispersed powder sample of Fe_3O_4.It shows loop and suggested recognizable large coercivity. In a SQUID study magnetic saturation attained Ms for the application of small field strength ~2KOe and coercivity was estimated as ~5Oe by approximation at 300K which is remarkably lesser than obtained from M-H loop tracer. From this it is interpreted that our hypothesis is not wrong. For the future scope, the study with large data is needed by which it could be satisfactorily check for correctness and clears the actual perspective.

IV. Conclusions:

i) Superparamagnetism is shown in the medium of anionic dispersion of SDS. Fe_3O_4 powder shows remarkably large magnetization compare to in a medium. This indicates in a medium of dispersion the switching action is faster and particles became non-interacting. ii) Magnetic saturation attained Ms for the application of small field strength and coercivity was found small. iv) The magnetic behavior suggests that these IONs in anionic dispersion of SDS is the ideal candidate for drug delivery in the point of view of Physics. For further Biological investigation will reveals its applicability. However in an anionic SDS aqueous medium superparamagnetism is enhanced.

Acknowledgment

Authors are very thankful to acknowledge the TIFR for XRD and SQUID data and support.

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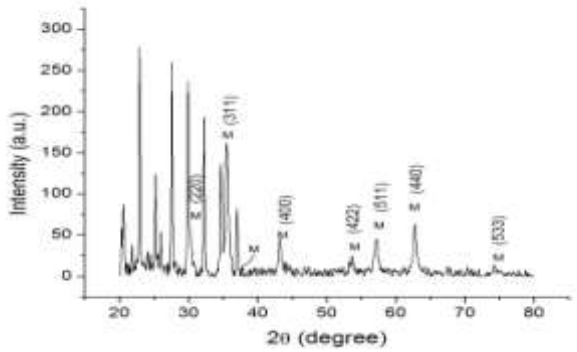

Figure1: XRD pattern for IONs in SDS shows peaks corresponding to lower intensity with broader peak profile are the Fe_3O_4 peaks.

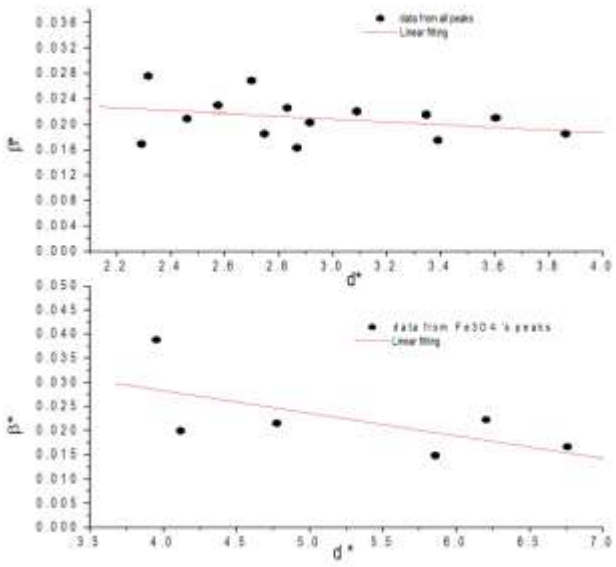

Figure 2 : Williamson Hall plot for size and strain analysis. The first figure shows plot for all peak except few of Fe_3O_4 whereas the second figure shows plot for Fe_3O_4.

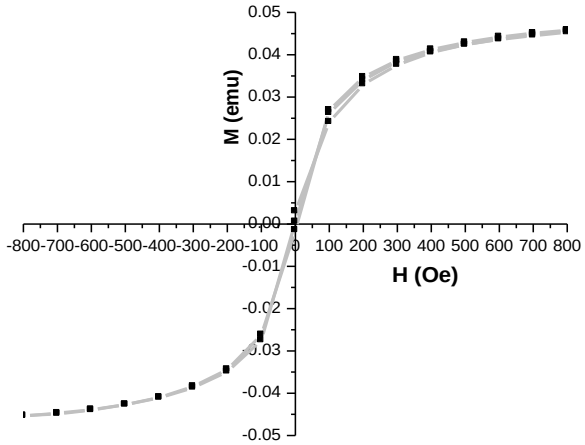

Figure 3: shows M-H curve of IONs