Research Paper

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SYNTHESIS AND CHARACTERIZATION STUDY MANGANESE FERRITE - USING CHEMICAL PRECIPITATIVE METHOD

[1] Karunagaran KP [2]Anandhi Sarangapani

Department of physics
Faculty of Arts & Science
Bharath Institute of Higher Education and Research
Chennai India -600 073

[1]shreekaranshailaja@gmail.com [2]Ananthi.Physics@bharathuniv.ac.in

Address for Correspondence

[1] Karunagaran KP [2]Anandhi Sarangapani

Department of physics
Faculty of Arts & Science
Bharath Institute of Higher Education and Research
Chennai India -600 073

[1]shreekaranshailaja@gmail.com [2]Ananthi.Physics@bharathuniv.ac.in

Abstract

Chemical co-precipitation and hydrothermal techniques are used to make magnetic manganese ferrite powder from chemical compounds in the chlorides of manganese and iron and Sodium hydroxide (NaOH) is used as precipitant agent. The calcinations were done at a temperature of 700°C for 6 hours. Through X-ray diffractometer (XRD) and a scanning electron microscope (SEM) with Energy Dispersive X-ray Spectroscopy (EDXS), the structure of a sample that had been prepared for the study was found (EDAX). The chemical bonds in spinel ferrites were found and confirmed with the help of IR absorption spectra.

Key words: Ferrite, co-precipitation, hydrothermal method, X-ray diffractometer (XRD), scanning electron microscopy (SEM), spinel ferrite.

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INTRODUCTION

One of the most important things in the electronics industry is ferrites. In general, they can be put into two groups: soft and hard ferrites. When it comes to soft ferrite materials, the coercive force is small, and the saturation magnetization is filled with a relatively small magnetic field. On the other hand, hard ferrites have a high coercive force, a high residual flux density, and they keep their magnetism even when they are not magnetized. Nano Materials are very important in the science and technology of today. Materials can be put into six main groups: those that are dielectric, magnetic, ceramic, glass, polymer, or semiconducting. There are many uses for magnetic materials, such as in memory devices, transformers, microwave devices, drug delivery, hyperthermia, and other things.

MAGNETIC MATERIALS

Depending on their magnetic susceptibility, all materials can be put into one of five types: diamagnetic, paramagnetic, ferromagnetic, antiferromagnetic, or ferrimagnetic. The magnetic susceptibility is the ratio of the magnetic dipole moment per unit volume to the magnetic field which is connected to the material. Based on their magnetic dipole moments, magnetic materials can be put into two main categories. because of the way magnets work, ferrite nanoparticles tend to stick together, which could hurt their performance in some situations. One idea for a solution is to disperse the nanoparticles in a nonmagnetic material [4–14].The magnetic properties of nanoparticles are influenced by a variety of factors, including their size, shape, chemical composition, crystal structure, and interactions with other particles.Magnetic compounds can be found in the environment, plants, animals, and even the human brain.Saturation magnetization, coercive force, and Curie temperature are examples of intrinsic magnetic qualities found in bulk/giant magnetic materials that are solely dependent on their chemical and crystallographic structure.These characteristics in nanoparticles, however, are influenced by their size and surface.Since nanoparticles have evolved over time, it is now possible to examine magnetic characteristics at all scales, from the large to the atomic.Thus, these magnetic nanoparticles occasionally display unique features such as super-paramagnetism, strong magnetic coercivity, and quantum tunnelling.

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EXPERIMENTAL METHODS

CHARACTERIZATION METHODS

For proper understanding of nanostructure materials have to characterize by physio-chemical techniques. X-ray diffraction (XRD) is used to determine the crystal structural purity of prepared samples. The surface morphology and crystalline structure of the samples are analyzed by High Resolution scanning Electron Microscopy (HRSEM). Magnetic properties of the samples are investigated by vibrating sample magnetometer (VSM).

Materials

Ferric chloride (99.999%), Manganese chloride (99 %) and sodium hydroxide (98%, GR Proanalysis), H_2O_2 (30% GR Proanalysis) were purchased from MERCK and used as received without further purification. Millipore water (H_2O) was used as solvent during experiments.

Methods

Preparation of Manganese ferrites (MnFe2O4) nanoparticles using a chemical co-precipitation method. The starting materials (analytical grade MnCl2-4H2O and FeCl3) and the co-precipitating agent (NaOH) were used. The MnCl2-4H2O and FeCl3 salts were dissolved in distilled water at the correct molar ratio of 2:2 and mixed well. Then, drop by drop, 8M of NaOH solution was added to the solutions of the above salts while the magnetic stirrer kept going (SP250, Lab Depot, Dawsonville, GA, USA). Extra NaOH (6M) was added to keep the pH at the desired range of 9–13, which controls the amount of precipitation and the size of the particles that form. Centrifugation (2–16 P, Sigma, Harz, Germany) at 13,000 rpm for 20 minutes was used to wash the precipitates ten times. The manganese ferrite test proved that there was no NaOH in the sample. The product was then dried in an oven at 80C for 3 days (76 hours) to get the perfect ferritization. To get the as-dried MnFe2O4 nanoparticles, the as-dried powder was ground with a mortar and pestle made of agate. The nanoparticles of MnFe2O4 were made to stick together by the following reaction:

MnCl2-4H2O + 2FeCl3 + 8NaOH ---- MnFe2O4 + 8NaCl + 8H2O

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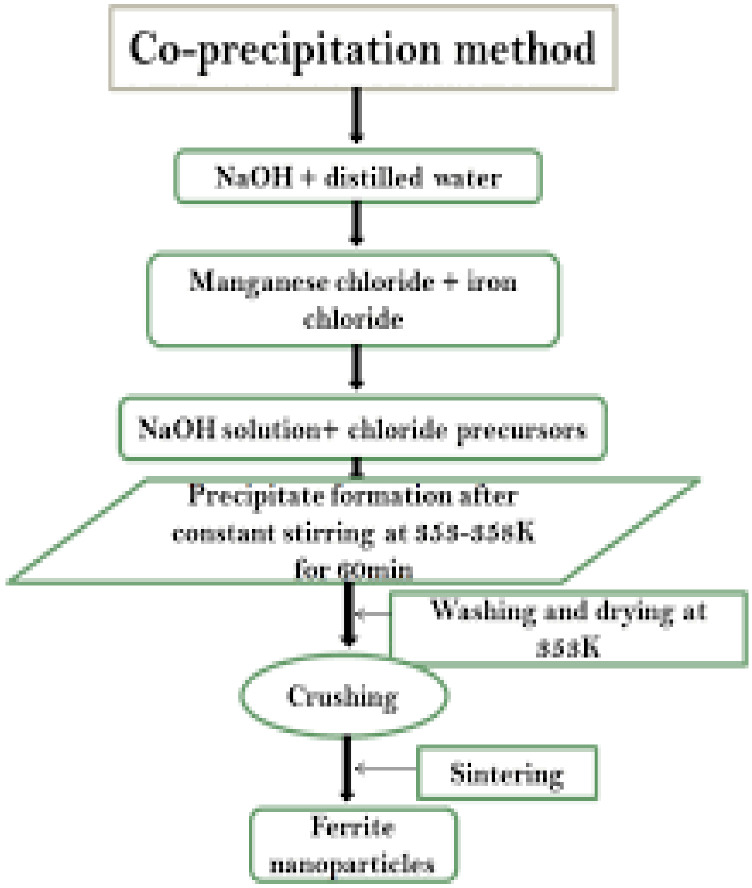

3.1-Flow chart for the preparation of Manganese ferrite

Results and Discussion:

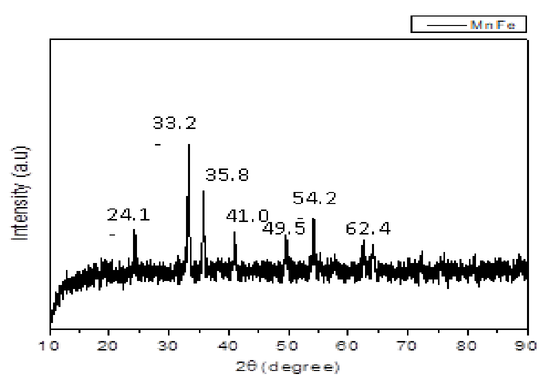

Fig 1 XRD- pattern of manganese ferrite nanoparticles

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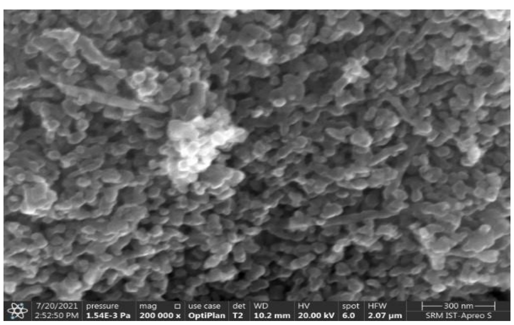
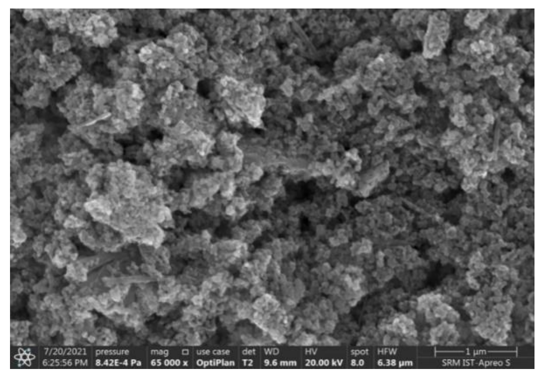
XRD- of manganese ferrite nanoparticles

The Fig.3.1, the XRD pattern is utilized to identify the phase and purity of the produced $MnFe_2O_4$ nanoparticles. The sharp diffraction peaks in the locations are acquired using an XRD diffract meter at the values of 24.18°, 33°.22, 35.11°, 41.0°,49.5°, 54.26° and 62.44°, which correspond to the crystal reflections(220)(222) (311), (400), (422), (511), and (440), respectively. In view of the distinctive diffraction peaks are properly indexed to and agree with a FCC –centered cubic phase of $MnFe_2O_4$ in spinal manganese ferrite (JCPDS card no. 38-0430). (Li-Xia Yang etc.:2013)

HR-SEM and EDAX study



MnFe



a) b)

Fig 2HR –SEM of Manganese ferrite

The morphological studies are done through HR-SEM. Fig 3.1a and 3.1b, in the image of samples show the diameter of most of the sphere which are in the range of 300nm. It is seen that sample consists of nanoparticles agglomerated together to form large grains. Then the surface roughness demonstrates the formation of a ferrite sphere via the construction of nanoparticles.

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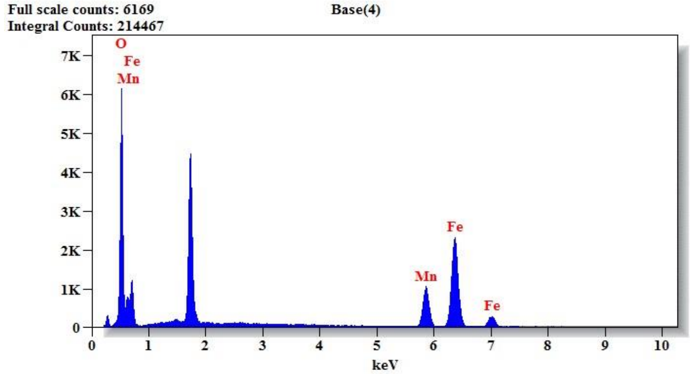

Element	Net Counts	Int. Cps/nA	Weight %	Atom %	Formula
O	29233	---	31.37	61.37	O
Mn	14324	---	17.93	10.21	Mn
Mn	13278	---	---	---	(null)
Fe	38127	---	50.70	28.41	Fe
Fe	8653	---	---	---	(null)
Total			100.00	100.00	

Fig 3. EDAX Spectrum of Mangnese ferrite

The above Figure shows EDAX spectrum of the manganese ferrite sample were obtained. The result shows that the manganese ferrite nanospheres as they were made had Fe, O, and Mn, and there was no sign of contamination. The ratio of Fe to Mn atoms is about 3:3, which means that the chemical formula of the Mn ferrite as it is made is not stoichiometric (Zhang, Zhang, Ni,J., and Zheng 2006).

CONCLUSION

The paper talked in detail about how simple chemical precipitation can be used to make manganese ferrite nanoparticles. The method is simple, cheap, and makes it easy to control the size of the particles. X-ray diffraction shows that MnFe2o4 nanoparticles are being made (XRD). The XRD pattern showed that the Manganese ferrite nanoparticles had a spinal cubic structure. High Resolution Scanning Electron Microscopy was used to figure out the shape and size of the product's particles (HR-SEM).

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