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A study on Synthesis and Characterization of Magnesium Iron Nitrate Mixed Nano Composites

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Abstract

Cobalt substituted nickel ferrites, Ni1-XCoXFe$_2$O$_4$, have been synthesized by using oxalic de-hydride as a fuel. Nano composites (ferrite particles) can be synthesized by using solution combustion method. As the combustion process involves exothermic reaction and a large amount of heat is released, the ferrites can be synthesized at lower temperature. X-ray diffraction studies reveal the formation of single phase spinel structure. Magnetic studies show variation of coercively and saturation magnetization with cobalt substitution and show higher coercively and saturation magnetization than pure nickel ferrites. From the Mossbauer recording, presence of two well resolved Zeeman sextets, which is due to Fe^{3+} ions distribution in tetrahedral and octahedral sites, ferri magnetic nature of ferrite materials is revealed.

Keywords: *Ferrites, Magnetic, synthesize, saturation, magnetization, chemical composition*

Introduction

For the first calculated amount of salts of Mn, Fe and Ni were dissolved in deionized water and stirred for a few minutes. 0.1 M NH_4OH solution was then slowly added drop-wise under vigorous stirring. The alkali addition was continued till the pH of the solution was 10 and was left undisturbed for 1hour for complete digestion. The precipitate was then washed thoroughly till pH 7 and then heated to 600 ^{0}C. For the next series "x" was kept fixed at 0.5 and the same synthesis steps were repeated. The sample was divided into three batches and heat treatment was performed at 600 ^{0}C, 900 ^{0}C. The samples were checked for their phase purity by x ray diffraction which confirmed the spinel phase without any impurity.

Dielectric measurements were performed within a frequency window of 1 Hz to 1 MHz the dielectric dispersion can be well explained by Koops and Maxwell – Wagner theory. Raman spectroscopy also gave detailed information about the structural order of the samples.The advance made in physics of solids has led too much of the recent progress in science and technology. Physics of condensed matter draw attention to chemical

composition, atomic configuration, electrical, crystal structure, magnetic ordering and saturation magnetization and the special preference of metallic ions for interstitial sites in the spinel lattice etc. of the solids. It also helps to co-relate the physical and chemical properties of solids and their use in technological applications.

In the recent years, solid state physics mainly concentrates on crystal structure, chemical and physical properties of solids. A proper understanding of the nature and properties of solids form the basis for developing new tailor made nano composites with the desired properties that can be used in many electrical and electronic devices.

Ferrites are in general ferromagnetic ceramic materials consisting of ferric oxide in major portion and metal oxides. On the basis of their crystal structure they can be grouped in to three categories namely, spinel ferrite, cubic garnet and hexagonal ferrites. The molecular formula of ferrites is $M^{2+}O.Fe^{3+}2O_3$, where M stands for the divalent metal such as Fe, Mn, Co, Ni, Cu, Mg, Zn or Cd. There are 8 molecules per unit cell in a spinel structure.Spinel Ferritesare also called cubic ferrite. Spinel is the most widely used family of ferrite. High values of electrical resistivity and low eddy current losses make them ideal for their use at microwave frequencies. The spinel structure of ferrite as possessed by mineral spinel $MgAl_2O_4$ was first determined by Bragg and Nishikawa in 1915.

Electrical properties of prepared samples were studied by dielectric studies and porosity of the samples derived from x-ray densities which utilizes structural parameters obtained through XRD measurement.

Synthesis and Characterization of doped Nano Composites

Cobalt ferrites nano composites are prepared by burning cobalt oxalate with iron oxalate using poly (vinyl alcohol) as a fuel for the combustion reaction in 1: 5 ratio. The burning process takes place in a separate container to the particular temperature which results into the possible formation of partial metal oxides *i.e.*(Co-O and Fe_2O_3). These oxides are mixed properly with PVA, grinded and burned again in a separate container at ratio 1: 1: 5, respectively. This process starts with formation of froth, evolution fumes and burns with flame; finally it was completed at particular temperature. The product cobalt ferrite obtained after the complete combustion process and is grinded in the pestle and motor for half an hour. It is washed with acetone and concentrated action to get rid of carbon particles in the final product.

Cobalt ferrite nano composites are doped with the silver metal nanoparticles using the combustion method. The process starts with burning of cobalt ferrite with silver metal nanoparticles, and PVA keeping the molar ratio as 2: 1: 5, respectively. Initially, it burns

with sooty flame followed by reduced non sooty flame for complete reaction. This reaction was arrested at a particular temperature around 500^0C to form the phase formed Ag doped cobalt ferrite nanoparticles. Later it is washed with acetone and concentrated action to remove the carbon particles and other organic impurity.

Nano composites are corner stones of nano-science and nanotechnology which are broad and interdisciplinary area of research and developmental activity that has been growing explosively worldwide in the past few years. Nanotechnology is based on the science that deals with tweaking of the matter at the atomic and molecular scale and the size range between 1- 100 nm [1].

Recently researchers are attracted much towards nano composites due its enhanced properties and applications [2]. The latest physical properties and advancement in sample preparation of the materials at nanosize accounts the progress of nanoscience [3-4]. The man in his quest for knowledge has been conceiving and developing physical world and its components in bigger than the biggest and smaller than the smallest dimensions of mass, length and time [5]. Sometimes the changes in particles size are in such extent that the completely new transpiration is digging up which helps in flowering of the world [6-7]. However the title is known about how the biological activity takes place for certain materials when it is reduced into nanoscale dimensions. In this world of elaboration nanotechnology, one of the main primary concerns should be the potential environment impact of nanoparticles (Nps).

A proper way of estimating the nanotoxicity is to monitor the response of the bacteria against these nanoparticles [8-9].

Discussion

The nanocrystalline mixed spinel nano composites and ferrites materials used in various technological issues like nano ferrite doped microstrip patch antenna for improved the overall antenna performance, microwave dielectric property study and antenna miniaturization. Application of nano ferrites are in fashion these days because of its simple preparation, compatibility with electrical circuits, low overall cost and light weight these have numerous application in almost every field some of them like medical, electric, power, communication, mechanical etc.

Doping rare earth ions into spineltypes ferrites, the occurrence of 4f-3d couplings which determine the magneto-crystalline anisotropy in spinel ferrite can also improve the electric and magnetic properties of spinel ferrites. The rare earth ions commonly reside at the octahedral sites by replacing Fe3+ ions and have limited solubility in the spinel ferrite

lattice due to their large ionic radii.There is absence of relaxation in Mn rich concentration due to the unavailability of hopping charges, for manganese nickel ferrite conductivity and resistivity can be explain on the basis of hopping of electron and hole charges on the octahedral site.

On relative intensity and peak position can be explained considering alloy effects, resulting from the introduction of a new ion at increasing content. Further, the Raman frequency depends on the Fe(Ni)–O and bond length. The intensity of the highest wavelength Raman mode (initially around 693 cm^{-1}) decreases with increasing Mncontent the intensity of the Raman mode peaking around 617 cm- 1 increase proportionally.

The Raman intensity of the signal increases as the sintering temperature is increased, as shown in figure (h) the intensity of Raman mode 617 cm^{-1} increases at 900C and mode 693 cm^{-1} is disappeared at 900C

The shift toward lower wave number is attributed to the crystalline disorder and also to the presence of grain boundaries, which are large in small-sized nano composites. Bandwidth, shows broadening for the small-sized nano composites (∼20 nm), which also supports the crystalline disorder. Raman shift toward lower wave number and the line broadeningare generally observed in polycrystalline materials and are attributed to the confinement of optical phonons in a small crystalline particle**.**

Nanocrystalline manganese Nickel ferrite particles for x=0 to x=0.5 and europium and terbium doped Nickel ferrite for x= 0.02, 0.05, 0.1 were prepared using wet chemical co-precipitation technique.Particles were found to be exhibiting a spinel structure with sizes varying from 21nm - 51nm. Overall result of xrd pattern confirms the spinel cubic structure with high high degree of crystallinity of prepared ferrites. Of the two types of liners viz. soil and synthetic liners commonly used in waste disposal facilities, soil liners seems to be indicative of the extensive use of clay soils as pollution barriers.

Result of Raman modes confirms the five Raman modes and distribution of cation distribution in octahedral and tetrahedral sub lattices in agreement with the as-synthesized samples. The mechanism of dielectric polarization was found to be similar to that of conduction process involving the hopping of charge carriers. The decrease in ε with Mn substitution point to the decrease in availability of Ni2+/Ni3+ and Fe2+/ Fe3+ pairs with increasing Mn. The tanƋ and exhibit strong relaxation peaks and relaxation time (Γ) was estimated from these relaxations.

Applications

Applications being developed for nano composites include adding antibodies to nanotubes to form bacteria sensors, making a composite with nanotubes for aircraft, adding boron or gold to nanotubes to trap oil spills, include smaller transistors, coating nanotubes with silicon to make anodes the can increase the capacity of Li-ion batteries by up to 10 times. In addition to this, applications being developed for nano composites include a nanotube-polymer nano composite to form a scaffold which speeds up replacement of broken bones etc. Transition metal ferrites, both doped and undoped, are magnetic candidates in a huge range of applications considering catalysis, sustainable hydrogen production application and electronic and magnetic devices, with others.

Cobalt ferrite material have attracted a great interest in fundamental and applied research due to their various properties like mechanical, hardness, thermal stability and anisotropy constant. All these characteristics encourage their use in wide range of applications from medicine to electronics. Relating to all these possible applications, different research groups performed various studies on the influence rare earth cations on the properties of $CoFe_2O_4$ in bulk form thin films and nanoparticles [11]. Cobalt ferrite as a magneto-strictive material has recently become of interest to many researchers due to its promising magneto-strictive properties. It has been proposed to be a suitable magneto-strictive material for some applications in the area of sensors and actuators. In such applications, speed of response with accurate displacements is important. Although cobalt ferrite has shown a small magneto-strictive coefficient, which is a disadvantage, it has also shown a very small hysteresis characteristic. It follows that, the results of using this material should lead to a smaller amount of energy loss and higher displacement accuracy at high frequencies, and these benefits may compensate this disadvantage.

Conclusion

Presented data to show that the water content – dry density criterion for compacted soil liners can be formulated in a manner that is different from the currently used approach in which the adequate strength and permissible compressibility is ensured. The approach recommended by them is based on defining water content – dry density requirements for a broad, but representative, range of capacitive energy and relating those requirements to hydraulic conductivity.

Grouting is very popular but at one time, it was supposed to be very mysterious task in civil engineering. For the grouting to be more effective, needs a lot of skill, understanding and perception.

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