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Synthesis And Characterization Of Magnesium Nano Ferrite

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Abstract:

In this study, the focus is on Synthesizing and Characterizing Magnesium Nano Ferrite using the sol gel method. , as a result of this

I have pure, homogeneous stoichiometric compound. And this is very suitable for our laboratory Conditions compared to other synthesis methods such as co-precipitation method, auto Combustion method, laser ablation method, chemical vapor deposition method. As I am synthesizing the Metallic nano ferrite, these are the compounds having stability, Mechanical hardness, high coercivity, moderate saturation, and super paramagnetic behavior,Availability of information on relatively cheaper synthesis techniques, improved magnetic and Electrical properties, biocompatibility and higher surface to volume ratio at nano level. In this present work I am using Magnesium nitrate, Ferric nitrate, Citric acid Which acts as a fuel and Ammonium hydroxide to maintain pH level 7. By mixing all these solutions in right Proportion I get sol on heating. The sol is stirred at 80°C to achieve the dried gel. Thereafter, the dried gel was self-ignited through sol-gel method to reduce the metal iron and to attain the residual precursor. Finally, the residue under calcinations temperature of 450°C for 3 hours will give magnesium nano ferrite. After synthesizing Magnesium nano ferrite I characterize the compound by Fourier Transform Infra-Red Spectroscopy (FTIR). The obtained spectrum shows the absorption peaks for metal oxides. FT-IR spectra confirmed that the presence of metal oxides absorption bands at lower frequency region 436 cm-1 and higher frequency region 559 cm"' due to tetrahedral and octahedral sites. This confirms normal spinel structure of Magnesium nano ferrite. The results of this study are useful for further applications, such as semiconductors, heterogeneous and photo catalysts, magnetic materials and sensors, bio-medical and electronic applications.

Introduction:

Nanotechnology refers to the branch of science and engineering devoted to designing, producing, and using structures, devices, and systems by manipulating atoms and molecules at nanoscale, i.e. having one or more dimensions of the order of 100 nanometres (100 millionth of a millimetre) or less.

As the size of the material decreases, the surface area to volume ratio increases, leading dramatic changes in properties can occur. At this scale, quantum effects become more prominent, leading to unique and unexpected behaviors. For example, materials may exhibit enhanced mechanical, optical, electrical, or magnetic properties compared to their bulk counterparts. These changes can be harnessed for various applications, such as in nanoelectronics, sensors, catalysis, and drug delivery.

Ferrite nanoparticles are a large group of magnetic particles. A ferrite is a type of ceramic compound composed of iron oxide mostly combined chemically with one or two metallic elements. They are electrically nonconductive, meaning that they are insulators, and ferrimagnetic, meaning they can easily be magnetized or attracted to a magnet.Spinel ferrites are a class of magnetic materials that have significant attention in recent years due to their unique properties and wide range of applications. These ferrites have a face centered cubic structure and are characterized by the general formula MFe_2O_4, where M represents divalent metal ions such as Mg, Zn, Cu, and Al. Spinel ferrites can exist in three different structural configurations: normal spinel, inverse spinel, and mixed spinel. In the normal spinel structure, all metal ions occupy tetrahedral sites, while all Fe3+ ions occupy octahedral sites. In contrast, the inverse spinel structure is characterized by all metal ions occupying octahedral sites, with Fe^{3+} ions distributed over both tetrahedral and octahedral sites. The mixed spinel structure, on the other hand, is a combination of both normal and inverse spinel structures.

Among the various spinel ferrites, magnesium ferrite ($MgFe_2O_4$) stands out due to its mixed spinel structure, a well-known soft magnetic, n-type semiconductor which imparts unique properties that make it suitable for a wide range of applications. Magnesium ferrite exhibits low saturation magnetization and high resistivity properties, making it ideal for use in sensors, photo catalysts, hypothermia treatment, and biomedical applications.

$MgFe_2O_4$ is usually synthesized by sol-gel auto combustion method , thermal treatment , coprecipitation method , hydrothermal synthesis , high energy ball milling and spray pyrolysis.Among these methods sol-gel method is widely used for the synthesis of nanoparticles of ferrite. This method has the advantages of simple preparation, cost-effective and gentle chemistry route resulting in fine and
homogeneous powder.
In the present investigation, $MgFe_2O_4$nanoparticles are synthesized by sol-gel method and characterize the obtained compound by Fourier Transform Infra-Red Spectroscopy (FTIR).

Materials and method:

Materials:

Magnesium Nitrate [$Mg(NO_3)_2.6H_2O$],Ferric Nitrate [$Fe(NO_3)_3.9H_2O$], Citric Acid[$C_6H_8O_7.H_2O$]
Ammonium Hydroxid [NH_4OH]. Double distilled water is used throughout the synthesis & citric acid is used as reducing agent.All chemicals in this work, were of analytical reagent grade

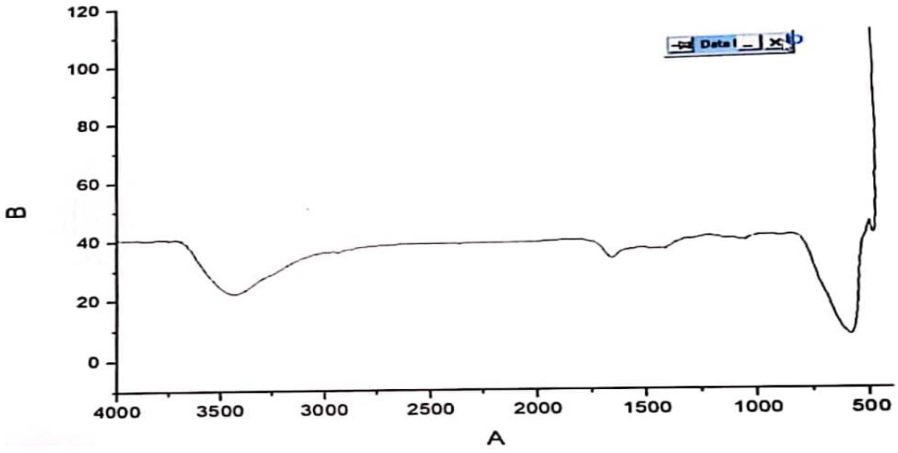
Method:

Take Ferric nitrate, Magnesium nitrate, citric acid separately in the ratio 2:1:4 and prepare one molar concentration of solutions each in 100ml distilled water.Mix Ferric nitrate and Magnesium nitrate aqueous solutions, Keep the mixture on magnetic stirrer (without heat) to make homogenous solution.
Add aqueous solution of citric acid to above solution, Keep the mixture on magnetic stirrer (without heat) to make homogenous solution. Check the initial pH of above solution (~1), To maintain the neutral pH value 7 add ammonium hydroxide drop wise.When pH reaches 7 heat the solution at 80°C for 3 hours. Sol is formed. On further heating Gel is formed.After Gel is formed heat that at 100°C for 1 hour.
Calcinate the residue at different temperatures for 3 hours.Crush the obtained compound using mortar and pestle. Characterization of obtained compound using different characterization techniques namely, X-Ray Diffraction (XRD), UV-visible Spectroscopy, Infra-Red Spectroscopy, Scanning Electron Microscopy (SEM), Fourier Transform Infra-Red Spectroscopy (FTIR).

The formation of $MgFe_2O_4$ structure in the synthesized samples are further supported by FTIR spectrum in this work

Results and discussion:

The structural characterization of the prepared Mg ferrite nanoparticles was carried out using Fourier Transform Infrared Spectroscopy.The spectrum of magnesium nano ferrite shows transmittance (%)-B verses wave number (cm^{-1})-A spectrum.The spectrum include four absorption peaks, Fig



First absorption peak at 3433 cm^{-1} that is broad with medium intensity, this corresponds to presence of O-H stretch, H-bonded this shows functional group of alcohols, phenols may be present.

Second absorption peak at 1625 Cm^{-1} that is broad with weak intensity, this corresponds to presence of C=C alkenyl stretch.

Third absorption peak at 559 Cm^{-1} that is broad with strong intensity, corresponds to intrinsic stretching vibration of metal oxygen at tetrahedral site. This is the absorption band for [Fe-0] were observed between 550-570 Cm^{-1}. Higher frequency band confirms spinel structure of ferrite.

The fourth absorption peak at 436 Cm^{-1} that is sharp with weak intensity, corresponds to intrinsic stretching vibration of metal oxygen at octahedral site. This is the absorption band for [Mg-0]. (lower frequency band).

Conclusion

In this work, Magnesium nano ferrites were prepared by Sol-Gel method. This provides an interesting synthesis technique with the advantages like low cost and simple preparation. Sol-Gel method is the easiest method that can be performed at various annealing temperatures. The obtained compound is characterized by Fourier Transform Infra-Red Spectroscopy (FTIR). The FTIR spectroscopy describes structural investigations, redistribution of cations between octahedral and tetrahedral sites of spinel ferrite nanoparticles and also the lattice vibrational modes. This confirms the nano crystalline normal spinel structure of magnesium nano ferrite.

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