Structural, Morphologic and Magnetic Properties of Strontium Ferrite Nanoparticles by Solgel Method

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ABSTRACT

Strontium ferrite (SrFe2O4), a direct band gap semiconductor compound, has recently received great attention due to its unique properties, because of the low cost, absence of toxicity and good abundance in nature. The observed physical and chemical properties SrFe2O4 emphasize that this material could has novel applications in optoelectronics including solar cell devices, sensors and batteries and also in biomedical sciences. SrFe2O4 nanoparticles are synthesized by simple chemical route using Ethylene glycol) as precursor. The prepared nanoparticles are characterized through the following techniques, TG/DTA Studies, X-ray diffraction, Fourier transform infrared spectroscopy, Uv visible spectroscopy and Scanning electron microscopy.

Keywords: *XRD; FT-IR; UV, SEM and TG-DTA.*

1. INTRODUCTION

Nanotechnology is the science that studies the use of matter on a nanometric scale. The history of nanotechnology has its beginning in the speech that Richard Feynman gave at the University of Caltech (California). In this famous speech, Feynman was the first to talk about nanotechnology, nanoscience and about all the possibilities it offers. Today, the field of nanotechnology is in full growth and has high hopes that are waiting to be fulfilled. This article describes in detail the history of Nanotechnology, its importance, applications, trends, and the future. The term nanotechnology describes all areas of research in the field of single atoms up to structural sizes of 100 nanometers or less. One nanometer equals one-billionth of a meter. The peculiarities of research in the nanoscale represent the altered properties of the objects in this size range. Volume properties take a back seat to the laws of quantum physics and thus allow unprecedented effects. Nanotechnology is now used in all technological research areas. These include, for example, the chemical industry, the semiconductor industry, mechanical engineering, and food technology. Nanoscience is a convergence of physics, materials science and biology, which deal with manipulation of materials at atomic and molecular scales; while nanotechnology is the ability to observe measure, manipulate, assemble, control, and manufacture matter at the nanometer scale. There are some reports available, which provided the history of nanoscience and technology, but no report is available which summarize the nanoscience and technology from the beginning to that era with progressive events. Therefore, it is of the utmost requirements to summarize main events in nanoscience and technology to completely understand their development in this field [1-3].

2. EXPERIMENTAL PROCEDURE

2.1. Materials

Strontium Nitrate [Sr (NO3)3.5H2O] and ferric nitrate [$Fe(NO_3)_3 \cdot 9H_2O$] ethylene glycol are precursor materials for the synthesizing Strontium Ferrite. The chemicals used in this work are analytical grade (merck), and used without further purification [4].

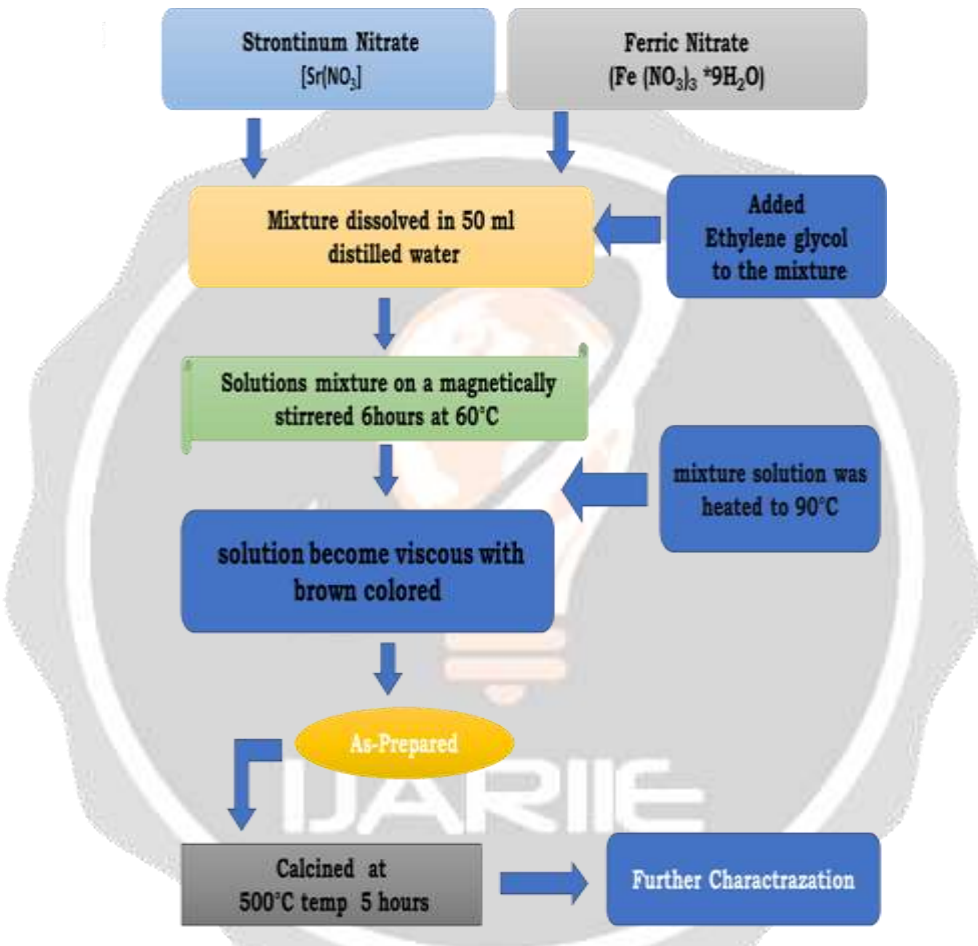

Fig 1. Flow chart $SrFe_2O_4$ nanoparticles synthesis

To prepare $SrFe_2O_4$ nanoparticle, the molar ratio of the ions to the Ethylene glycol is maintained as 1:2. Strontium Nitrate [Sr $(NO_3)_3.5H_2O$] and ferric nitrate [$Fe(NO_3)_3 \cdot 9H_2O$] were dissolved in 50 ml of distilled water with magnetic stirring to get homogeneous solution and de-ionized water was used for the sample preparation. Finally Ethylene glycol added drop wise to the stirring solution and the mixture was stirred for 5 hours. The solution is heated to 90 °C with constant stirring for the solvent evaporation. The yellow gel is formed and gradually transformed to xerogel. The residual organic precursor present in the sample is removed by heating at 2 hrs which yields a brown-coloured fine particle. The as-prepared Strontium ferrite is annealed at 500 °C in air atmosphere for 5hours. The volatile matters such moisture and other unwanted components were removed finally, to get the $SrFe_2O_4$ nano particle.Bismuth ferrite was prepared by the sol-gel method. Synthesis of $Srfe_2O_4$ by the schematic diagram as shown in Fig.2.

Fig. 2 synthesization of $SrFe_2O_4$ nanoparticle.

3. RESULTS AND DISCUSSION

3.1. XRD analysis

XRD analysis The XRD pattern of the $SrFe_2O_4$ nanoparticles was recorded by using a powder X-ray diffractometer {Schimadzu model: XRD 6000 using CuKα (λ=0.154 nm) radiation}, with a diffraction angle between 30º and 60º. Figure 3 shows the XRD patterns of the as-prepared $SrFe_2O_4$ nanoparticles. he patterns show the formation of single phase cubic spinal crystal structure. The $SrFe_2O_4$ nanoparticles contained no impurity peaks within the limit of X-ray detection. The broad peaks of X-ray diffraction patterns stipulate that the particles of the synthesized samples are in nanometer range. The average crystallite size of the samples could be calculated using Scherrer's formula

$$D = 0.9\,\lambda / \beta \cos\theta \text{ ----- (1)}$$

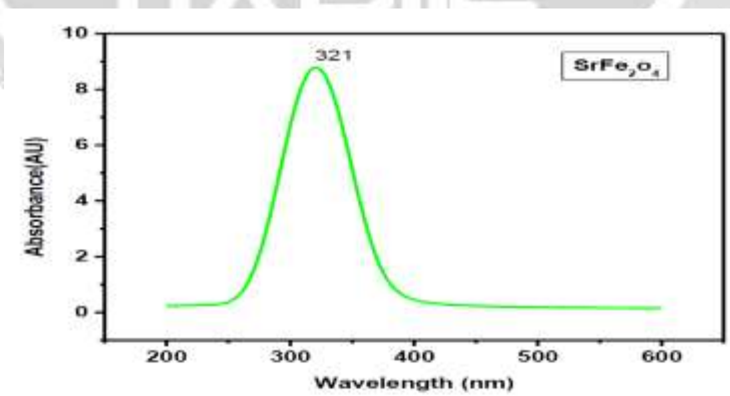

Fig. 3. XRD pattern of $SrFe_2O_4$ nanoparticles.

Where λ is the X-ray wavelength (CuKα radiation and equals to 0.154 nm), θ is the Bragg diffraction angle, and β is the FWHM of the XRD peak from the X-ray line broadening using Scherrer equation and it was found about appearing at the diffraction angle θ. The average crystalline size was calculated 18 nm [9].

3.2 Fourier Transform Infra Red (FT-IR)

The FTIR spectrum of the $SrFe_2O_4$ nanoparticles was taken using an FTIR model Bruker IFS 66W Spectrometer. In order to determine the chemical structure of the sample, the FTIR spectrum was observed above the frequency range of 4000-500 cm^{-1} as shown in Figure 4. The decomposition of hydroxide to oxide phase for the formation of spinel ferrites was well reflected in the FTIR spectrum. It has been reported that the IR bands of solids are usually attributed to the vibration of ions in the crystal lattice. The bands at 522 cm^{-1} and 464 cm^{-1} represented tetrahedral and octahedral modes of $SrFe_2 O_4$. The band located at 3589 cm^{-1} could be attributed to the symmetric vibration of -OH groups. The bands with peaks observed at 1449 cm^{-1} could be assigned to O-H bending vibration. The peak at 1579 cm^{-1} was ascribed to H-O-H bending vibration of the free or absorbed water. The bands at 857 cm^{-1} due to the C=Ogroup [10].

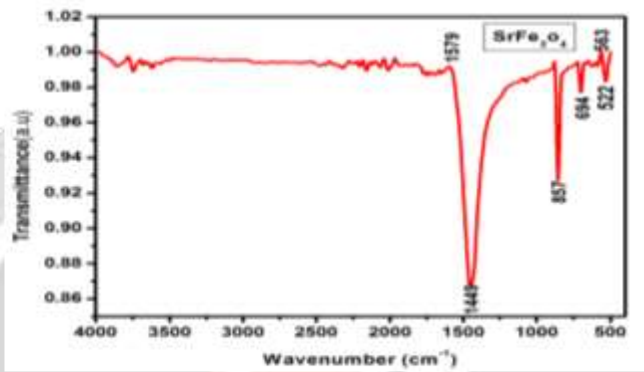

Fig 4. FT-IR image of $SrFe_2$ O_4 nanoparticles

3.3 UV -Vis spectrum

In order to investigate their optical properties the optical absorption spectrum of the $srfe_2o_4$ NPs were recorded in the range of 200-800 nm and shown in Fig. 5. Figure showed the characteristic peak of $srfe_2o_4$ with its strong exciton absorption edge at 321 nm. UV absorbance spectra exhibit a blue shift which could be ascribed to the reduced particle size and also due to the interactions of capping agents with various superficial groups on $srfe_2o_4$ [11].

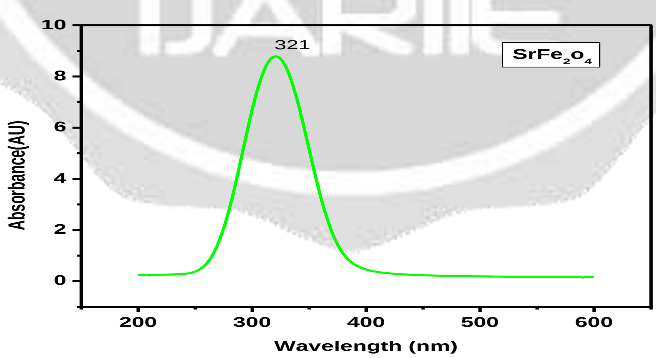

Fig 5. UV image of $SrFe_2$ O_4 nanoparticles

3.3 SEM analysis

The surface morphology characteristics of the synthesized nickel ferrite nanoparticles were investigated using SEM. The Scanning Electron Micrographs (SEM) Fig. 6 shows that the morphology of the particles is very similar. The micrographs exhibit the even distribution of nanoparticles of nickel ferrite. It also indicates the polyhedral shape and narrow size distribution of the particles. As the sample synthesized by milling and annealing results in a very fine powder, so there is formation of soft agglomeration between particles of Strontium ferrite [12,13].

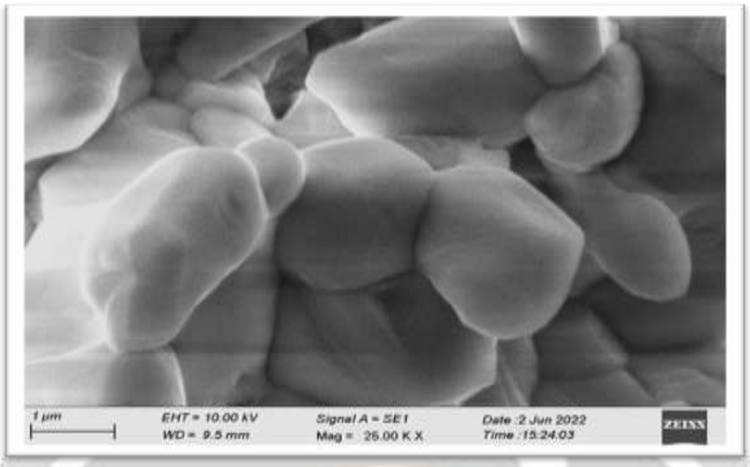

Fig. 6. SEM images of $SrFe_2O_4$ nanoparticles

3.4 VSM studied

The magnetic properties are saturation magnetization (Ms), remanent magnetization (Mr), and coercivity (Hc,) increasing with the effect of calcination temperatures. VSM studies revealed the hysteresis curve of $SrFe_2O_4$ nanoparticles prepared under the conditions of Fe3+/ $Sr2^+$ mole ratio and calcination temperature which was calcinated at 500°C. . The corecivity (Hc), saturation magnetization (Ms) and retentivity (Mr) values of the synthesized the remnant magnetization (Ms), Retentivity (Mr) and coercive field 49.200 Oe, 7.2379E-3 emu/g, and 1.2676 emu/g. Accordingly, coercivity, remanent magnetization and saturation magnetization of $SrFe_2O_4$ nanoparticles can be useful in various applications. The spinel strontium ferrites were found as highly active in catalytic, permanent magnetic, hard magnetic devices, and microwave applications [14].

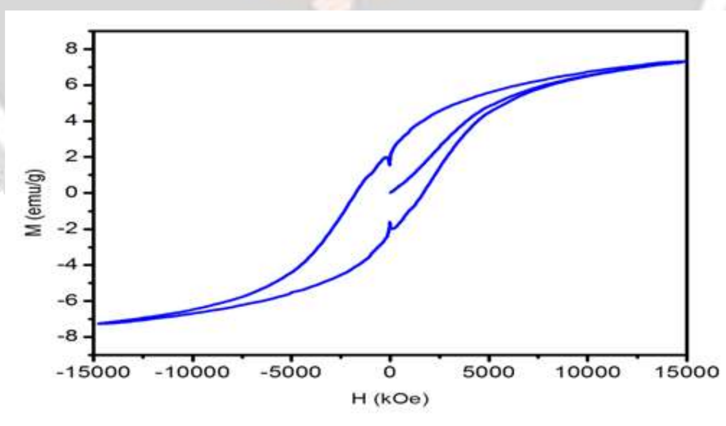

Fig.7. VSM image of $SrFe_2O_4$ nanoparticles.

The magnetic properties of nanoparticles are varied by size which could play significant role in physics. By comparing other methods, this sol-gel method is a good candidate for the preparation of nano material structures because it is a relatively easy, low-cost and reproducibility. Permanent magnetic, hard magnetic devices, and microwave applications. The magnetic properties of nanoparticles are varied by size which could play significant role in physics [15,16].

4. CONCLUSION

The nano-sized $SrFe_2O_4$ materials were prepared by a simple high-performance, low-cost and high yield sol-gel method. The structural, compositional and magnetic behavior of the synthesized products was well studied. The XRD study reveals that the resulting product was $SrFe_2O_4$ nanoparticles with the 500 °C. calcined temperature. The particle size calculated from XRD 18nm. The FT-IR spectrum confirmed the presence of the Strontium ferrite phase in the sample at 500 °C. calcination temperatures, FT-IR analysis confirmed that bands in the range 400 –700 cm^{-1} are due to the stretching vibration of oxygen atom and metal ions (M–O) that is Fe–O confirming the formation of spinel ferrite. The SEM images reveal that the particles were spherical in shape. A typical magnetic hysteresis loop was observed at room temperature, indicating that the $SrFe_2O_4$ nanoparticles show a weak ferromagnetic order. The remnant magnetization (Ms), Retentivity (Mr) and coercive field 49.200 Oe, 7.2379E-3 emu/g, 1.2676 emu/g.

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