Effect of Gamma Radiation on Electrical and Magnetic Properties of Bismuth Doped Cobalt Ferrite Nanoparticles

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Bismuth doped Cobalt ferrite nanoparticles has been prepared by sol-gel auto combustion method. Attempts have been made to study the electrical and magnetic transport properties of $CoBixFe_{2-x}O_4$ nanoparticles. The phase identification and morphological studies have been carried out by X-ray diffraction (XRD), Raman spectroscopy, Transmission electron microscopy (TEM) and Field emission scanning electron microscopy (FESEM).Obtained results confirm the presence of single phase spinal structure having space group Fd3m. In addition, spherical grains having diameters ranging from 20-30 nm has been detected through the FESEM and TEM micrographs. Further, Mossbauer study is conducted to observe the distribution of the cobalt and bismuth in the spinel ferrite. Magnetic susceptibility measurements both for MT and MH show the enhancement for saturation magnetization M_s and coreicivity H_c on the Bi substituted samples and with the irradiation. The isomer shift (δ), quadrupole splitting (Δ), and hyperfine field (H_f) corresponding to various concentration of Bi have been discussed with gamma irradiation.

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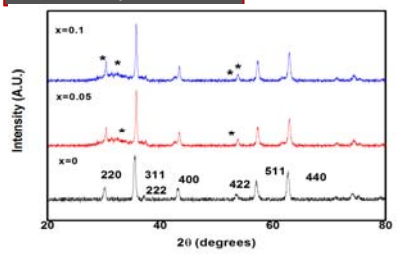
ABSTRACT:
Bismuth doped Cobalt ferrite nanoparticles has been prepared by sol-gel auto combustion method. Attempts have been made to study the electrical and magnetic transport properties of $CoBixFe_2$-xO_4 nanoparticles. The phase identification and morphological studies have been carried out by X-ray diffraction (XRD), Raman spectroscopy, Transmission electron microscopy (TEM) and Field emission scanning electron microscopy (FESEM).Obtained results confirm the presence of single phase spinal structure having space group Fd3m. In addition, spherical grains having diameters ranging from 20-30 nm has been detected through the FESEM and TEM micrographs. Further, Mossbauer study is conducted to observe the distribution of the cobalt and bismuth in the spinel ferrite. Magnetic susceptibility measurements both for MT and MH show the enhancement for saturation magnetization M_s and coreicivity H_c on the Bi substituted samples and with the irradiation. The isomer shift (δ), quadrupole splitting (Δ), and hyperfine field (H_f) corresponding to various concentration of Bi have been discussed with gamma irradiation.

INTRODUCTION::
- ❑ $CoFe_2O_4$ (CFO) is a hard magnet among soft spinel magnets which is characterized with large magneto-crystalline anisotropy and magneto-striction,
- ➢ chemical stability,
- ➢ unique nonlinear spin-wave properties and
- ➢ high resistivity along with low eddy current loss
- ➢ hard magnetic material
- ➢ high coercivity
- ➢ moderate magnetization
- ➢ large magnetic anisotropy
- ➢ large magnetostrictive coefficient
- ❑ Cobalt ferrite has an inverse spinel at bulk and partial inversion in nano order

Cation distribution is given by $(Fe^{3+}_{\delta}M^{2+}_{1-\delta})_A\ [Fe^{3+}_{2-\delta}M^{2+}_{\delta}]_B\ O_4$, where
δ is the degree of inversion, for the normal spinel,
δ = 0 whereas for the inverse spinel system,
δ = 1 and its value lies between 0 and 1 depending upon the synthesis techniques, calcination and sintering temperature.

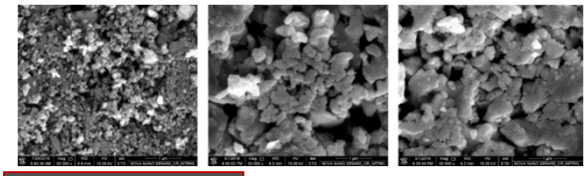
Structural analysis of $YBaCuFeO_5$

XRD Analysis:

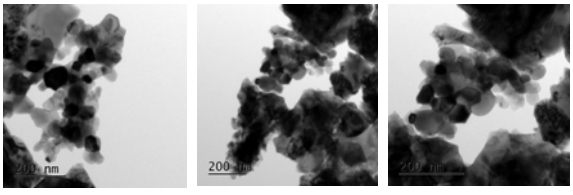


- (JCPDS-KDD) file number of (22-1086).
- Single phase fcc spinal structure.
- From the XRD pattern it is identified for x = 0.00 shows only peaks consistent with cubic spinal phase and rest of all the samples with the composition, x = 0.05 to 0.1, have additional peaks marked with the "*" sign, which corresponds to the element of Bismuth.

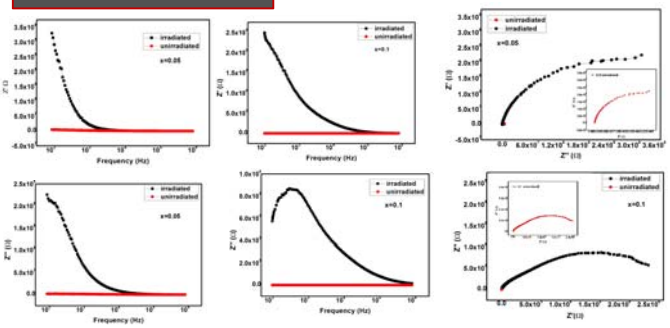
FESEM Analysis:



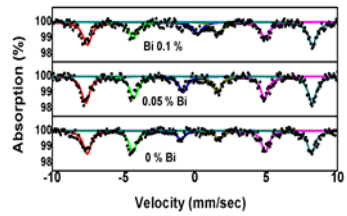
TEM Analysis:

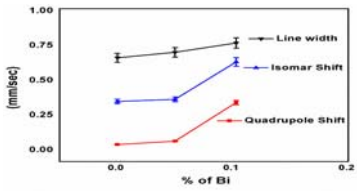


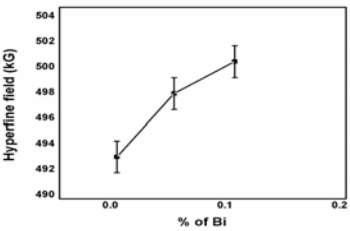
Dielectric studies:



Mossbauer study:



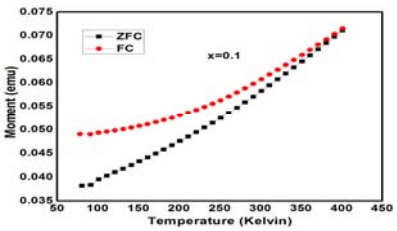


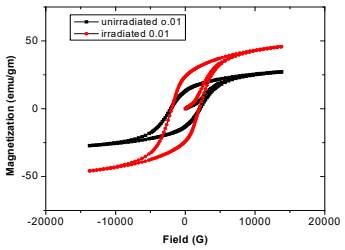


Mossbauer spectra shows the distribution of the cobalt and bismuth in the spinel ferrite.

- ❑The Mössbauer spectra exhibits a normal magnetic sextet, due to Fe^{3+} at the tetrahedral (A) sites and another due to Fe^{3+} at octahedral [B] sites.
- ❑The presence of a six-line pattern in all the spectra confirmed that they are from magnetically ordered ferrite products.
- ❑The isomer shift (δ), quadrupole splitting (Δ), and hyperfine field (H_f) corresponding to the tetrahedral (A) site and octahedral [B] sites can be obtained by a curve-fitting process (Win Normos software).
- ❑The δ values at both the (A) and [B] sites are nearly same for x = 0.0 and 0.05, indicating the s-electron distribution of the Fe^{3+} ions could be insensitive to the Bi^{3+} content.
- ❑The δ value at the (A) site is increased for x = 0.1, while at the [B] site it is decreased with increasing nonmagnetic Bi^{3+} content, which can be explained through the bonding nature of Fe^{3+} with Co^{2+} and Bi^{3+} at both sites.
- ❑With increasing 'x', Bi^{3+} can occupy both the tetrahedral (A) and octahedral [B] sites.
- ❑The increase in H_f with increase in Bi^{3+} ion concentration can be attributed to super transferred hyperfine field components, strongly influenced by the super exchange coupling with neighbouring ions and the magnetic moments of these ions.

Magnetic study:





CONCLUSION: Bi doped cobalt ferrite nano form shows increase in particle size with increase in Bi concentration.
The Mössbauer spectra exhibits a normal magnetic sextet, due to Fe^{3+} at the tetrahedral (A) sites and another due to Fe^{3+} at octahedral [B] sites.
It was observed from the room temperature M-H loop that irradiated sample showed higher saturation magnetization value and lower coercivity as compared to the unirradiated cobalt ferrite.

References:
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