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Surface Modification Effect on Magnetic Characteristic of Epoxy Ferrite Particle Composites

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Abstract: ***In this study, surface modification of ferrite nanoparticles were effectively prepared using (3-aminopropyl) triethoxysilane (APTES). The chemical structure and morphology of the acquired nanoparticles were studied spectral analysis techniques such as XRD. Both of Modified ferrite nanoparticles (MFNs) and ferrite nanoparticles (FNs) were used in the preparation of epoxy nanocomposites with different weight fraction. XRD approved that MFNs was successfully prepared with highly crystalline structure. also the average particle size of nano filler decreased to ~20.21 nm after silane surface modification. Surface modification of ferrite nanoparticles enhanced the dispersion of ferrite fillers in epoxy resin due to which homogeneously dispersion of modified ferrite nanoparticles improved magnetic property of epoxy composite compare to cured epoxy and normal ferrite epoxy composites. Enhanced dispersion of Modified ferrite nanoparticle into epoxy resin was successfully performed which has been shown improve magnetization of epoxy ferrite composite compare to normal epoxy ferrite composite by 24.29%.***

Keywords: Ferrite Nanoparticles, Nano-magnetic Polymer Composites, Spectra, Magnetic Characterization, Silane Coupling

I. INTRODUCTION

In the new era of development, demand of high density electronic component along with low cost, high performance, smaller size and multi functionality features has been increasing. These features can be obtain by selecting suitable fillers such as aluminium, Carbon and graphite, Al nitrides, silver, Barium titanate etc. High density electric circuit was accomplished by evolution of composite materials with high permeability and permittivity. In this manner, much works have been done on the advancement of composites materials with both high porousness and permittivity to meet the necessities of the multifunctional components. To work nanoparticles as a multifunctional composites, some excellent properties have been applied i.e. non-corrosiveness, light weight, mechanical strength, and dielectric tenability. For Composite Materials, Polymers have classified as Excellent Host matrix. A few propelled polymer composites have been blended with a wide assortment of incorporations like metals, semiconductors, carbon nanotubes, and nanoparticles. The composites with polymers had come in picture as an essential material for many high frequency applications however ferrites and its composites have certain level of disadvantage such as inappropriate compatibility with polymer matrix, greater loss and stiffness while certain type of coating providing the way to covenant with those constraint of polymer composite. In all the Properties of the polymers, the most important property i.e. magnetic property which is based on separation has been applied in numerous fields those are biotechnology and biomedicine with cell, protein purification and enzyme immobilization. Magnetic properties are more helpful to recover the samples and much useful to provide power and efficiency separation on large scale operation. The support of magnetic property is not limited here it can support superparamagnetic, strong magnetic responsiveness, high stability, narrow size distribution and low nonspecific adsorption of protein as well. Some Applications require narrow sized distribution, high and uniform magnetic content and High Ms which can be achieved by magnetic properties of polymers. Epoxy resin Play an important role for providing electrical resistivity, low dielectric constant and easy processing. These all properties of epoxy can be limited by magnetic property. Only Epoxy resin are not enough to provide good mechanical property hence variety of approaches invented to improve epoxy coating mechanical properties. In this regards Nano fillers has been coated with organic and inorganic Nano pigments which enhance epoxy toughness and resistance on the mechanical property of epoxy coating. By doing coating with different fillers, higher tensile modulus and tensile strength was found as compare to pure coating. Shape and size also play a significant role in affecting the mechanical property of epoxy. Shape and size effect can be mitigate by adding suitable filler into epoxy composites. One of the example is by reinforcing Nano alumina powder with different shape and

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size increase mechanical property i.e. tensile strength and fracture toughness of the coating. Ferrite particle filled composite material based on polymer matrix materials are called bonded magnets which is the current research interest for possible application.

Concerning current study, modified ferrite nanoparticle epoxy were formulated through filling epoxy matrix with modified ferrite nano particles and normal ferrite nano particles. For investigation the effect of treatment of reinforced particles with silane on the magnetic properties of composite; microstructural, magnetic characterizations were performed using XRD and VSM.

II. MATERIALS AND METHODS

The commercially obtainable araldite epoxy resin (CY230) which is based on diglycidyl ether of bisphenil A (DGEBA) and curing agent TETA (HY 951) which is commonly known as triethylenetetraamine were purchased from M/S Huntsman India Limited. 3-amino propyl triethoxy silane were purchased by Himedia Laboratory Pvt. Ltd. India. Ferrite nanoparticles (FN)(M.W.159.69,95%) were purchased from RESEARCH-LAB FINE CHEM Industries, Mumbai, India.

Firstly, 0.5 g of Ferrite nanoparticles, was dispersed into ethanol (400 ml) using ultra-sonication for 20 min. The chemical modification of ferrite particles with silane was started by adding 2 ml of APTES drop-wise to the dispersed solution of ferrite ethanol slurry. Powerful mechanical stirring has been applied for this system and maintained for 24 h. The obtained modified material was then centrifuged, washed with ethanol-distilled water solution (1:1) four times and finally dried at 90±5 ◦C to obtain Modified ferrite nanoparticles.

Epoxy composites was filled with loading different percentage of modified ferrite nanoparticle and normal ferrite nanoparticles. Separately, both ferrites particles were firstly mixed well into epoxy resin(CY 230) and then dispersed using ultrasonication for 15 min in ice bath. After addition of the hardener(HY 951), the epoxy- modified ferrite nanoparticle and epoxy - normal ferrite nanoparticles were kept for curing at room temperature for 7 days in teflon moulds to avoid stacking.

III. CHARACTERIZATIONS

The crystallinity of the epoxy- modified ferrite nanoparticle (MFEs) and epoxy - normal ferrite nanoparticles (FEs) samples was characterized using X-ray diffraction (wide angle XRD) analysis. The diffraction patterns were measured by a Rigaku-Geiger-flex diffracto-meter using Cu–Kα radiation at 25°C over. The analysis was run though"1.54˚A wavelength, 40 kV voltage and 40 mA current". The 2θ range was 4–80◦with a rate of 1◦/min. Magnetic properties of cured epoxy, epoxy- modified ferrite nanoparticle (MFEs) and epoxy - normal ferrite nanoparticles (FEs) samples were recorded at room temperature using a vibrating sample magnetometer Princeton EG&G Applied Research, model 155 with maximum current 22.5A at 900s-1.

IV. RESULTS AND DISCUSSION

Fig. 1 shows the XRD for Modified ferrite nanoparticle (MFNs) and Normal ferrite nanoparticles (FNs samples. The found XRD patterns attributed for the "rhom-bohedral phase" for "α-Fe2O3" conferring to ICDD ref. card04-008-7623. The shown XRD patterns exhibit extremely crystalline and pure "α-Fe2O3" specimens [12]. Also, the growth of the peaks heights approves enchasing the intensity of crystallization. The average crystalline size of Modified ferrite nanoparticle was determined to be about 20.20 nm using Scherrer's formula as explained in "Eq. (1)".

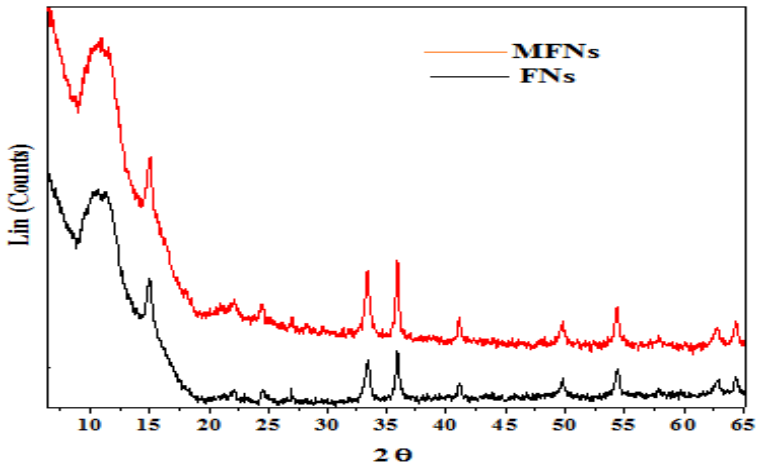

Fig. 1 XRD pattern of Modified ferrite nanoparticle (MFNs) and Normal ferrite nanoparticles (FNs)

$$T = K \lambda / \beta \cos \theta \qquad (1)$$

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"T" is the average crystalline size. "K" is a factor (0.89). "θ" and "λ" are respectively the Bragg's angle and wavelength. "β" is the value of peak width at half of maximum height after subtracting the line width in radians.

Fig.2 has shown the magnetic characteristics of cured epoxy, FEs and MFEs with concentration of MFNs are obtained by measuring their M–H loops in the applied field ranging −6 kOe to 6 kOe. M-H curve of cured epoxy has revealed magnetization $2.9x10^{-3}$ emu/g indicating. However, with increase concentration of MFNs, magnetic moment increased and has been shown a range 6.80x10-2 to 18.06 x10-2 emu/g. This relates to the growth in magnetic moment of MFNEs-I, MFNEs-II, MFNEs-III and MFNEs-IV by 6.80x10-2, 8.72 x10-2, 13.70 x10-2 and 18.06 x10-2 emu/g respectively as compared to cured epoxy.

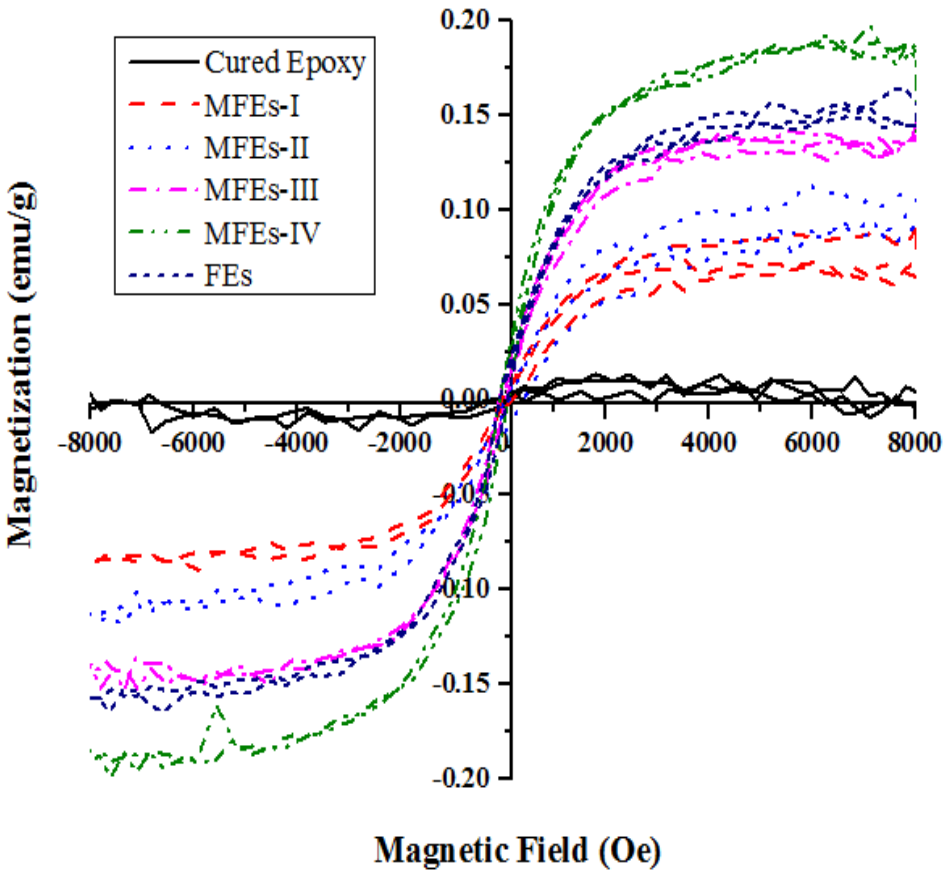

Fig. 2 VSM of different Epoxy-Modified ferrite nanoparticle (MFNEs), Epoxy-Normal ferrite nanoparticles (FNEs) and Cured Epoxy

Whereas magnetic moment of FEs shows 14.53 x10-2 emu/g. Surface modification of ferrite nanoparticles enhanced the dispersion of ferrite fillers in epoxy resin due to which homogeneously dispersion of modified ferrite nanoparticles improved magnetic property of epoxy composite compare to cured epoxy and normal ferrite epoxy composites.

V. CONCLUSIONS

The surface modification of ferrite nanoparticles was effectively achieved by using 3-aminopropyltriethoxysilane (APTES) as coupling agent to prepare Modified ferrite nanoparticle(MFNs).The chemical structure of the crystalline Modified ferrite nanoparticle was confirmed by XRD pattern. Enhanced dispersion of Modified ferrite nanoparticle into epoxy resin was successfully performed which has been shown improve magnetization of epoxy ferrite composite compare to normal epoxy ferrite composite by 24.29%.

VI. ACKNOWLEDGMENT

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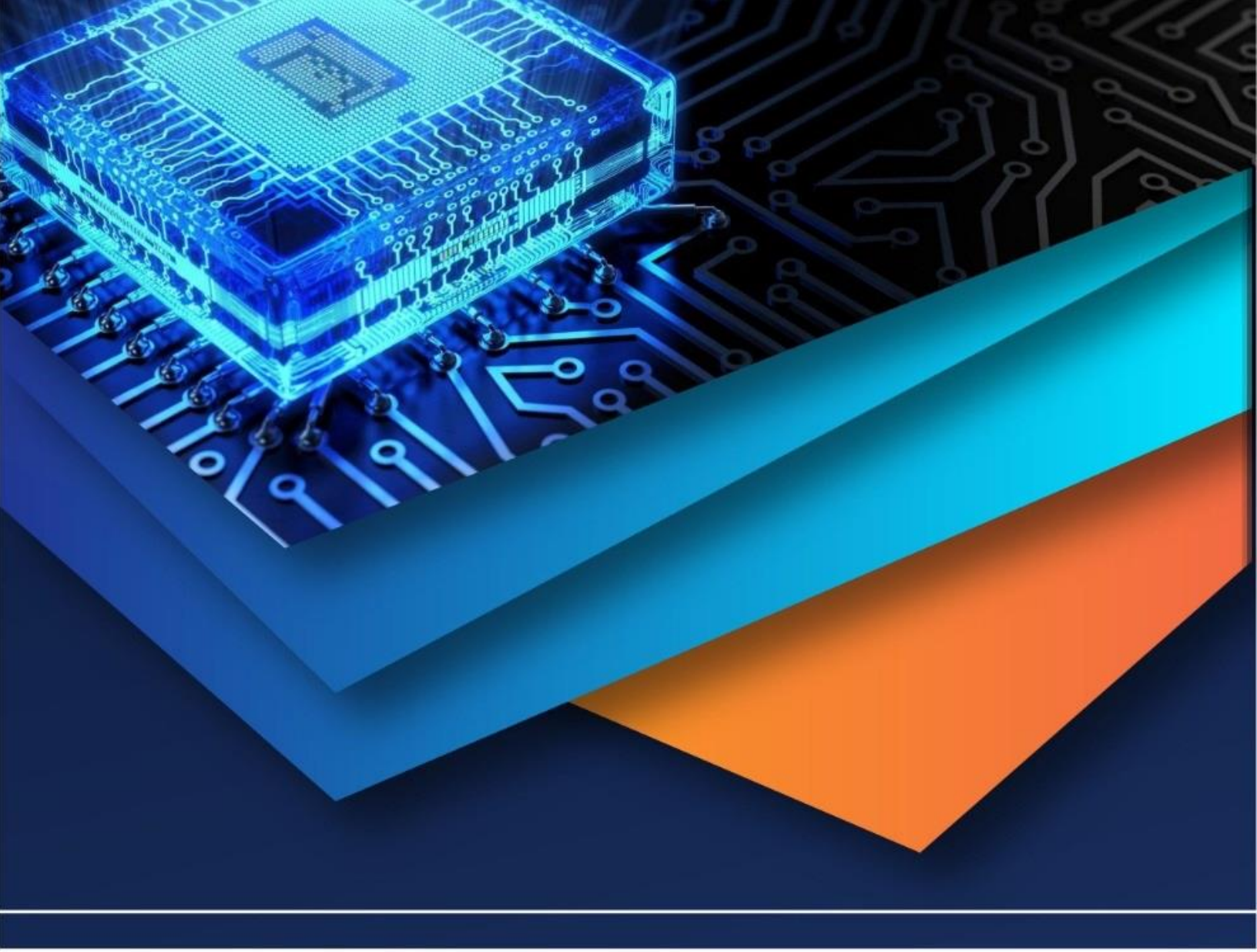

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