

## CHARACTERIZATION ANALYSIS OF MANGANESE FERRITE NANO MATERIAL - USING CHEMICAL ROUTE

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### Abstract

Magnetic manganese ferrite powder is synthesized via chemical co-precipitation and hydrothermal techniques are using chemical compound in metallic chlorides of manganese and iron. As a precipitant agent namely sodium hydroxide (NAOH) are used. The performed calcinations temperature at 700°C for 6 hours. The investigation of the structural compound are prepared sample was identified through X-ray diffractometer (XRD) and The FT-IR absorption spectra analyses were used for the detection and confirmation of the chemical bonds in spinel ferrites nanoparticles. The investigation of magnetic property of manganese ferrite nanoparticles reveals that the saturation magnetization is high, hysteresis in the region of measured field strength.

**Key words:** Ferrite, co-precipitation, hydrothermal method, X-ray diffractometer (XRD), FT-IR spinel ferrite, VSM

### INTRODUCTION

Ferrites are one of the most essential materials in the electronic industry. It is generally possible to classify them into soft and hard ferrites. In the case of soft ferrite materials, the coercive

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force is small, and saturation magnetization is filled with a comparatively small magnetic field. On the other hand, hard ferrites have high coercive force and residual flux density, and maintain the spontaneous magnetization. In other words, soft ferrites are attracted to permanent magnets, and hard ferrites are permanent magnets. Soft ferrite materials are produced for transformers and inductors at higher frequencies. Hard ferrite materials have been used extensively for acoustic devices and motor magnets.

Nanoscience is the study of fundamental phenomena of structures of molecules having their dimensions in the range of 10 nm to 100 nm (also termed as nanoscale). Nanoscience is an interdisciplinary field where the expertness of researchers from physics, materials science, chemistry, biology and engineering is required to develop nanomaterials and hence nanodevices. Further, many physical phenomenon become more noticeable as the size of system approaches to nanoscale. In this chapter, the magnetic materials have been described with a focus on ferrites and their classification. Recent literature survey has also been included for the spinel ferrites. Finally, the motivation behind this work has been described.

Once the range of a crystal is decreased to the nanometer size, the electronic formation is altered from continuous bands to discrete or quantized electronic levels. Consequently, the continuous optical transitions in the molecule become quantized and therefore their properties become size controlled.<sup>11</sup> This in turn leads to changes in chemical features such as electronic, structural, spectroscopic, magnetic and thermodynamic.<sup>10</sup> The size of quantum dots determines their properties such as their electronic absorption as well as their melting points. In magnetic materials, size effect has brought about a new phenomenon known as superparamagnetism. In metals, very small sized particles of about 1-2 nm in diameter exhibit unexpected catalytic activity as observed in gold nanoparticles.<sup>10</sup>

All materials can be categorized based on their magnetic behaviour into one of five types (diamagnetic, paramagnetic, ferromagnetic, antiferromagnetic and ferrimagnetic) subject to their magnetic susceptibility. The magnetic susceptibility is the proportion of magnetic dipole moment per unit volume to the connected magnetic field. Nanometric manganese ferrite is a much-studied material for industrial and medical applications, such as microwave absorption, catalysis, magnetohyperthermia and drug delivery [1–4], due to its high saturation magnetization and good chemical stability [5]. However, due to magnetic attraction, ferrite nanoparticles tend to form

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agglomerates, which may compromise their performance for certain applications. One of the proposed solutions has been to disperse the nanoparticles in nonmagnetic materials [4–14].

Magnetism is as a result of magnetic moments associated with individual electrons. Magnetic moments originate from two main sources: orbital motion and electron spin. The net magnetic moment is the sum of these moments from all electrons.

The magnetic property of a material depends on the response of electron and magnetic dipoles to an applied magnetic field and these are classified into diamagnetic, paramagnetic, antiferromagnetic, ferrimagnetic and ferromagnetic materials. Diamagnetism is a very weak form of magnetism and only persists when an external field is applied. The induced magnetic moment is as a result of change in the orbital motion of electrons which creates an opposite field to that of the applied magnetic field.

## 2. Experimental

### Materials

Ferric chloride (99.999%), Manganese chloride (99 %) and sodium hydroxide (98%, GR Proanalysis), H<sub>2</sub>O<sub>2</sub> (30% GR Proanalysis) were purchased from MERCK and used as received without further purification. Millipore water (H<sub>2</sub>O) was used as solvent during experiments.

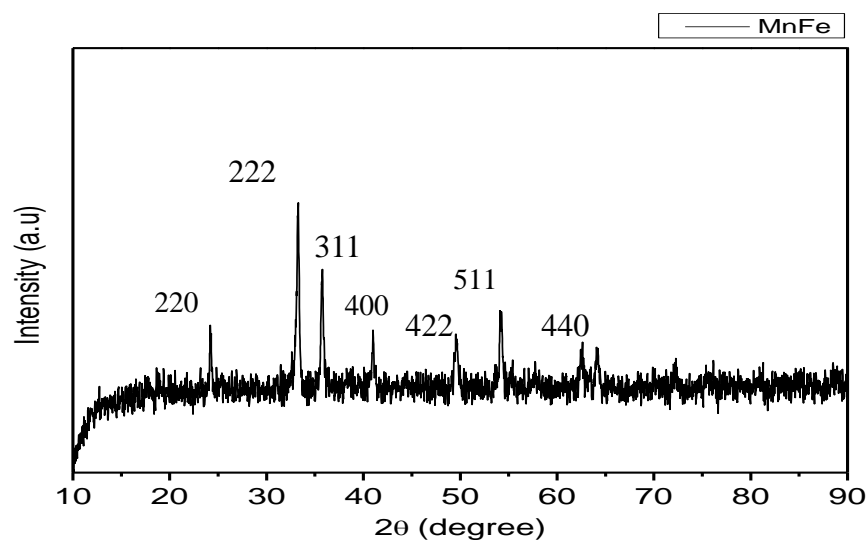
### Methods

Preparation of Manganese ferrites (MnFe<sub>2</sub>O<sub>4</sub>) nanoparticles using a chemical co-precipitation method for which we used the starting materials (MnCl<sub>2</sub>·4H<sub>2</sub>O and FeCl<sub>3</sub>) of analytical grade and NaOH as the co-precipitating agent. The MnCl<sub>2</sub>·4H<sub>2</sub>O and FeCl<sub>3</sub> salts were dissolved in distilled water in the required molar ratio of 2:2 and underwent thorough mixing. Then 8M of NaOH solution were added drop-wise by micropipette into the above salts' solutions under continuous stirring by magnetic stirrer (SP250, Lab Depot, Dawsonville, GA, USA). Extra NaOH (6M) was added to maintain the pH to the desired level of 9–13 that plays a determining role in controlling the precipitation and the precipitated particles' size. The precipitates collected through centrifugation (2–16 P, Sigma, Harz, Germany) at 13,000 rpm for 20 min were washed ten times by centrifugations. The manganese ferrite test confirmed that the sample was free from NaOH. The product was then dried in an oven at 80C for 3 days (76 hours) for perfect ferritization. The as-dried powder was ground with an agate mortar and pestle to obtain the as-dried MnFe<sub>2</sub>O<sub>4</sub> nanoparticles. The precipitates of the MnFe<sub>2</sub>O<sub>4</sub> nanoparticles were obtained according to the following reaction,



### 3 Characterization Techniques

The Powder X-ray diffraction of all the samples were carried out by Bruker D2 PHASER X-Ray Diffractometer using  $\text{CuK}\alpha$  (1.5418 Å) radiation in the  $2\theta$  range of  $10\text{--}80^\circ$ . Raman spectra were recorded using LabRAM HR (Horiba-Jobin) with the excitation wavelength of 514 nm by Argon-ion laser. The crystal structure and morphology of the nanocomposites were examined using high-resolution transmission electron microscopy (HRTEM, JEOL JEM-2010, Japan). X-ray photoelectron spectroscopy (XPS) spectra were recorded using KRATOS analytical equipment with  $\text{AlK}\alpha$  radiation ( $h\nu = 1486.6$  eV). The photoluminescence (PL) spectra were recorded using Perkin-Elmer spectrophotometer with an excitation wavelength of 385 nm. The magnetic behaviors of the samples were analyzed using Lakeshore vibrating sample magnetometer (VSM-7410)



**Fig. 1 XRD- pattern of manganese ferrite nanoparticles**

*Research Paper***XRD- pattern of manganese ferrite nanoparticles**

From the Fig.1, the XRD pattern is utilized to identify the phase and purity of the produced MnFe<sub>2</sub>O<sub>4</sub> nanoparticles. The sharp diffraction peaks in the locations are acquired using an XRD diffract metre 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 the a FCC –centered cubic phase of MnFe<sub>2</sub>O<sub>4</sub> in spinel manganese ferrite (JCPDS card no. 38-0430). (Li-Xia Yang etc.:2013)

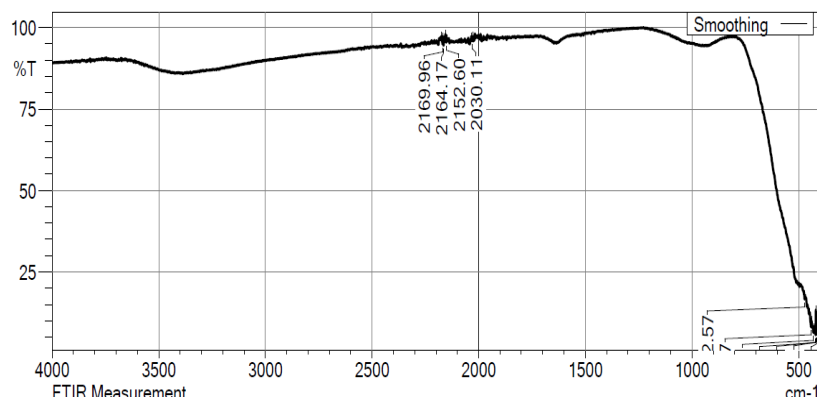
**FT-IR SPECTROSCOPY**

Fig:2 –FTIR

From the fig 2- shows the FT-IR spectra illustrate that absorption bands of Mn–O and Fe–O bonds appeared at 404, 502, and 556 cm<sup>-1</sup>, respectively, for pure spinel manganese ferrite that was calcined at 873 K. (Fig. 3 at 873 K). These bands provide evidence of the formation of the metal ions oxygen in the tetrahedral and octahedral sites in the spinel structure, as suggested by previously published data [13]. The IR bands of solids are usually assigned to the vibration of ions in the crystal lattice. The absence of the peaks in the range of 1000–1300 cm<sup>-1</sup> and 2000–3000 cm<sup>-1</sup> in the calcined

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sample at 700C confirmed that the O–H mode, C–O mode, and CQH stretching-mode of organic sources did not exist [14]. This IR analysis was very useful for establishing the temperature of calcination at 873 K by removing unwanted ions that can pollute the crystal lattice during preparation. At the lower temperature of 873 K, however, there were still traces of broadband absorption peaks at 1497 and 3504 cm<sup>-1</sup> due to traces of adsorbed or atmospheric CO<sub>2</sub> and O–H stretching vibration, respectively (Naseri , Bin Saion and Abbastabar Ahangar 2011).

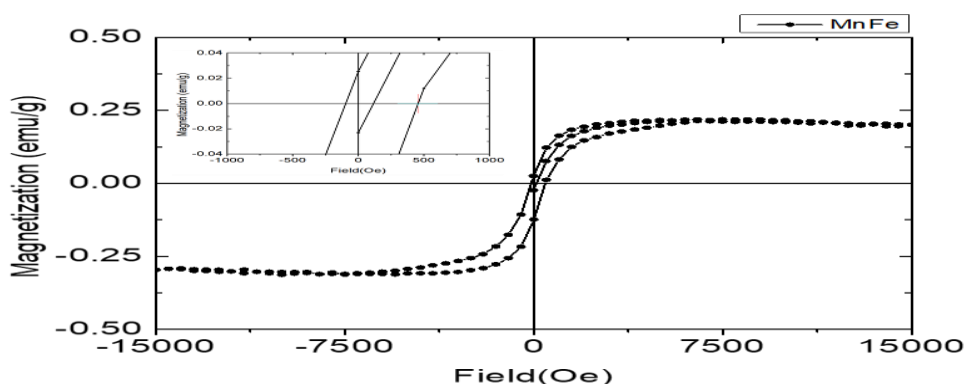
**Vibration sample magnetometer measurements.**

Fig 3

The hysteresis loops, obtained by M(H) measurements, are consequence of magnetic domain aligning their magnetic moments in the presence of a magnetic field. This behavior can be described by three characteristic points of a hysteretic curve: saturation magnetization, remnant magnetization and coercive field. Saturation magnetization occurs when all the sample magnetic domains are aligned in the field direction. Remnant magnetization is the sample remaining magnetization when the magnetic field is removed. Coercive field is the required field to take the sample magnetization to zero. All these points are marked in figure 3.

Figure 3 represents the magnetization curves measured at 300K. As-prepared manganese ferrite nanospheres showed high magnetization performance. The magnetic saturation values reached Ms55 emu/g. As depicted in Figure , it is hard to see an obvious hysteresis loop at the full scale. In the closeup view, the curve presents a very small hysteresis loop with a remnant Mr of 1.2 emu/g and a coercivity Hcof 100Oe, denoting the ferromagnetic behaviour of the sample.

## CONCLUSION

The paper thoroughly discussed the synthesis of manganese ferrite nanoparticles by the employment of simple chemical precipitation technique. The method is relatively simple, low cost and their particle size can be easily controlled. The formation of  $MnFe_2O_4$  nanoparticles is confirmed by X-ray diffraction (XRD). XRD pattern revealed the Manganese ferrite nanoparticles which belonged to the spinal cubic structure. The IR absorption spectra analyses were used for the detection and confirmation of the chemical bonds in spinel ferrites. The investigation of magnetic property of manganese ferrite nanoparticles reveals that the saturation magnetization is high, hysteresis in the region of measured field strength.

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