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ISSN : 2454 – 308X | Volume : 03 , Issue : 08 | October – December 2017

Prepration and characterization of polymer based ferrites

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***Abstract*— This review is designed to be a comprehensive source for polymer nanocomposite research, including fundamental structure/property relationships, manufacturing techniques, and applications of polymer Nano composite materials. Asphaltenes can cause enormous losses in the oil industry, because they are soluble only in aromatic solvents. Therefore, they must be removed from the petroleum before it is refined, using flocculants agents. Aiming to find new materials that can work as flocculent agents to asphaltenes, cobalt ferrite nanoparticles were chemically modified through acid-base reactions using dodecylbenzene sulfonic acid (DBSA) to increase their lipophilicity. Nanoparticle synthesis was performed using the co-precipitation method followed by annealing of these nanoparticles, aiming to change the structural phase.**

The ion conducting polymer composite specimen has been prepared by using Polyvinyl- pyrrolidone (PVP) and Potassium hydroxide (KOH) using double distilled water as the solvent. The solution cast techniques was used to prepare the specimens. The main objective of the project is to study structural and mechanical properties of the polymer composite specimen. The conductivity and micro structure analysis has been carried out.

Keywords- polymer; ferrite; nanomaterial, polymer,

I. INTRODUCTION

The development of radar absorbing materials (RAM) is fundamental in stealth technology, as well as in other applications in the microwave range. The reduction of electromagnetic interference and the solution of electromagnetic compatibility problems are necessary. Thus, many researchers are focusing their interest on producing materials suitable for large EM wave absorption. The absorption of EM waves occurs in magnetic materials due to their magnetic losses. Ferrites are also used as microwave absorbers. Some ferrites absorb microwave by loss interactions of the electric and magnetic field vector of incident waves and in the process convert microwave energy

Into thermal energy. Spinel ferrites based on Ni-Zn have been used as high-frequency ferrites for transformer cores, rod antennas, and radio frequency and more recently as radar absorbing materials (RAMs). Ferrites with a submicron grain size are some of the most promising materials in magnetic Nano composites for the absorption of microwave radiation. (Fadzidah Mohd Idris1, 2014)

II. FERRITES

Ferrites are known for their magnetic effect as early as 1954.These are the main materials (oxides) responsible for magnetic effect in magneto polymer matrix composites (MPMCs). Gabriel and co-workers (G. Andrei, 2006) proposed a model explaining the mechanism by which magnetism evolve in magneto polymer matrix composites. They explained the generation and evolution of magnetism in magneto polymer composite on the basis of mechano-quantic theory in which paramagnetism of oxygen (at tetrahedral or octahedral sites in ferrite) is explained by means of molecular orbital method (MOM). The diagram in Fig.1 below is utilized to explain paramagnetic behavior of oxygen molecule. It is clear that there are two unbound electrons in the anti-bonding orbitals π_{2px} and π_{2py} and according to Hund's rule anti-bonding orbitals having the same energy are populated by one and only one electron at one time.

This accounts for paramagnetic behavior of oxygen in the presence of external magnetic field. Another theory accounts for unequal distribution of cat-ions and anions in

Ferrite unit cell at tetrahedral and octahedral sites which even after cancellation bear a net positive effect and thus become a source of responsive behavior in an applied external magnetic field. (Pulla, 2012)

A. Type of ferrite

There are two types of ferrites.

- Soft ferrites
- Hard ferrites

1) Soft ferrites

Ferrites (magnetic materials) which become magnetic upon application of magnetic field and returns back to their natural demagnetized state after removal of magnetic field are called "soft ferrites". An example of these ferrites is NiZn, MnZn. Out of these, NiZn ferrites and its derivatives have low to high Curie temperature (TC) (130–500 °C) which makes them very close to hard ferrites. In fact, in case of application of strong magnetic field and/or severe plastic deformation (mechanical working), they actually can retain their permanent magnetic character even after removal of applied magnetic field. On the other hand, MnZn class of ferrites (MnZn and its derivatives) have low Curie temperature (TC) (150–200 °C) which make them so called "perfect soft" magnetic materials as they do not retain magnetism upon removal of applied magnetic field and comes back to their demagnetization state. (Kandare, 2017)

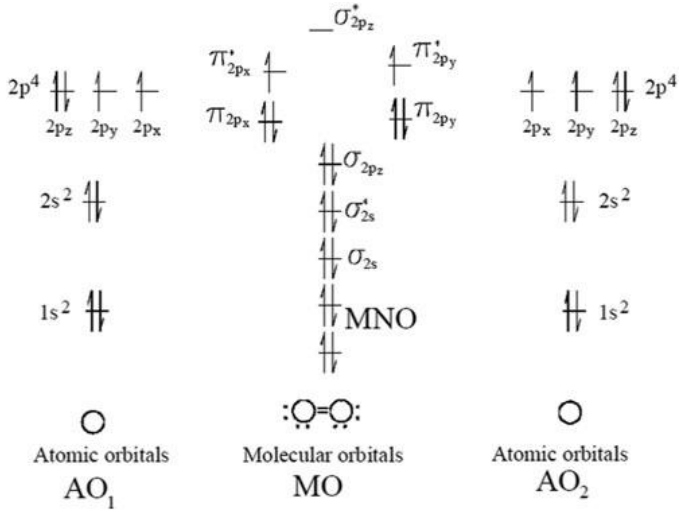

fig 1.Schematic representation of chemical bonds in O2x molecule, using MOM.

2) Hard ferrites

Ferrites which do not come back to their demagnetized state but retains their magnetism even on removal of applied field are called "hard ferrites". For example, barium ferrites, strontium ferrites, and cobalt ferrites. All these ferrites have their magnetic domains aligned and/or unaligned with a net positive magnetic effect in the direction of magnetic field in such a way that upon removal of applied field the "net positive effect" incurred in sample stays there indefinitely and becomes the source of the their permanent magnetic nature.

Another table below compares the salient features and properties of hard and soft ferrites describing each merits and disadvantages. (Kandare, 2017)

III. LITRETURE REVIEW

1. **(Lígia N. M. Ribeiro, 2017)** describe the use of biomaterials composed of organic pristine components has been successfully described in several purposes, such as tissue engineering and drug delivery. Drug delivery systems (DDS) have shown several advantages over traditional drug therapy, such as greater therapeutic efficacy, prolonged delivery profile, and reduced drug toxicity, as evidenced by in vitro and in vivo studies as well as clinical trials. Despite that, there is no perfect delivery carrier, and issues such as undesirable viscosity and physicochemical stability or inability to efficiently encapsulate hydrophilic/hydrophobic molecules still persist, limiting DDS applications.
2. **(Rurik Farias-Mancilla1, 2016)** according that Prior to their use for microwave absorption, different compositions of NixZn1-xFe2O4 (x = 0.5, 0.6, 0.7 and 0.8) were prepared via mechanical alloying and sintering. X-ray diffractometry (XRD) was used to investigate the crystalline phase formation. Scanning transmission electron microscopy (STEM) and field emission electron microscopy (FeSEM) were used to investigate the particle size and surface morphology respectively. The complex-permeability components, μ′ and μ″, were also measured using an Agilent 4291B material analyzer from 1 MHz to 1 GHz. From the XRD results it is shown that at 900ºC the full phase of nickel zinc ferrite was formed. The μ″ values suggest that the ferrite sample can absorb well microwave energy for frequencies 1 MHz to 1 GHz and higher. This is proved by microwave absorption measurements carried out up to 12 GHz.
3. **(Cristian Munteniță, 2016)** Sustained efforts have been extensively devoted to prepare new composite materials based on nano-ferrite modified epoxy resins. Generally the modifying agents are used in order to

change mechanical properties of final composite. In this study, composites were fabricated with two types of nano-ferrites and three types of epoxy resins. The aim of the analysis was to identify the effect of nano-ferrites on the bending behaviour of composites. From generated results it is noticed that, in the case of composite materials modified with ferrites, subjected to the bending test, breaking is influenced by the type and amount of modifying agents.

4. **(Yadhu Krishnan, 2015)** define Fine particles of gamma ferric oxide is prepared by the sol-gel method and characterized by taking XRD. Natural rubber based gamma ferric oxide composites (RFCs) with different ferrite loading are prepared by incorporating ferric oxide into the matrix according to a specific recipe. Cure characteristics and mechanical properties are determined as per ASTM standard. Magnetic studies are carried out using a vibrating sample magnetometer. This study throws light on the processability of rubber composites filled with ceramic fillers like gamma ferric oxide in natural rubber. Magnetic composites with desired magnetic properties are properly designed by tuning filler to matrix ratio.
5. **(I. NEAMTU, 2005)** said Magnetic nanocomposites are an important class of advanced functional materials on the basis of a magnetic material and a matrix. To achieve unique mechanical, physical, chemical, and biomedical properties, one must be able to tailor only the surface structures of a nanoparticle. This requires the deposition of ultrathin and uniform films using the possibility offered by cold-plasma polymerization process. The paper presents the synthesis of a magnetic composite based on ferrite and a vinyl polymer, with some data of physico-chemical characterization.
6. **(G. MURTAZAa, 2015)** reserch of Nano crystalline Mn0.5Zn0.5Fe2O4 has been successfully synthesized using co-precipitation method and the effect of multiwall carbon nanotube composite have been studied. XRD pattern indicate a transition in the structure of the ferrite after the loading of the multiwalled carbon nanotubes. The saturation magnetization increases from 2.26 emu/g to 9.35 emu/g with the increase of multiwall carbon nanotubes. The thermal stability of the material increases with the increase of multiwall concentrations. Materials exhibit the super paramagnetic behavior. The coercivity value increases from 82 Oe to 152 Oe with the increase percentage of multiwalled carbon nanotubes (MWCNTs). The synthesized ferrite sample by the co-precipitation technique exhibits the single phase Face center cubic structure.
7. **(K. P. Murali1, 2015)** define epoxy matrix nanocomposites with nickel nanoparticles of two different sizes were processed and characterized to investigate their structure-magnetic property correlations. Crystal structure, morphology, density, resistivity and magnetic properties of the nanocomposites with different filler contents were compared for different size scales. Nanocomposites with 25 nm nanoparticles showed higher coercivity, higher frequency stability and lower loss, though the permeability was suppressed. Coarser nickel particles (100 nm) showed a permeability of *5.5 but stability only up to 200 MHz. The structure-magnetic property correlations were validated using analytical models to provide valuable design guidelines for permeability and frequency- stability in particulate nanocomposites.

IV. TYPE OF POLYMERS

A. Natural polymer: -

The polymers, which occur in nature are called natural polymer also known as biopolymers. Examples of such polymers are natural rubber, natural silk, cellulose, starch, proteins, etc.

B. Semi synthetic polymer:-

They are the chemically modified natural polymers such as hydrogenated, natural rubber, cellulosic, cellulose nitrate, methyl cellulose, etc.

C. Synthetic polymer:-

The polymer which has been synthesized in the laboratory is known as synthetic polymer. These are also known as manmade polymers. Examples of such polymers are polyvinyl alcohol, polyethylene, polystyrene, polysulfone, etc.

V. BEHAVIOR OF POLYMERS

There are three types of behaviors in polymers, they are

A. Thermal Behavior

Thermoplastic and thermosetting polymers differ in that thermoplastic polymers actually melt and lose all semblance of crystallinity at high temperatures. After polymerization

the thermosetting plastics can lose its strength if they are subjected to higher temperature

The most critical effect of increased temperature is an increased rate of chemical reaction. The mechanical strength of the polymer drops rapidly at the same temperature where the polymer becomes susceptible to chemical reaction.

B. Mechanical Behavior

A polymer in molten state is amorphous in nature and has random chain orientation. By quenching structure of the molecules at higher temperatures can be preserved at lower temperature. The tension produces most of the initial deformation and improves the alignment of the molecules. As a result the stress-strain relationship is not like those of metals, because the molecules of elasticity are increased when the stress is applied directly against the polymer chain after the alignment has occurred.

C. Electrical Behavior

There is considerable use of plastics in electrical insulation. They can be made conductive and has some applications

1. **Dielectric constant:** the dielectric properties of polymers are sensitive to the polarization of the structure.
2. **Conductivity:** Although polymers are inherently insulators their compositions can be adjusted to permit some conductivity. (Sharma2, 2013)

VI. EFFECT OF DOPING OF COBALT FERRIDE

Cobalt ferrites are best known candidate for use in various diversified applications. Recently Mn doped Cobalt ferrites have received renewed attention across the world for understanding of their tenable behavior and tuning of fundamental magnetic properties to optimize them in advanced applications as revealed from various literature reviews. As such, three systems of Mn doped Cobalt ferrites with composition Co1-xMnxFe2O4, CoMnxFe2-xO4 and Co1+xMnxFe2-xO4, where x =0.125, 025, 0.375, 0.500have undertaken for analytical study to predict effect of Mn substitution and resulting probabilistic applications using an empirical equation of lattice constant a, which derived from inverse spinel structure depending upon ionic distribution among the A (tetrahedral) and B (octahedral) sites at room temperature:

$$a = \sqrt[3]{(\{(V_{A-O}) + [V_{B-O}] + V_{R-O}\} \times 8\ sublattices\ in\ a\ spinel\ unitcell)} -$$

Where,

V_a = Volume of tetrahedral sub-lattice

V_b = Volume of octahedral sub-lattice

V_r = Volume of remaining oxygen ions

u = Oxygen ion parameter, arising from displacement of oxygen along the direction perpendicular to the diagonal of the cube, and for ideal structure it is equal to 3/8 (=0.375). rA, rB, and rO are the ionic radius of A cation, B cation and oxygen ion respectively, the values of constituent cations and oxygen anion obtained from the literature. (Khan, 2016)

VII. COUNCLUSION

- There are some limitations due to technical difficulties encountered during the processing (mixing) of ferrites in polymer resins and some inherent disadvantages associated with limiting percentage of ferrites beyond a certain threshold of mixing. This challenge has been overcome efficiently in recent years by application of various mixing techniques employing different technologies.
- Three materials namely, barium, cobalt, and strontium ferrite were tested and examined for their suitability and application in polymer resins for developing magnetic properties for aerospace structures.
- The specific properties can be tailored in the Nano composites by mixing different proportions of polymer and ferried particles.

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