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A Dissertation report submitted on

Effect of calcination temperature on structural, optical and magnetic properties of Y doped Barium Hexaferrite

By

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To

Department of physics

Impartial fulfillment of the requirement for the

Award of the degree of

Master of Sciences

Under the guidance of

Dr. A.K.Srivastava

Phagwara, Punjab

DECLARATION

I hereby declare that the dissertation report entitled “Effect of Calcination Temperature on the structural, Optical, Magnetic Properties of Y doped Barium Hexaferrite” submitted for the M.Sc. (Hons.) Physics degree is entirely my original work and all ideas and references have been duly acknowledged. It does not contain any work for the award of any other degree or diploma at any university.

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M.Sc. (Hons.) Physics

CERTIFICATE

This is to certify that Ms. Ravneet Kaur has completed the dissertation report entitled “Effect of Calcination Temperature on the Structural, Optical, and Magnetic Properties of Y doped Barium Hexaferrite” under my guidance and supervision. To the best of my knowledge, the present work is the result of her original investigation and study.

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Ravneet Kaur

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INTRODUCTION

Recently M type hexaferrites have drawn attention because of their remarkable properties. Commercially and technologically hexaferrites have become massively important material for the manufacturing of the magnetic materials [1]. They are extensively used as permanent magnets. They have common application in superconductors, sound devices, magnetic devices, fridge magnets, capacitor applications, microelectronics, microwave devices (cell phones), plastoferrites, magnetoelectric(ME) and multiferroic (MF) [1 -7].

The family of hexaferrites like M,U,W,X,Y is known for its magnetic properties. Out of this family, ferrite having magnetoplumbite structure with space group P63/mmc possess better properties than others (spinel and garnet)

Researchers have tried to substitute cations like La-Co [6], La-Na [8], Ca-Cr [9], Mg- Mn-Co-Ti [10], Al [11] , Co-Ti, Bi-Ti [12], Eu [13], Bi [14], Co-Zn-Sn [15],Sr-Y[16]. Rare earth metals and transition metals have small ionic radii so they can replace barium and ferric ions respectively.

There are number of synthesis methods for hexagonal ferrites like co-precipitation, salt-melt method, ion exchange, sol-gel [17], citrate synthesis [18], hydrothermal synthesis [19], glass crystallization [20], the combustion method[21], self- propagating high temperature synthesis(SHS) [22], spray drying [23], water-in-oil microemulsions [24].

The properties of nano-materials are different from bulk materials from which they are derived. Now-a-days the chief attention is on the synthesis of nano-particles. To meet the nanotechnology there is a great importance for the preparation of ferrite in nano-range. Nanotechnology can be defined as the field in which we can visualize, alter and control the individual atoms and molecules. It also gives the important accepting of the connections between the physical belongings and measurements of particles. It agrees with materials in nanometer scales (10^{-9} m). This technology also gives the idea of creating nanostructures of meta-stable stages. It also includes mechanisms like superconductivity and magnetism.

In the field of nanotechnology the development of ferrite materials, is one of the major advances as they offer remarkable magnetic behavior which proves to be useful in many modern day applications such as ferrite cores, inductors, transformers, fridge magnets ferrite magnets and in microwave devices.

Researchers, over a period of time have been keenly interested in the sphere of ferrites and many successful attempts have been made to synthesize ferrite materials that show improved magnetic properties such as saturation magnetization, anisotropy constants etc for better use in applications. Ferrites are deliberated much improved than the other magnetic tools as they have small eddy current losses and have high electrical resistivity. M –type hexaferrite having formula

$MFe_{12}O_{19}$, where M can be Sr, Pb, Ba have been a question of attention because these compounds have been the work mount of long-lasting magnet fair. Strontium hexaferrite has been studied for magneto-optical recording and magnetic recording media. They are ferromagnetic as they can be magnetized or attached to a magnet also they are electrically nonconductive. Ferrites can be divided into two classes based on magnetic coercivity, resistance to being demagnetized.

1.1: SOFT FERRITES

Soft Ferrites are the substances which have low coercivity. The value of magnetizing field required to be applied in opposite direction so as to reduce the residual magnetism to zero is called coercivity of the material. Low coercivity states that the materials magnetization can effortlessly reverse direction without dispersing significantly energy though the materials great resistivity avoids eddy current loss in the core of RF transformers and inductors uses the soft ferrites. Coercivity of soft ferrites is smaller and energy loss is also small. Examples: zinc ferrite, Nickel ferrite, Soft iron, Electromagnets, Transformer cores.

1.2: HARD FERRITES

Hard ferrites are those which have high coercivity and great retentivity. Permanent magnets are made up of the hard ferrites, as hard ferrites have the great coercivity & great residual magnetism. Mainly Iron oxide and strontium carbonate are used to manufacture the hard ferrite. The high value of coercivity confirms that the materials are very tough to become demagnetized. They also have permeability. Examples: strontium ferrite, barium ferrite.

TYPES OF HEXAFERRITES:

(i)THE W FERRITES

General formula of W type ferrites is $BaMe_2Fe_{16}O_{27}$, where Me is the D block elements or the particular divalent cation and the barium that could be replaced by additional group elements. All W type ferrites ensure uniaxial anisotropy, exception is Co_2W ferrite having formula($BaCo_2Fe_{16}O_{27}$), and the molecular mass of 1581 g and the density $5.31gcm^{-3}$. It has a cone of informal magnetization at constant angle 70° to c- axis from the $-273^\circ C$, at which the point, its anisotropy revolves to the c-axis with the growing temperature till it converts uniaxial at the temperature of $280^\circ C$, and the magnetization becomes constant in the c-axis with additional rise in the temperature.

(ii)THE M FERRITES

General formula of M type ferrite is BaM , $BaFe_{12}O_{19}$. The melting point of M type ferrite is $1390^\circ C$ confirmed in the year of 1936. Though, the structure of M type ferrite had not

established as existence of isomorphous with the hexagonal magneto - plumbite till it had been considered and characterized magnetically by Philips in 1950. It was deliberated as the unfamiliar ferrites as per it was confined with no nickel and cobalt, however this was attractively firm with the coercivity of 160-255kA/m. They had a great electrical resistivity of $108\Omega\text{cm}$ and also it has great magnetic uniaxial anisotropy beside the c-axis. BaM having molecular mass of 1112 g and the determined density is of 5.295gcm^{-3} , even though in the certainty a ceramic material repeatedly which had a density less than 90% of hypothetical density. Rigidity of the BaM in the c-axis had been measured to be 5.9 GPa and dignified as 6.0Pa.

(iii) THE X FERRITE

They were first described in the year of 1952 as they had varied phase of M and W ferrite. The general chemical formula of X ferrites is $\text{Ba}_2\text{Me}_2\text{Fe}_{28}\text{O}_{46}$, in which Me is the D block element or the certain divalent cation. First described X ferrite is the Fe_2X , $\text{Me} = \text{Fe}^{2+}$ and this was establish that it had the uniaxial magnetic anisotropy beside a c- axis. The density is of 5.3gcm^3 . Totally X ferrites have the uniaxial anisotropy at RT, exception is the Co_2X , it had cone of magnetization (at 74°) to the c- axis. Alike W ferrite they appear like, the cone vagaries to implement an alignment parallel to the c-axis at the greater temperature, 143°C in this saturation.

(iv) THE Y FERRITES

The first ferroplana ferrites to be exposed, is Y ferrite and currently identified as almost all Y ferrites had the favored plane of magnetization upright to the c-axis at RT. General formula for the Y ferrites is the $\text{Ba}_2\text{Me}_2\text{Fe}_{12}\text{O}_{22}$, where Me is the small divalent cation, and Zn_2Y and Co_2Y were the first made for ferrites. Co_2Y have molecular mass of 1410 g, and having density 5.40g cm^3 . At RT, the Co_2Y has planer anisotropy but it fluctuations to cone of magnetization below -58°C . the temperature from -58°C to the curie point, the anisotropy rests in favored plane. The Cu_2Y is the single Y ferrites which were initiate to had a desired the uniaxial way of the magnetization.

(v) THE Z FERRITES

The general formula of Z ferrites are $\text{Ba}_3\text{Me}_2\text{Fe O}_{41}$. They are exposed at that period as the ferroplana Y ferrites were found. Molecular mass of Co_2Z is 2522g and it has 5.35g cm^3 density. Entirely Z ferrite have the uniaxial anisotropy parallel to the c-axis, exception is the Co_2Z , as it is a planar at RT but then it has the composite magnetic anisotropy, atleast 4dissimilar anisotropic positions. At small temperatures the Co_2Z had informal cone of magnetization, at the angle of 65° to the c-axis, and it always constant up to -103°C . Between -103°C and -53°C angle rises to the 90° , and the desired magnetization remnants in the basal plane.

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There are number of synthesis methods for hexagonal ferrites like co-precipitation, salt-melt method, ion exchange, sol-gel [17], citrate synthesis [18], hydrothermal synthesis [19], glass crystallization [20], the combustion method[21], self- propagating high temperature synthesis(SHS) [22], spray drying [23], water-in-oil micro emulsions [24].

In this work we have studied the M-type barium hexaferrite $Ba_{0.8} Y_{0.2} Fe_{10.3} Co_{1.7} O_{19}$ synthesized via sol – gel auto combustion method. The target of this research is to study the effect of calcination temperature on structural, optical, dielectrical and magnetic properties of the synthesized samples. Calcination of the prepared sample was done at 850°, 950°,1050° and 1150° Celsius temperature.

REVIEW OF LITERATURE

Hasab et al. (2007) have adopted the sol-gel technique to make the strontium hexaferrite nanoparticles using metal nitrates and ammonia which is used to adjust the PH Reagent n-decyltri-methylammonium bromide is used as the cationic surfactant and citric acid, acetyl acetone, glycine and oxalic acid are used as fuels. Temperatures form the hexaferrite and the crystallite size in the existence of dissimilar fuels had compared together. The results had showed the smallest crystallite size 37.3nm and lowest formation temperature in the existence of citric acid was 900 °C.

Jotania et al. (2008) have prepared the W-type hexaferrite nanoparticles with composition of by microemulsion technique and auto combustion method with and without surfactants at several sintering temperatures. X-ray Diffraction is used to study the structural properties, VSM is used to study the magnetic properties, Scanning Electron Microscopy is used to analyze the surface features, thermal properties were studied by Thermo gravimetric analysis Differential Scanning Calorimetric (DSC) and Fourier Transform Infrared Spectroscopy (FTIR) is used to detect the chemical group that are attached to the formed powder. Magnetization was depend on the surfactant used. Sample which prepared in presence of poly-ox ethylene (20) sorbitan monooleat showed small saturation magnetization and the sample which formed in the occurrence of a surfactant cetyltrimethylammoniumbromide (CTAB) exhibited the extraordinary saturation magnetization as compared to the normal samples.

Bsoul and Mahmood (2009) studied the structural and magnetic properties of $(BaFe_{12-x}GaxO_{19})$ nanoparticles with varying x from 0 to 1.0. The samples have been prepared by the technique of ball milling and are studied using XRD, VSM and TEM. It was found that the particles and the crystallites have same average size of 41nm approximately for wholly

samples which are examined. The M_s was reduced a little and nonlinearly with the increasing x , and it was recognized to the dissimilar preferential site occupation of the Ga at high and low concentration ranges. The H_c was reduced marginally with growing value of (x) for small concentrations of Ga, x is less than or equal to 0.2 and then better with the increase Ga concentration up to the value $x = 1$.

Junliang *et al.* (2009) have synthesized the quasi- single domain M-type barium hexaferrite powders using the technique of sol-gel. The effects of citric acid on the metal ions and the Ph values on the sol gel, phase configurations of the created powders and the magnetic properties are calculated. They found that chelation of the barium and the ferrite ions was important for the phase realization of the barium hexaferrite; the phase compositions of the prepared particles different from a multi-phased mixture to a single phase of (M-) for the gradual complete complexing of the barium and the iron ions with citrate as pH values and metal ion were increased.

Iqbal *et al.* (2009) have prepared the Y-type hexagonal ferrites of the nominal composition (()) by the technique of sol-gel. The XRD patterns of samples have showed a micrographs and crystalline nature of the samples with undeviating particle dimension spreading. Crystallite extent distribution of samples was deliberate of range of 46nm-59nm. The resistivity of samples decreased on growing temperature but increased on the increasing Zr-Co contented. The Doping of Zr-Co significantly affected lattice c-parameter, the crystallite size, the Curie temperature, the DC resistivity, and drift mobility.

Iqbal and Farooq (2010) synthesized and characterized hexaferrite nanomaterial. XRD results had showed specific peaks of the magnetoplumbite structure for taken compounds. Values of M_s was establish to rise in the range of 65-78 and retentivity was establish to rise in the ranges of 43-48 emu/g. The magnetic susceptibility studies have showed the piercing ferrimagnetic to paramagnetic transition in range of 500-672K temperature.

Liu. *et al.* (2010) have prepared a sequence of powders of the M-type barium hexaferrite doped with some elements like Zn, Sn and Co with x equal 0 to 2 by co precipitation process. The structural property was characterized by X-ray powder diffraction, particle morphology was characterized by SEM and the vibrating sample magnetometer is used to analyze the magnetic properties. The results after characterization showed that the crystalline nature of the sample falls with the rise in the doping volume of x . A high saturation magnetization and a temperature dependence of coercivity was close to zero for doped barium hexaferrite when the value of x lies between 0.3 and 0.4.

Singhal *et al.* (2011) have prepared M-type hexaferrite and the where M can be Ba, Sr and Pb by technique of auto combustion process to examine shielding influence of the inorganic ions like KBr, KCl and KI on phase progression of hexaferrite. The FTIR frequency bands are detected in frequency range 560 – 580 and 430 – 470. X-ray diffractographs not show any peaks for

obtained samples, showing amorphous nature of the samples, but regular peaks for M-type structure were found for annealed samples. Negligibly change in the lattice constant 'a' and 'c' was noted with replacement of Al in hexagonal ferrite. Magnetic dimensions showed that value of coercivity for whole the samples with KCl and KBr improved as KCl and KBr acted as a deactivators. The value of coercivity reduced with KI replacement as it oxidized to in hardening. The saturation magnetization of hexaferrite decreased with ion substitution for ion due to preferential occupancy of ion in the octahedral sites.

Davoodi and Hashemi (2011) synthesized Sn-Mg relieved strontium hexaferrite with configuration of $SrFe_{12-x}(Sn_{0.5}Mg_{0.5})_xO_{19}$ ($x=0-1$) by method of chemical co precipitation. Deionized water 50/50 was used as the solvent. The only phase hexaferrite were achieved at the pH of 13 and the Fe^{3+}/Sr^{2+} molar ratio of nine after animated at the temperature of $800^{\circ}C$. With growing the Sn-Mg contents from ($x=0$ to $x=0.8$) the average particle size of the samples was reduced from 82 to 56nm. The magnetic properties of the hexaferrite are calculated using the VSM. On increasing the Sn-Mg from $x=0$ to $x=0.8$ it reduced the H_c from the value of 4728.9 to 1455.5Oe and increased saturation magnetization (Ms) from 51.34 to 65.49emu/g. A method called the vector network analyzer was used to examine the microwave absorption properties. According to the microwave quantities, it had been instigate that doped the taken hexaferrite composites had more operative electromagnetic absorption properties than the undoped hexaferrite.

Nakamura et al. (2012) studied that the Y- type hexaferrite having composition ($Ba_2Mg_2Fe_{12}O_{22}$) had been conducted with the single crystal specimen. The spins were in the cplane down to 60 K. For transition from the ferromagnetic to proper screw spin structure takes. At temperature 16 k, the spins inclined about 15degree from the c-plane. Below the temperature 50K, the spin reorientation transition to the longitudinal conical structure was also predictable.

Wang et al. (2013) prepared strontium ferrite with Nd^{3+} , Al^{3+} and Ca^{2+} substitution of Fe^{3+} and Sr^{2+} ions by the conventional solid phase reaction process. The Nd^{3+} substitution shows 10 % – 20 % improvement in coercivity for the substitution content less than 10 %. The Ca^{2+} substitution is favorable to the enhancement of saturation magnetization due to the accelerated reaction of Fe_2O_3 and $SrCO_3$. The samples with Al^{3+} substitution of Fe^{3+} show the lowest saturation magnetization, although the highest coercivity was achieved for a homogeneous grain size less than 1 μm . The combinatory substitution Nd^{3+} , Ca^{2+} and Al^{3+} leads to the optimum magnetic properties with $\sigma_s = 52 Am^2/kg$ and $H_{c_j} = 412 kA/m$.

Fenfang Xu et al. (2014) synthesized the composite of chiral polyaniline (PANI)/barium hexaferrite (BF) by in situ polymerization using L-camphorsulfonic acid as chiral dopant. The structural features of the obtained composites were characterized by FTIR, XRD and FESEM techniques. Open circuit potential was measured in D-/L-alanine electrolyte in order to identify the chirality of the composite. Microwave absorbing properties were investigated by measuring

complex permittivity and complex permeability in the frequency range of 26.5–40 GHz. As a result, chiral PANI/BF composite exhibited excellent microwave absorbing properties with the minimum reflection loss of 30.5 dB at 33.25 GHz with a thickness of only 0.9 mm, and the absorption bandwidth of the reflection loss below ≤ 10 dB could reach 12.8 GHz (from 26.5 to 39.3 GHz), which almost covered the whole Ka band (26.5–40 GHz). The enhanced microwave absorbing properties were attributed to the helical structural characteristic and the good impedance matching between BF particles and chiral PANI.

Talwinder Kaur et al. (2015) synthesized M-type barium hexaferrite [$\text{Ba}_{1-x}\text{Nd}_x\text{Co}_x\text{Fe}_{12-x}\text{O}_{19}$ ($x = 0.0\text{--}0.5$) (BNCM)] powders, using the technique of citrate Precursor method. When the pattern of powders was subjected to X-ray diffraction, it shows the formation of M-type hexaferrite phase. The formation of sample is observed to be at 440 °C as per the analysis of thermogravimetric analysis/differential thermal analysis/derivative thermogravimetry. The presence of two prominent peaks near 430 and 580 cm^{-1} in FTIR spectra indicates the formation of M-type hexaferrites. The saturation magnetization, retentivity, squareness ratio and coercivity were calculated by M-H curve obtained from VSM. UV–Vis NIR spectroscopy had given that band gap depends on size of the crystallites. At low frequency, the dielectric constant is found to be high and decreases with increase in frequency. This kind of behaviour is described on basis of the Koop's phenomenological theory and the Maxwell–Wagner theory.

Talwinder Kaur et al. (2015) synthesized M-type barium hexaferrite $\text{Ba}_{0.7}\text{La}_{0.3}\text{Fe}_{11.7}\text{Co}_{0.3}\text{O}_{19}$ powder, using sol gel method, which is heated at different temperatures 700, 900, 1100 and 1200 °C. The X ray diffraction (XRD) powder patterns of the heated samples show the foundation of pure phase of M-type hexaferrite after the temperature of 700 °C. The Thermo gravimetric analysis shows that weight loss of synthesized sample becomes constant after the temperature of 680 °C. The existence of two prominent peaks, at 432 cm^{-1} and 586 cm^{-1} in FTIR spectra, gives the info of the formation of M-type hexaferrites. The saturation magnetization, retentivity, squareness ratio and coercivity were calculated by M-H curve obtained from VSM. The maximum value of coercivity (5602 Oe) is originated at temperature of 900 °C. The dependency of band gap on temperature was calculated by using UV–vis NIR spectroscopy. At low frequency, the dielectric constant is found to be high however it decreases with increase in frequency. Such kind of dielectric behavior is described on basis of the Koop's phenomenological theory and the Maxwell Wagner theory.

INSTRUMENTS

Following instruments are used to know the properties of synthesized hexaferrites:

- **X- ray Diffraction:**

X-ray diffraction (XRD) method is the best operative method to define the crystal structures of the materials. X-ray diffraction can also identify the chemical compounds, but it cannot identify the chemical compound from their compositions.

- **Fourier Transform Infrared Spectroscopy:**

Fourier Transform Infrared Spectroscopy also called FT-IR, is the best used and mostly vibrational spectroscopy method. It uses the infrared spectroscopy transform technique called fourier transform which is used to acquire an infrared spectrum in a entire range of the wavenumbers instantly. The chief component in the FTIR system is the Michelson interferometer.

- **Ultraviolet Spectroscopy:**

Ultraviolet spectroscopy is used to study the band gap of the synthesized material.

- **Vibrating sample magnetometer:**

A vibrating sample magnetometer (VSM) works on Faraday's law of induction, which says that a changing magnetic field will produce an electric field. This electric field can be calculated and can tell us the information around the changing magnetic field. A VSM is used to measure the magnetic behavior of magnetic materials.

SYNTHESIS METHOD \ RESEARCH METHODOLOGY

Nanoferrites possess magnetic properties which depends commonly on the grain size and phase purity which are much affected by the synthesis techniques. There are many methods to synthesize nanoferrites which include the traditional ceramic sintering route, mechanical grinding, the micro-emulsion technique, the hydrothermal reaction, the glass crystallization technique like sol-gel technique, salt-melt technique etc. Nowadays the most commonly used method is the sol-gel method. It has been used for the preparation of nano grained hexaferrites. Main advantages of this method are:

- low cost
- energy efficiency and
- high production rate.
- Lower calcination temperature
- Ultrafine resultant particles

In sol-gel method the amount of reactants can be easily controlled.

Sample preparation steps and chemical used:

We have synthesized Y-Co substituted barium hexaferrite using AR grade nitrates, citric acid and ammonium solution. We have adopted sol gel auto combustion method. In this method, first of all, dissolved in distilled water and then mixed together. The pH of the solution is maintained by ammonium solution at around 7. The mixtures are heated at 80⁰C for 4 hours at magnetic stirrer and then heated at 280⁰C in a hot plate for 3 hours. The samples are heated as follows:

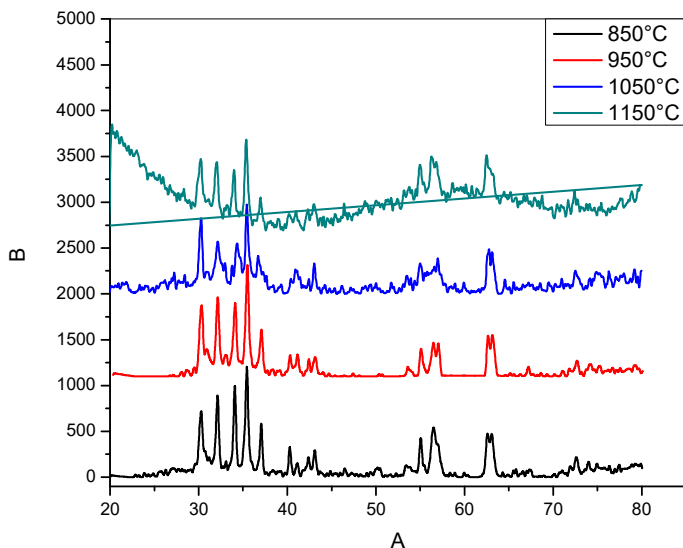
- Sample A: 850⁰C in the furnace for 6 hours.
- Sample B: 950⁰C in the furnace for 6 hours.
- Sample C: 1050⁰C in the furnace for 6 hours.
- Sample D: 1150⁰C in the furnace for 6 hours.

Chemical required to synthesizing the strontium hexaferrite

- Barium nitrate AR grade [Ba(NO₃)₂] : 4.181g/mol
- Yttrium nitrate AR grade [Y(NO₃)₃.4H₂O] : 1.3878g/mol
- Cobalt nitrate AR grade [Co(NO₃)₂.6H₂O] : 49.594 g/mol
- Ferric nitrate GR grade [(Fe(NO₃)₃.9H₂O) : 83.224g/mol
- Citric acid anhydrous [C₆H₈O₇.H₂O] : 31.2200g/mol
- Liquor ammonia [AR grade] NH₃ to control the pH of the initial solution between 2 to 10.47.

RESULTS AND DISCUSSIONS

XRD STUDY:



FTIR:

To find out the results of FTIR of the synthesized samples, it is compulsory to transform the powdered form of samples into thin pellets by using KBr press. To transform the powdered form of sample into thin pellets, a mixture of the sample and KBr, which is repeatedly taken in the ratio of 1:10 have been grinded with mortar and pestle. This mixture of sample was then pressed to create the thin pellet. The spectra of the samples were obtained in the range 400 to 4000⁻¹ with IR prestige-21 FTIR (model-8400S).

The bands in the range of 400-600 cm⁻¹ assigned to be for broadening of metal oxygen bond, the bands in the range of 1500-2000 cm⁻¹ indicates the presence of carboxylic acid, the peaks in the range of 3000-3600cm⁻¹ assigned for the OH-, the peaks in the range of 1400-1600cm⁻¹ are assigned for the nitrate ions.

Bands in the range of 1000–100 cm⁻¹, the IR bands of solids, are generally allotted to vibration of ions in the crystal lattice. But in our case mainly two broad metal-oxygen bands have been seen in the IR spectra of ferrites. The maximum one generally located in the range of 600–550 cm⁻¹, which is corresponded to the stretching vibrations of metal ions at the tetrahedral site, however the lowermost, detected in the range of 450–370 cm⁻¹ is allotted to stretching vibrations in octahedral sites.

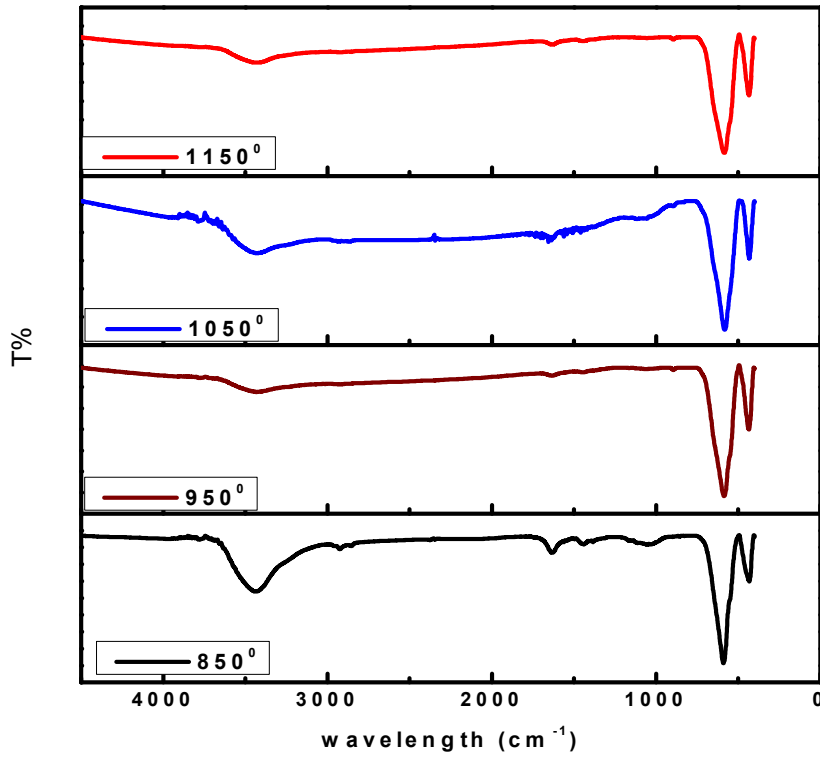


Figure 2: FTIR Spectra for **Ba_{0.8}Y_{0.2}Fe_{10.3}Co_{1.7}O₁₉ hexaferrites**

MOSSBAUER:

Mossbauer Spectroscopy:

Figure 4 shows the room temperature Mössbauer spectra for Ba_{0.8}Y_{0.2}Fe_{10.3}Co_{1.7}O₁₉ nanohexaferrites. The values of isomer shift, quadruple splitting and hyperfine field are listed in Table 3. As a result of the electrostatic interaction between the nucleus and electrons in a solid, the nuclear energy levels are shifted in both the source and the absorber. The shift is called isomer shift which can be represented as below: $\sigma = 2\pi Z e^2 [|\Psi_a(0)|^2 - |\Psi_s(0)|^2] (R_{ex}^2 - R_{gd}^2) / 5$

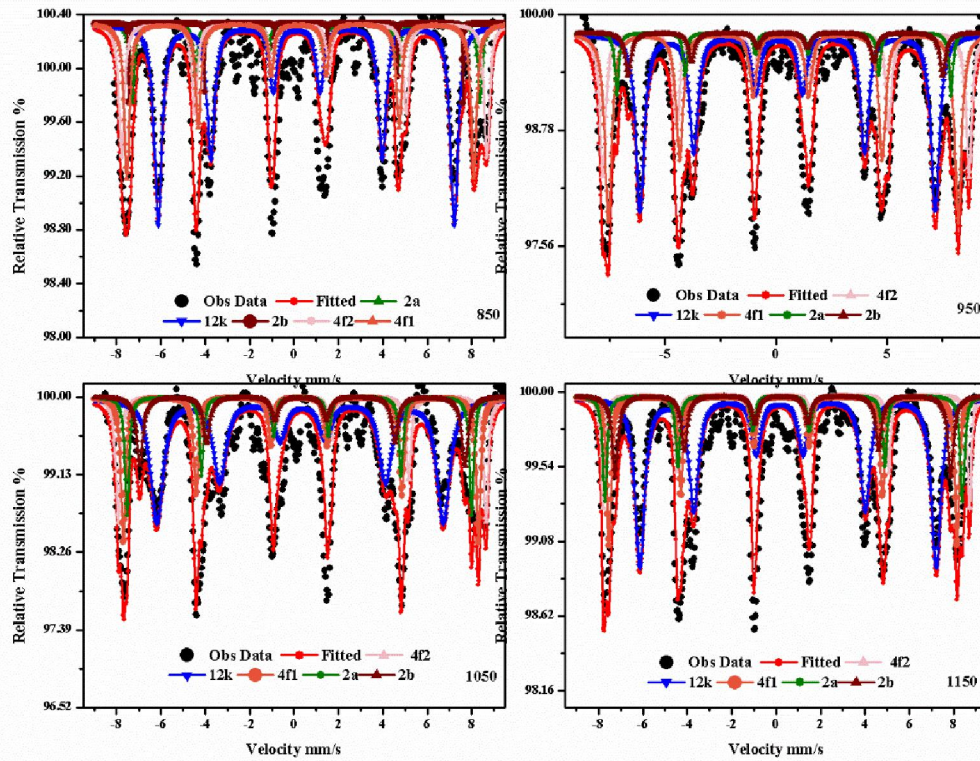


Figure 4 : Mössbauer spectra for $\text{Ba}_{0.8}\text{Y}_{0.2}\text{Fe}_{10.3}\text{Co}_{1.7}\text{O}_{19}$ hexaferrites

Table 3:

X	Sub Spectrum	Line width (mm/s)	IS ' δ ' (mm/s)	Q. Splitting	Hyperfine Field ' H_f '	(T) Area %
850	12k	0.41	0.32	0.43	41.47	43.88
	4f2	0.28	0.37	0.16	51.15	20.50
	4f1	0.29	0.24	0.07	48.59	23.16
	2a	0.22	0.31	0.44	48.69	9.10
	2b	0.01	0.19	-0.23	46.78	2.91
950	12k	0.45	0.33	0.37	41.32	36.57
	4f2	0.31	0.37	0.14	51.29	20.40
	4f1	0.36	0.27	0.10	48.95	31.47
	2a	0.20	0.31	0.09	46.81	5.78
	2b	0.30	0.36	0.12	44.04	5.78
1050	12k	0.69	0.32	-0.11	40.11	42.43

	4f2	0.25	0.36	0.00	51.50	15.47
	4f1	0.25	0.26	0.08	49.70	18.18
	2a	0.22	0.28	-0.08	48.25	12.89
	2b	0.33	0.33	0.06	45.54	11.02
1150	12k	0.52	0.35	0.37	41.50	45.19
	4f2	0.18	0.38	0.15	51.30	10.83
	4f1	0.24	0.28	0.05	48.75	18.62
	2a	0.23	0.29	0.10	50.06	12.48
	2b	0.31	0.27	0.06	46.98	12.88

Fig. 4 shows the Mossbauer spectra for the $\text{Ba}_{0.8}\text{Y}_{0.2}\text{Fe}_{10.3}\text{Co}_{1.7}\text{O}_{19}$ samples treated at temperatures of 850, 950, 1150 and 1050 °C, respectively.

Vibrating sample magnetometer:

Magnetic Property:

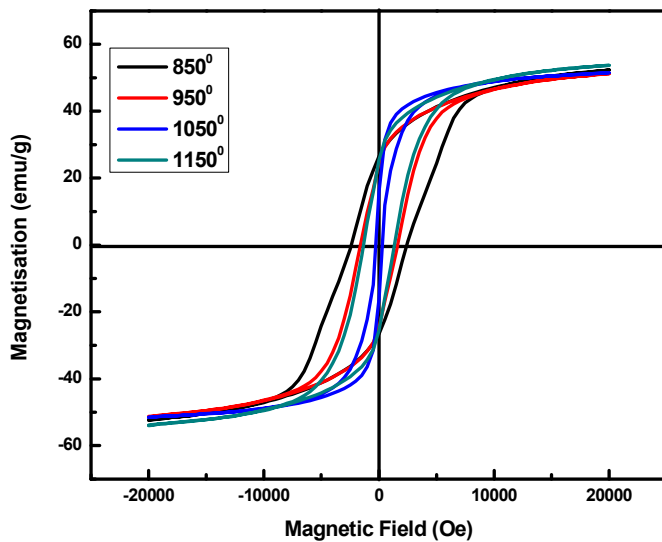


FIGURE 5: M-H curves for $\text{Ba}_{0.8}\text{Y}_{0.2}\text{Fe}_{10.3}\text{Co}_{1.7}\text{O}_{19}$

Temperature	M_s (emu/g)	M_r (emu/g)	H_c (Oe)
850 ⁰	52.25	26.52	2393
950 ⁰	51.24	24.66	1605
1050 ⁰	51.6	16.33	305
1150	53.70	25.60	1349

Temperature	M _s (emu/g)	M _r (emu/g)	H _c (Oe)	SR(M _r \M _s)	K(HA ² \Kg)	Magnetic Moment
850 ⁰	52.25	26.52	2393	0.50755981	6.251727119	9.757819786
950 ⁰	51.24	24.66	1605	0.48126464	4.112019616	9.569199728
1050 ⁰	51.6	16.33	305	0.31647287	0.78690184	9.63643064
1150	53.70	25.60	1349	0.47672253	3.62207347	10.0286109

SUMMARY

Magnetic nanoparticles exclusively hard nano ferrites have many applications in the field of permanent magnets, magneto-optic materials, microelectromechanical systems (MEMS), microwave devices and bio-medical. The physical and chemical properties of such nanoparticles mainly depend on the production method and chemical structure. In many applications, the particles size range from 1 to 100 nm. The main significance of the nanomaterial has three chief explanations:

- 1) Here is severe range of the nano structure, increasing properties like the physical property, extending from the naturally happening nanomagnets and they are very easy to form.
- 2) The involvement of nanoparticle effects in the improvement and explanation of the properties of innovative magnetic resources.
- 3) Nanomagnetism unlocks the entrance for innovative technologies.

The M-type nano-hexaferrites have been synthesized using sol-gel auto combustion technique and then characterized using XRD, FTIR and VSM. The XRD results of these studies confirmed the presence of hexagonal structure in prepared samples. The saturation magnetization, retentivity, coercivity and anisotropy are calculated using VSM.

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