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SYNTHESIS AND FTIR STUDIES OF COBALT SUBSTITUTED BARIUM HEXAFERRITE NANOPARTICLES

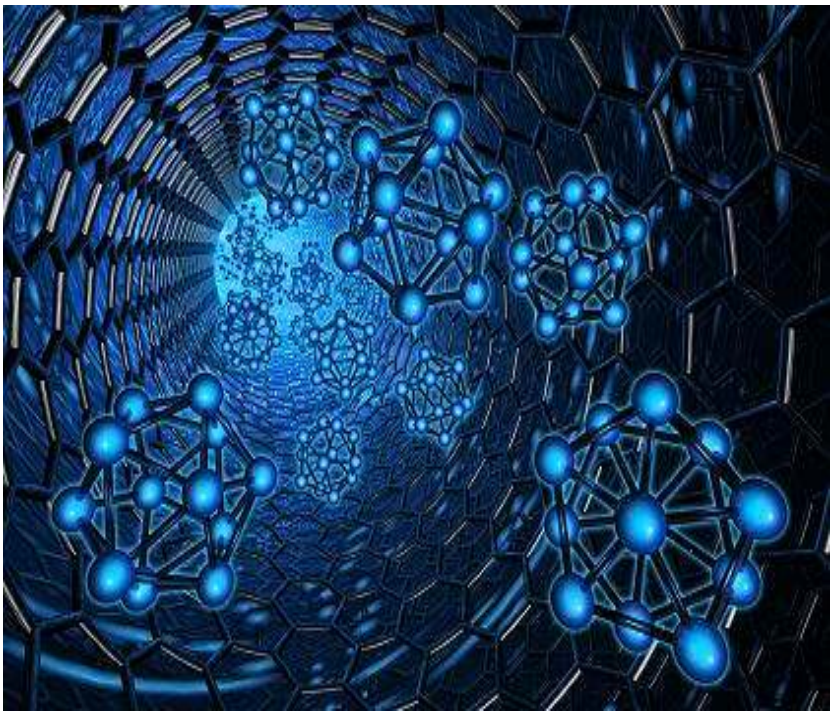
Varsha C. Chavan
Department of Physics, Yashawantrao Chavan Mahavidyalaya, Tuljapur Dist. Osmanabad (MS) INDIA

Short Profile

Varsha C. Chavan is working at Department of Physics in Yashawantrao Chavan Mahavidyalaya, Tuljapur Dist. Osmanabad (MS) INDIA.

Co-Author Details :

Surendra S. More
Department of Physics, Yashawantrao Chavan Mahavidyalaya, Tuljapur Dist. Osmanabad (MS) INDIA.



ABSTRACT:
The present paper deals with the investigations on how the Fourier transform infrared spectroscopy studies of cobalt substituted M-type $BaFe_{12}O_{19}$ ferrite nanoparticles prepared by sol-gel auto-combustion technique. Fourier Transform Infrared (FTIR) spectroscopy technique for the confirmation of crystal structure is outlined.

KEYWORDS
M-type, FTIR, Nanoparticles.

INTRODUCTION

The permanent magnet and high density magnetic recording media [1–3] are just two of the many applications that exist for M-type hexagonal barium hexaferrite with its stoichiometric chemical formula $BaFe_{12}O_{19}$, often denoted as BHF. Barium exaferrite ($BaFe_{12}O_{19}$), an M-type ferrimagnetic material, has hexagonal symmetry with space group $P6_3/mmc$. A unit cell of BHF consists of two formula units of $BaFe_{12}O_{19}$, i.e. 64 ions. Oxygen forms the closed packed structure while Fe and Ba ions are distributed among five sublattice sites namely 2a, 12k, 4f2 (octahedral), 2b (trigonal bipyramidal), and 4f1 (tetrahedral) [4]. Due to high commercial interest in the suitability of this compound as a material for magnetic recording, much effort has been made to the production of cation substituted BHF to further improve its magnetic attributes.

The electrical and magnetic properties of substituted BHF ferrites are strongly dependent on the synthesis conditions as disproportionate charge distributions generally occur for multivalent cationic doping. There is also a concomitant structural implication when doping with $Co^{2+/3+}$ ions influencing the magneto-dielectric properties of this compound. Thus, cobalt doping in particular has been the subject of many such investigations [5-7]. Various techniques were proposed to synthesize BHF nanoparticles and these mainly included the traditional ceramic process,18 chemical coprecipitation method [8, 9] sol–gel method [10] gel self-combustion method [11] microwave-induced combustion synthesis [12], aerosol pyrolysis technique [13], sonochemical approach [14], glass-crystallization method [15], and spark plasma sintering process [16, 17]. The sol–gel method has been demonstrated to be the optimal technique to synthesize BaM nanoparticles with a narrower grain-size distribution due to its atom-level mixture of metal cations and low-crystallization temperature. In this study the effect of Co^{2+} substitution in place of Ba^{2+} prepared by sol-gel auto-combustion technique has discussed in details.

2.EXPERIMENTAL TECHNIQUES

Co2+ substituted M-type barium hexaferrite nanoparticles with the generic formula $Ba_{1-x}Co_xFe_{12}O_{19}$ (x=0.0, 0.50 and 1.0) were prepared by sol-gel auto-combustion technique using AR grade nitrates of respective cations. Citric acid was used as chelating agent. All starting materials were dissolved in de-ionized water with required molarities. The metal nitrate to citric acid ratio was mentioned at 1:3. The solutions of the precursors were mixed and heated on hot plate with violent stirring. The pH of the solution plays a major role in the formation of a compound. The pH of the solution was kept at 8 by using ammonia solution. The as-prepared samples were sintered at 600 ^{0}C for 6h and used for characterization. The Fourier Transform infrared (IR) spectra were recorded using Perkin-Elmer spectrometer.

3.RESULTS AND DISCUSSION

Fourier infrared spectra of all the samples of the $Ba_{1-x}Co_xFe_{12}O_{19}$ (x= 0.0, 0.5 and 1.00) ferrite nanoparticles were recorded at room temperature in the range 400 cm^{-1} - 4000 cm^{-1} on a Perkin Elemer spectrometer (Model 783). To study the FTIR spectra of all the samples, about one gram of fine powder of each sample was mixed with KBr in the ratio 1:250 by weight to ensure uniform distribution in the KBr pellet. The mixed powder was then pressed in a cylindrical die to obtain clean disc of approximately 1 mm thickness. The IR spectra were used to locate the band position. The infrared spectra reviles the detailed information about the structural changes occurred due to the Co^{2+} substitution in $BaFe_{12}O_{19}$ M-

type hexaferrite material. The positions of all adsorption bands of the products are very similar, while their relative intensities varied (Figure 1).

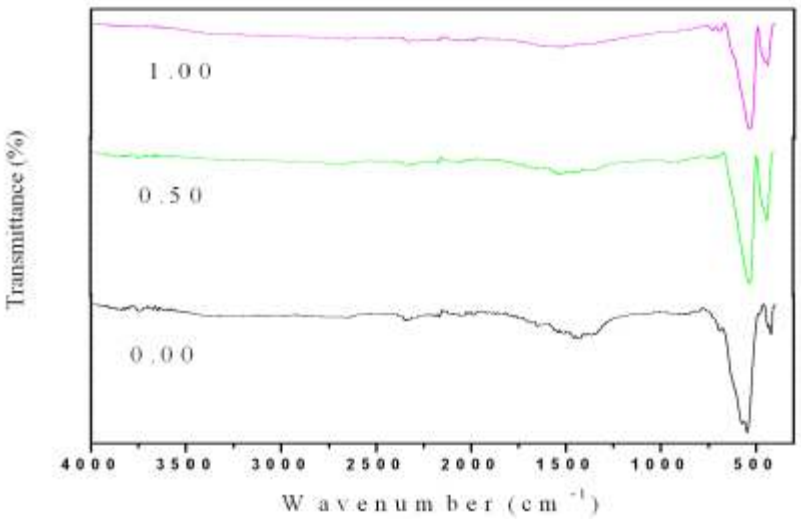


Figure 1: Fourier infrared spectra of $Ba_{1-x}Co_xFe_{12}O_{19}$ (x= 0.0, 0.5 and 1.00) ferrite nanoparticles

The spectra recorded for all the samples shows two strong characteristic absorption bands in the area between 400 cm^{-1} and 800 cm^{-1}, which are related to the Fe–O stretching vibration band in octahedral and tetrahedral sites [18, 19]. Band in the range 420–443 cm^{-1} corresponds to the assignment of Fe-O bending by Fe-O_4 and Fe-O stretching by Fe-O6 whereas, the band in the range 530–550 cm^{-1} corresponds to the Fe-O stretching by Fe-O_4. For the undoped ferrite, the absorption peak at about 579 cm^{-1} is distinguished which is associated with Ba–O stretching vibration band. This peak cannot be observed in the doped samples [20]. The small absorption peak (for x = 0.00 and 0.25) in the range 1360–1460 cm^{-1} related to M–O–M bands (Metal–Oxygen–Metal) such as Co–O–Co and Fe–O–Fe bands [19].

4.CONCLUSIONS

In summary, we have successfully synthesized $Ba_{1-x}CoxFe_{12}O_{19}$ nanoparticels by sol-gel auto-combustion technique. It is observed that the increase in the Co^{2+} content causes the change in the intensity of the FTIR spectra. Lattice constant 'a' and 'c' increased with the increase in Dy^{3+} substitution. Dy^{3+} substitution also affects the other structural parameters such as density and porosity of BaM nanoparticles.

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