Synthesis andCharactrization of $SrFe_{12}O_{19}$(Strontiumhexaferrite) Nanomaterials by Chemical Citrate precursor method.

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Abstract.

Strontiumhexaferrite (**$SrFe_{12}O_{19}$**) nano materials have been prepared with Citrate precursor method in deionized water. In chemical based citrate precursor method, generally nitrate of metal is taken because nitrates of most metals is highly soluble in water. Also nitrate of iron and strontium and citric acid are taken in stoichiometr proportions and then dissolved in deionized water. and mixed together and magnetic stirred at 60^0 C to 80^0 C temperature for 2 hours . Brown Slurry so formed is known as precursor. Then the precursor was dried in an oven at a temperature of 80^0C. This dried material is the citrate precursor . Then Citrate precursor was annealed at 700^0 C in a temperature controlled muffle furnace .

These samples were crushed in a crucible and the powdered samples were stored. After that, these samples were characterized through X-Ray diffraction for its size & properties. The samples ware studied for their full report showing their magnetic properties based on the hysteresis loop formation for the samples prepared at 700^0C temperature. The particle size was determined in scherrer,s formula.

I INTRODUCTION

Strontiumhexaferritewith chemical formula of $SrFe_{12}O_{19}$ have been widely used as permanent magnet.. It was widely used in the fabrication of computer data storage, high-densityperpendicular magnetic and magneto-optic recording, magnetic fluids and certain microwave devices.For ideal performance, ultrafine strontium hexaferrite powder (≈0.1 μm) with homogeneous particle size distribution and controlled magnetic properties is important . It is difficult to obtainultrafine and monodispersed particles by the Citrate precursor method which involves the stoichiometric mixture of strontiunitrat,Ironnitrate and citric acid at temperatures (about 80 °C) .

In order to achieve highly homogeneous ultrafine particles of Strontiumhexaferrite, various techniques were investigated, such as

- Citrate precursor method

- Ceramic method
- Co-precipitation method
- Sol-gel method
- Combustion system
- Hydrothermal precipitation
- Spray drying
- Freeze random
- Freeze drying

The objective of the present work is to give possible explanation and to investigate the influence ofSr2+/Fe3+ molar ration and the addition of surfactants on the synthesis of nanocrystalline strontium hexaferrite particles by Citrate precursor methods using nitrate precursors.

II TECHNIQUES AND EXPERIMENTAL PROCEDURE

Once we have synthesized citrate precursor for ferrite nanomaterials. These precursors were annealed using muffle furnace that was annealed at different temperature for thermal decomposition and structure feature. The powder sample was characterized using XRD & VSM for size, phase and magnetic studies.

To characterize the samples prepared by the methods discussed in the previous section, various techniques were used. Techniques and theexperimental procedures are described as follows :-

3.1 X - RAY DIFFRACTOMETER (XRD)

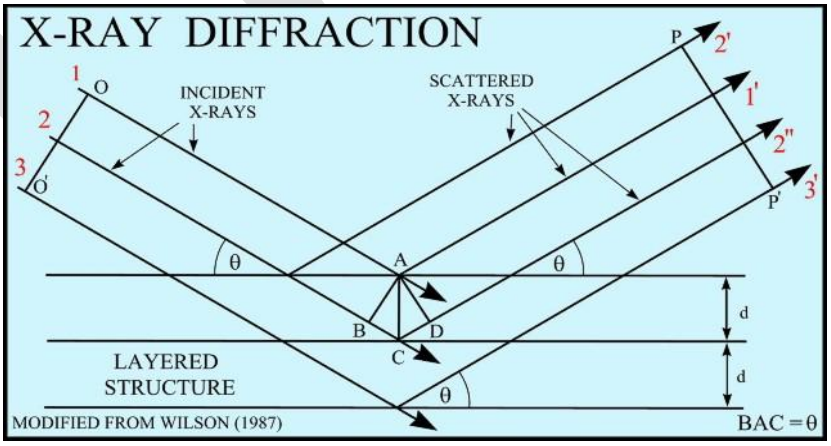

Fig. 3.1

X-ray diffraction (XRD) is a versatile, non-destructive technique that reveals detailed information about the chemical composition and crystallographic structure of natural and manufactured materials.

Crystal lattice

A crystal lattice is a regular three-dimensional distribution (cubic, rhombic, etc.) of atoms in space. These are arranged so that they form a series of parallel planes separated from one another by a distance d, which varies according to the nature of the material. For any crystal, planes exist in a number of different orientations - each with its own specific d-spacing.

Constructive interference

When a monochromatic X-ray beam with wavelength lambda is projected onto a crystalline material at an angle theta, diffraction occurs only when the distance traveled by the rays reflected from successive planes differs by a complete number n of wavelengths.

Bragg's Law

By varying the angle theta, the Bragg's Law conditions are satisfied by different d-spacings in polycrystalline materials. Plotting the angular positions and intensities of the resultant diffracted peaks of radiation produces a pattern, which is characteristic of the sample. Where a mixture of different phases is present, the resultant diffractogram is formed by addition of the individual patterns. Based on the principle of X-ray diffraction, a wealth of structural, physical and chemical information about the material investigated can be obtained. A host of application techniques for various material classes is available, each revealing its own specific details of the sample studied out of various possible X-ray diffraction methods, the powder is of special importance because of its applicability to all crystalline materials and also because it is the most convenient method by which diffraction data can be obtained.

We are characterizing sample prepared in powered form with many randomly arranged crystals (i.e. polycrystalline materials). A crystal consists of set of highly ordered parallel with specific spacing between them. These separations act as diffraction sites to incident X-ray beams. The diffracted beams will interfere either constructively or destructively depending on whether the path difference between them is an integral multiple nor half odd integer multiple of the X-ray wavelength. If the path difference is between these two extreme cases; there will exist beams with lower amplitude. These beams are cancelled from beams from other planes. This cancellation will occur as far as there are many planes. However, in a very fine crystal, this cancellation will not occur for angles near Bragg's angles at which constructive interference occurs and broadening will be noticed in the peaks. Hence there is connection between the size of the crystal and this broadening which can be formulated by scherrer's formula given by

$$T = K\lambda / \beta\cos\theta$$

Where 'T' is depth or thickness of the crystallineβ is the full width at the half maximum (FWHM) and θB is the Bragg's angle for a specific peak. When the constructive X-ray beams are accumulated detected using a diffract meter, they will produce a fingerprint X-ray pattern

that is characteristic to the structural composition to the material. Hence the X-ray diffraction provides useful information about crystal structure and crystalline size of the material.

3.2 VIBRATING SAMPLE MAGNETOMETER

PRINCIPLES

A vibrating sample magnetometer (VSM) operates on Faraday's Law of Induction, which tells us that a changing magnetic field will produce an electric field. This electric field can be measured and can tell us information about the changing magnetic field. A VSM is used to measure the magnetic behavior of magnetic materials.

A VSM operates by first placing the sample to be studied in a constant magnetic field. If the sample is magnetic, this constant magnetic field will magnetize the sample by aligning themagnetic domains, or the individual magnetic spins, with the field. The stronger the constant field, the larger the magnetization will be. The magnetic dipole moment of the sample willcreate a magnetic field around the sample, sometimes called the **magnetic stray field**. As the sample is moved up and down, this magnetic stray field is changing as a function of time andcan be sensed by a set of pick-up coils.The alternating magnetic field will cause an electric field in the pick-up coils according to Faraday's Law of Induction. This current will be proportional to the magnetization of the sample. The greater the magnetization, the greater the induced current. The induction current is amplified by a transimpedance amplifier and lock-in amplifier. The various components are hooked up to a computer interface. Using controlling and monitoring software, the system can tell you how much the sample is magnetized and how itsmagnetization depends on the strength of the constant magnetic field. A typical measurement of a sample is taken in the following manner: the strength of the constant magnetic field is set.The sample begins to vibrate the signal received from the probe is translated into a value for the magnetic moment ofthe sample the strength of the constant magnetic field changes to a new value. no data is taken during this transition the strength of the constant magnetic field reaches its new value the signal from the probe again gets translated into a value for the magnetization of thesample the constant magnetic field varies over a given range, and a plot of magnetization (M) versus magnetic field strength (H) is generated.

Results & Discussion

Synthesized materials were annealed at 700ºC &.The XRD pattern for Stroniumhexa ferrite particles annealed at temperatures 700ºC is shown in figure3.2 respectively. Also the magnetization curve for this samples are showninfigure3.4

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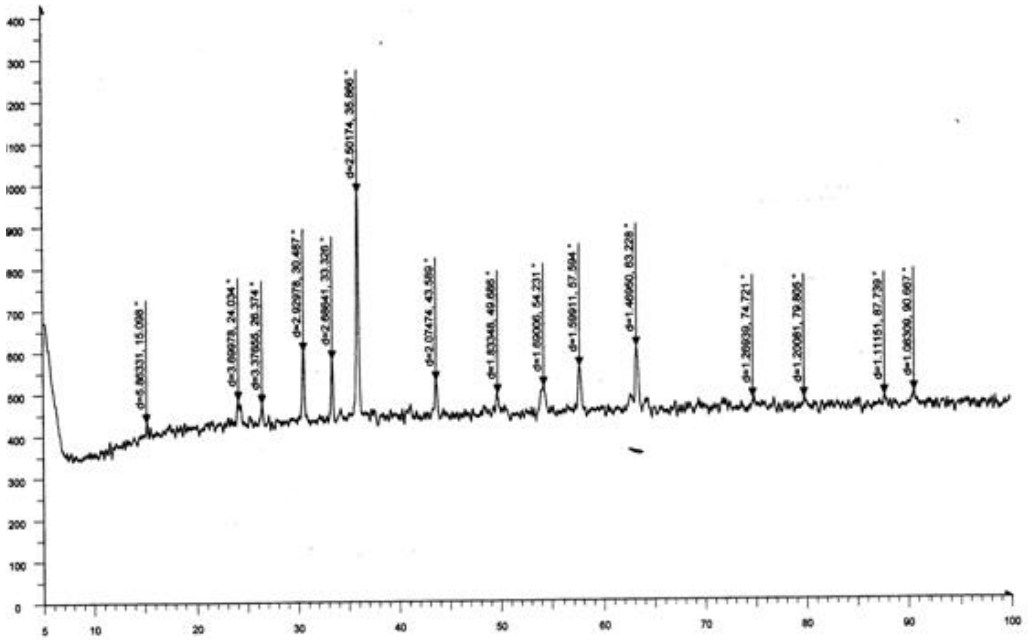

Fig 3.2 XRD pattern for $SrFe_{12}O_{19}$ annealed at 700^0C

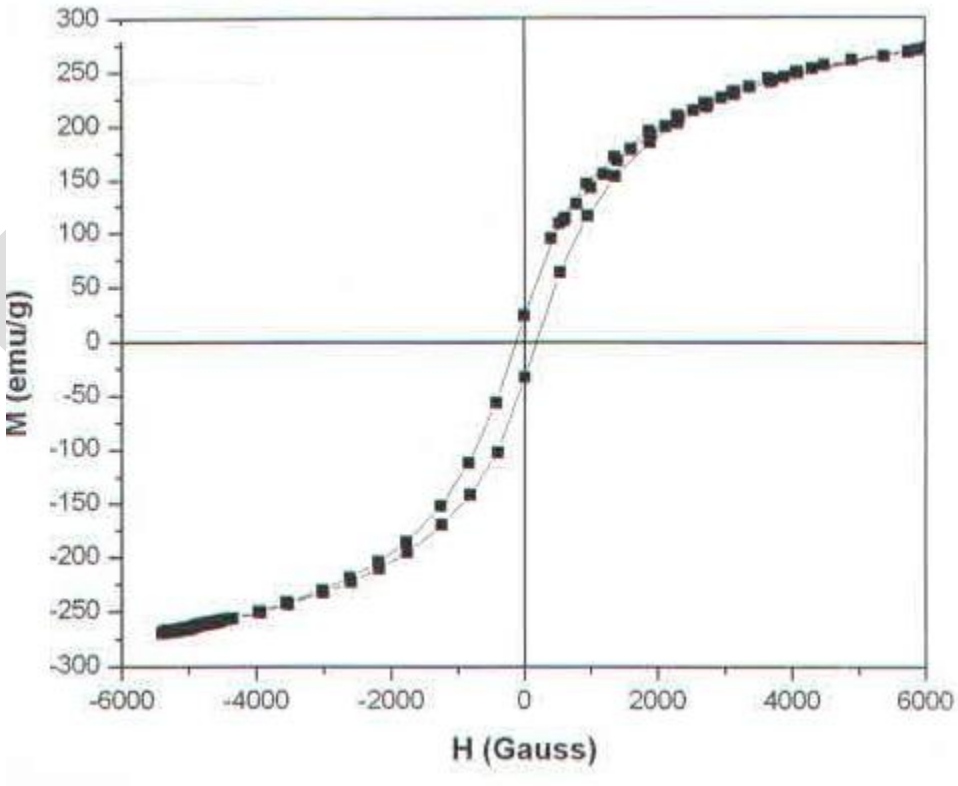

Fig..**3.4- magnetization curve for $SrFe_{12}O_{19}$Nanomaterial annealed at 700°C.**

Table 1: Observed data of XRD And VSM for **$SrFe_{12}O_{19}$(Stroniumhexa ferrites)** nanomaterials annealed 700ºC

Annealing temp.	**Particle size(nm)**	**M(emu/g)**	**Coercivity (G)**	**Retentivity (emu/g)**
700ºC	57	270.75	125	1.01

The X-ray diffraction pattern annealed at at 700ºC. We observed particle size increases with increase in annealing temperature. Many researchers have observed the same phenomenon[1,2]. The average particle size was calculated using Scherrer's formula[3].

The magnetic properties were measured using vibrating sample magnetometer. We have observed that the magnetic properties depends on particle size. Only magnetization increases with increase in the annealing temperature while retentivity and coercivity decreases. **$SrFe_{12}O_{19}$**behave as a n- type semiconductor based on the inverse spinel structure being characterized by high electrical resistivity (10^5-10^6 Ωcm) high curie temperature (640-680) magnetization 25 emu/g

CONCLUSION, SUMMARY AND FUTURE PLANN

The observed data corresponds to soft ferrite Nanomaterials, its possible application may be in the following areas:-
Transformer cores
Microwave absorption
Nano medicine
Electronics industry
Ferrite wave absorbers,
Information Storage,
Medical techniques like separation, immunoassaySynthesized samples are strontium hexaferrite.The samples are in Nanometer range and belongs to 57nm .
Particle size increase with increase in the annealing temperature.
Coercivity and retentivity decreases with increase in the particle size

- Magnetization is greater for particles having larger size
- Magnetic resonance imaging and many others.
- In this research project, we have synthesized stroniumhexaferrite nanoparticles and studied their structural and magnetic properties. Further we want to prepare these nanomaterials by other physical and chemical method such as Ball milling, ceramic

method, Sol-Gel method, Freeze drying, hydrothermal precipitation, combustion systems, etc.

- In addition to these characterization tools X-Ray diffractometer and vibrating sample magnetometers,we want to use other characterization tools such as Mossbauer spectrometer, LCR meter, photoluminescence spectrometer, Fourier transform infrared spectroscopy for their optical, electrical and mechanical properties studies.
  In future also, we will try to synthesized and characterize nanomaterials using various methods so that they can be used for various technological applications.

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