ABSRACT

Title- **Development, characterization and applicational studies of ferrite containing nanoconducting polymers**

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Abstract

Synthesis of uniform nanoparticles (<100 nm) of magnetic materials have attracted much attention in past few decades because of their unique magnetic properties and immense potential for application in high density recording media, biotechnology, ferrofluids, and pigments in corrosion protection organic coating materials. Each application requires a specific size and surface chemistry in addition to stability. Hence, controlling the particle size as well as size distribution and preventing particle aggregation are the key issues in this field. Coating the magnetic materials with polymers to control particle size is one of the current methods adopted in recent years. The surface conductivity of Fe_3O_4 particles has been fund to improve by many orders of magnitude when coated with polyaniline (PANI). The PANI coated Fe_3O_4 nanoparticles holds significant applicational scope because the conducting polymer coating enhances the electrical and mechanical properties of the composite material besides retaining the magnetic properties.PANI is one of the most important conducting polymers because of its relatively low cost, successful combination of chemical and physical properties, having numerous applications in antistatic additives, electromagnetic screens, anticorrosion coatings, and organic light emitting diodes, electromechanical actuators, electrochromic mirrors, and etc. The protection of metals from corrosion by PANI is one of the current applicational areas of research. PANI provides passivity to the surface of the metal by formation of the metal oxide layer. The effectiveness of PANI is much higher in comparison with zinc traditionally used for corrosion inhibition purposes (the mechanism of Zinc action is different). The most important criteria for selection of these materials is the stability in ambient atmosphere, price, density, deposition and nanotechnology.

The overall objective of the research was to prepare iron oxide nanoparticles with a simple process that is preferably cost-effective in order to produce nanoparticles exhibiting controlled growth. As nanoparticles have a strongly tendency to agglomerate together, PANI was used encapsulate and to stabilize the surface of the nanoparticles. The nanocomposites were fabricated using Fe_3O_4/PANI as fillers in the matrices of renewable resource based polymers (alkyd, polyurethane) using different volume fractions. It has been divided into six chapters:

Chapter 1- Introduction & Literature Review

This chapter discusses about the nanotechnology, magnetic nanoparticles, conducting polymers and the synthesis strategies of nanoparticles, processibility of conducting polymers, their properties as well as the general applications of nanoparticles and nanoconducting polymers. The significance of ferrite based nanopolymeric composites

and their applications in the field of corrosion protection and electrochromic devices have also been highlighted.

Chapter 2- Synthesis & Characterization Techniques

In this chapter the principle and application of various techniques used for the synthesis of nanoparticles, and nanoconducting polymer are discussed. The characterization techniques namely: FT-IR, UV-visible, XRD, TEM, SEM and VSM the 2 and 4 probe methods of conductivity have been described. The standard ASTM methods adopted for the determination of physico-chemical (refractive index, specific gravity etc), physico-mechanical (scratch hardness, impact resistance, bend) and corrosion (chemical resistance) tests of the coatings are also mentioned.

Chapter 3 -Synthesis & Characterization Of Magnetic Nanoparticles

The chapter 3 discusses the preparation of virgin ferrite nanoparticles using a modified co-precipitation method. The problem of aggregation can perhaps be solved by modifying the synthetic routes to synthesize the Fe_3O_4 nanoparticles with good superparamagnetism and least aggregation. The nanoparticles were characterized using FT-IR, XRD, SEM and VSM, Impedance as well as Cyclic Voltametric (CV) studies. The results of these studies suggest that the modified co-precipitation method can be used for the controlled synthesis of Fe_3O_4 nanoparticles that may find potential applications in the field of biosensor and corrosion protective coatings.

Chapter 4-preparation, spectral, electrical & magnetic characterization of polyaniline (pani) encapsulated fe_3o_4 nanoferrite.

This chapter highlights the encapsulation of ferrites nanoparticles with PANI to introduce the functionality on the surface of nanoparticles and nanocomposites. The investigation of the PANI/ferrite nanocomposites was carried out for spectral (FT-IR, UV-Visible, X-Ray), morphological (SEM, TEM) and magnetic properties (VSM).A simple chemical method was adopted for the synthesis of ‘‘agglomerate free’’ Fe_3O_4/PANI nanocomposite where the nanoparticles were entrapped in the growing PANI chains. The structural characterizations of the Fe_3O_4/PANI nanocomposites revealed that the encapsulation of ferrite particles by PANI resulted in significant amount of doping, which enhanced the electrical conducting properties of Fe_3O_4/PANI nanocomposites, while the inherent magnetic behavior of ferrites is responsible for the magnetic properties.

Chapter 5- Development of nanostructured PANI/alkyd & PANI-ferrite/ alkyd dispersed sustainable resource based corrosion protective composite coatings.

This chapter 5 presents the synthesis and characterization of nanostructured PANI and PANI-ferrite based composite resins using soy oil alkyd - a renewable resource. A critical obstacle in assembling and maintaining a nanoscale material is usually its tendency to agglomerate, which is a deterrent to its applications. The utilization of PANI/ferrite nanocomposites may serve as a suitable alternative to the problem of dispersion and agglomerate formation as the coating is expected to provide a binder matrix for the particles, to prevent grain growth, agglomeration, thereby yielding uniform overall size distribution. The coatings of composite resin were investigated for their physicochemical, mechanical and corrosion protective performances as well as electrochemical corrosion measurements by open circuit tests. The PANI/ferrite dispersed coatings system provided corrosion protection comparable to the existing commercial formulations.

CHAPTER 6 - Development of nanostructured PANI dispersed sustainable resource based corrosion protective polyurethane composite coatings

This chapter discusses the synthesis and characterization of methyl orange(MO) -doped nano PANI and the formulation of PANI and castor oil based polyurethane (COPU) nanocomposites using different loadings of the former. The corrosion protective performance of PANI/COPU nanocomposites were measured by open circuit potential, corrosion protective efficiency tests as well as physicochemical and mechanical characteristics of coating materials. The effect of the PANI loading on the coating properties has also been explored. The virgin castor oil polyurethane and pristine MO-PANI coatings exhibited poor physicomechanical as well as corrosion resistance properties. The dispersion of small amount (0.5-2wt %) of MO-PANI remarkably enhanced the scratch hardness, impact resistance performance. These composite coatings were found to act as “corrosion indicators” by changing color upon exposure to different corrosive media, which reflected their “smart sensing nature”. These coatings were found to exhibit promising corrosion resistance performance.

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