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STRUCTURAL AND MAGNETIC PROPERTIES OF MANGANESE FERRITE NANO MATERIAL - BY CHEMICAL METHOD

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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 nemely 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 scanning electron microscope (SEM) with Energy Dispersive X-ray (EDAX). 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), scanning electron microscopy (SEM), spinel ferrite, magnetic properties etc.,

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, In the case of soft ferrite materials, the coercive force is small, and saturation magnetization is filled with a comparatively small magnetic field. On

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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. Materials can be broadly classified as dielectric materials, magnetic materials, ceramics, glasses, polymers and semiconducting materials. Among these, magnetic materials have a variety of applications like memory devices, transformers, microwave devices, drug delivery, hyperthermia etc. Further, the rapid developments in the field of nanotechnology have opened large opportunities for understanding and utilization of magnetic materials. 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 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].

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_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 Ferrite Nanospheres. Al reagents are analytically pure and used as-received without further purification. In a typical experiment, synthesized Manganese ferrites ($MnFe_2O_4$) nanoparticles using a chemical co-precipitationmethod for which we used the starting materials ($MnCl_2$-$4H_2O$ and $FeCl_3$) of analytical grade

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andNaOH as the co-precipitating agent. The $MnCl_2$-$4H_2O$ and $FeCl_3$ salts were dissolved in distilled water in the required molar ratio of 1:2 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 9–12 that plays a determining role in controlling the precipitation and the precipitated particles' size. The product was then dried in an oven at 80 °C for 76 h for perfect ferritization. The as-dried powder was ground with an agate mortar and pestle to obtain the as-dried $MnFe_2O_4$ nanoparticles. The precipitates of the $MnFe_2O_4$ nanoparticles were obtained according to the following reaction,

$MnCl_2$-$4H_2O + 2FeCl_3 + 8NaOH \rightarrow MnFe_2O_4 + 8NH_4Cl + 8H_2O$

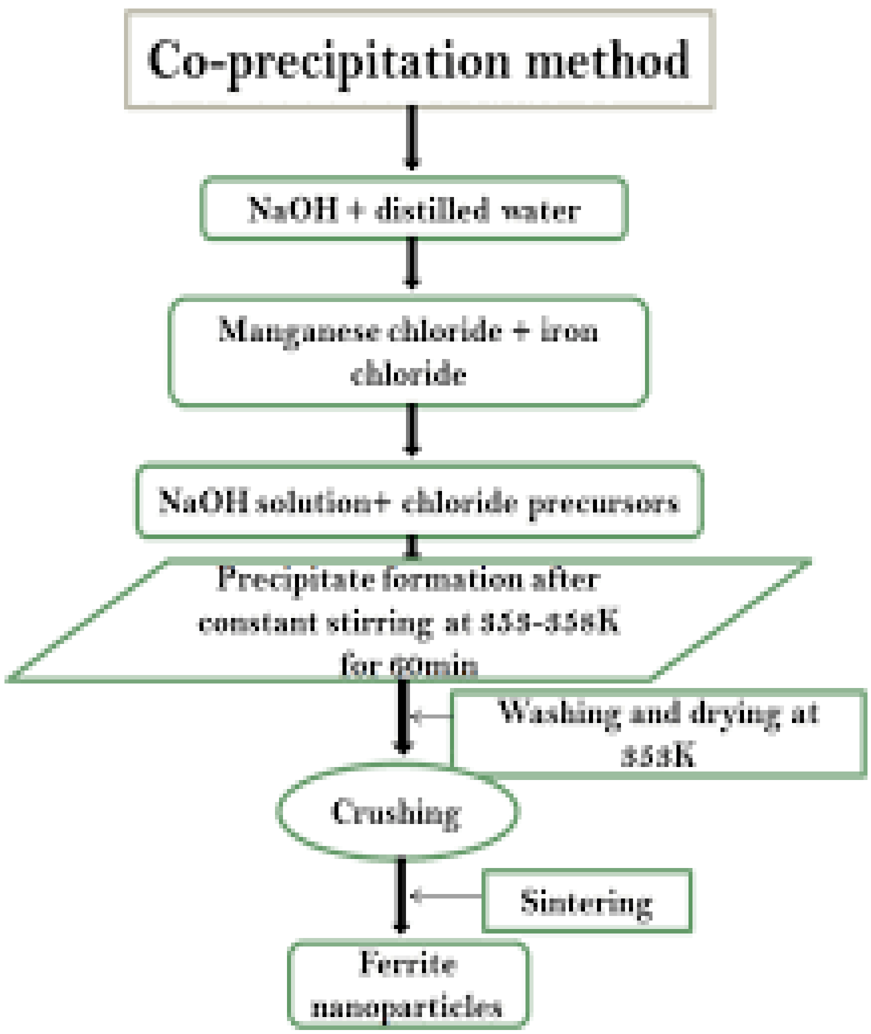

Fig 1-preparation of Manganese ferrite

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XRD- pattern of manganese ferrite nanoparticles

The XRD particle diffraction patterns of the $MnFe_2O_4$(fig.2) show the development of a Nanocrystalline product that is compatible with the spinal ferrite structure of MnFe2O4 nanoparticles. Crystalline nature can be derived from the appearance of sharp diffraction peaks in the XRD pattern prepared by the Chemical method. From the Fig.2, the XRD pattern is utilized to identify the phase and purity of the produced MnFe2O4 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 MnFe2O4 in spinal manganese ferrite (JCPDS card no. 38-0430). (Li-Xia Yang etc.:2013)

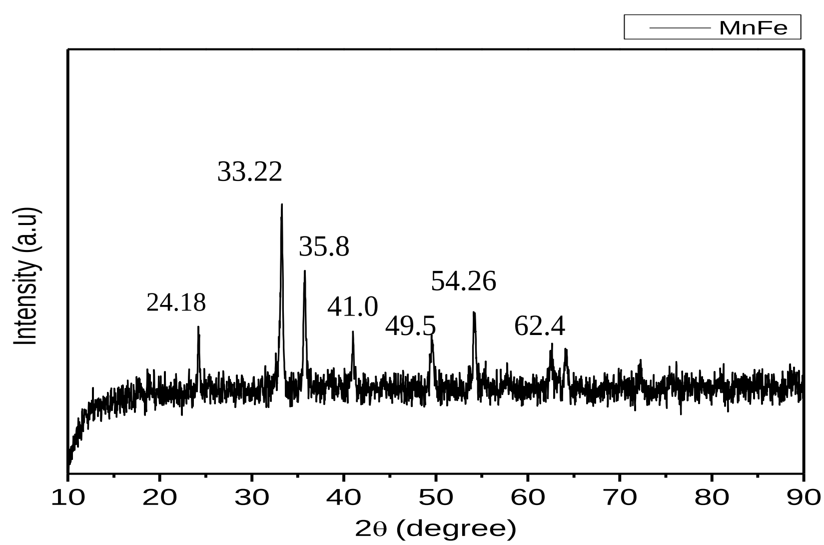

Fig. 2 XRD- pattern of manganese ferrite nanoparticles

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HR-SEM

The morphological studies through HR-SEM. ig 4 and 4b, 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.

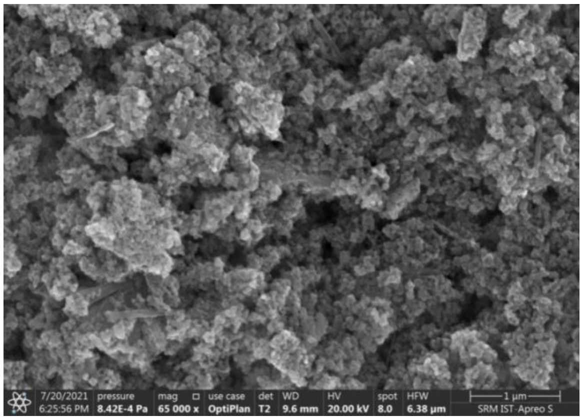

Fig 4 a-HR –SEM of Manganese ferrite

Magnetic behavior of $MnFe_2O_4$

Figure 5 depicts the M-H curve of MnFe2O4 nanoparticles at room temperature. When a ferromagnet is demagnetized, its ferromagnetic domains are misaligned.

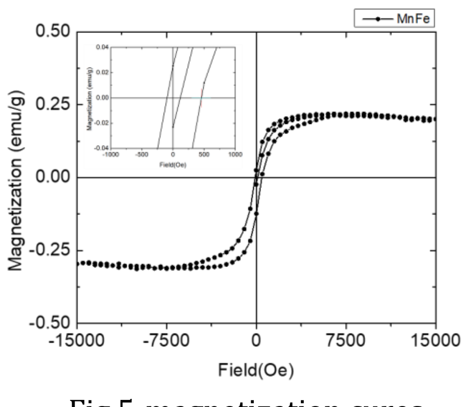

Fig 5-magnetization cures

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 .Figure 5 represents the magnetization curves measured at 300K. As-prepared manganese ferrite nanoparticles 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 close up view, the curve presents a very samll hysteresis loop with a remnant Mr of 1.2 emu/g and a coercivity Hcof 10Oe, 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 MnFe2o4 nanoparticles is confirmed by X-ray diffraction (XRD). XRD pattern revealed the Manganese ferrite nanoparticles which belonged to the spinal cubic structure. The morphology and particle size of the product were determined from High Resolution Scanning electron microscopy (HR-SEM). 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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