IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 09, Issue 5 (May. 2019), ||S (II) || PP 06-08

Synthesis and Gamma Radiation Effect on the Structural Properties of Cobalt Ferrite Nanoparticles

Vishnu B. Raut[1], Jitendra S. Kounsalye[1], Apparao R. Chavan[1], V. K. Mande[1], S. K. Vyawahare[2]

[1]*Department of Physics, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad, India (M.S.)*
[2]*P.G. and Research Center, Deogiri College, Aurangabad, India (M.S.)*
Corresponding Author: Vishnu B. Raut

Abstract: In the present work, cobalt ferrite nanoparticles were synthesized by sol-gel auto combustion method using citric acid as a fuel. The metal nitrate to fuel ratio was taken as 1:3. The as prepared powder of cobalt ferrite was sintered at 550°C for 4 h and used for further characterizations. The sintered pellet of cobalt ferrite is gamma irradiated using Co^{60} source. The structural characterizations were made using X-ray diffraction technique for both gamma irradiated and unirradiated cobalt ferrite nanoparticles. X-ray diffraction (XRD) pattern revealed the formation of single phase cubic spinel structure. No extra peak has been observed in both the XRD patterns. The Bragg's reflections in the XRD pattern show changes in the intensity and broadening. The crystallite size calculated from Scherrer's formula was found to be 28.76 nm for gamma unirradiated and 44 nm for gamma irradiated cobalt ferrite nanoparticles. The lattice constant found to be 8.383 Å for gamma unirradiated and 8.377 Å for gamma irradiated cobalt ferrite nanoparticles. Thus, the values of structural parameters indicate the strong influence of gamma irradiation.

Keywords: Cobalt ferrite nanoparticles, Gamma irradiation, XRD.

Date of Submission: 09-05-2019 Date of acceptance: 25-05-2019

I. INTRODUCTION

Recently, magnetic nanoparticles are studied intensively because of their novel physicochemical properties.Many magnetic nanoparticles like Fe_3O_4, Fe_2O_3, γ-Fe_2O_3have been synthesized at nanoscale and studied for various properties by means of standard techniques. Ferrite nanoparticles are also very important from the point of their technological applications. Interest in these nanoparticles arises mainly due to their smaller size, large surface to volume ratio and chemical stability. They have been technologically important on account of their high resistivity and negligible eddy current losses, high saturation magnetization, high magneto anisotropy constant. Spinel ferrite possesses combination of ferromagnetic like magnetic and insulator like electrical properties and therefore, they are of prime interest to many researchers. On account of their interesting electrical and magnetic properties they have large number of applications ranging from microwave frequency to radiofrequency. They find application in the field of magnetic, electronics, magneto electronics, optical devices, optoelectronic devices, sensors, catalyst, drug delivery systems, medical diagnostics, ferrofluids etc [1-4].

These applications of spinel ferrite nanoparticles are depends on characteristics features like moderate saturation magnetization, low coercive value, superparamagnetic nature, uniform size distribution, chemical stability, biocompatibility, easily separable etc [5-6]. All these characteristics of magnetic nanoparticles are dependent mostly on method of preparation and associated parameters. Many wet chemical methods have been developed to synthesize spinel ferrite nanoparticles. The wet chemical methods include chemical coprecipitation, sol-gel auto combustion, sol-gel synthesis, reverse micelle, microemulsion etc [7-8]. Among these methods sol-gel auto combustion method is more popular and largely used by many researchers. The method produces fine, nanosized,homogeneous, chemically stable nanoparticles of spinel ferrites. It is a great challenge for the researchers to obtain such magnetic nanoparticles for desired applications.

Spinel ferrites are characterized by the formula MFe_2O_4 where M is a divalent cation of different ionic radii such as cobalt, nickel, manganese, magnesium, zinc etc. Spinel ferrite structure is cubic FCC type with space group $Fd3mO_h^7$. The crystal structure of spinel ferrite possess two interstitial sites namely tetrahedral (A) and octahedral [B] sites, in which cations of different valence and size can be incorporated bringing wide variation in the electrical and magnetic properties. These properties of spinel ferrite can be modified by doping various cations like Cd, Al, Cr etc or by irradiating it by means of swift heavy ions (SHI), Laser radiations,

Gamma radiations etc [9]. Gamma irradiation may produce defects in the structure and thereby changes in the structural, morphological and other properties can be achieved [10].

In the family of spinel ferrite, cobalt ferrite is one of the best candidate exhibiting excellent electrical and magnetic properties for number of applications. Cobalt ferrite possesses inverse spinel structure which can be changed or modified when irradiated by gamma rays. Cobalt ferrite is a hard magnetic material with high saturation magnetization and high electrical resitivity.

In view of the above facts the aim of the present work is to synthesize cobalt ferrite nanoparticles using sol-gel auto combustion method and investigate the effect of gamma radiation on its structural properties. The structural properties were studied by means of X-ray diffraction technique at room temperature. The prepared cobalt ferrite nanoparticles were irradiated by Co^{60} gamma source.

II. EXPERIMENTAL

Cobalt ferrite nanoparticles were synthesized by sol-gel auto combustion method using AR grade cobalt nitrate (Co $(NO_3)_2$ $6H_2O$) and ferric nitrate (Fe $(NO_3)_3$ $9H_2O$) as a raw materials. The nitrates were dissolved in double distilled water. Citric acid was added in the mixed solution of the nitrates as a fuel. The mixed solution is stirred continuously and kept at a temperature of 60°C. The resultant mixture converts into sol after some time and then converts into gel. The temperature is slightly raised about 100°C. After that, bubbling and ignition takes place. Finally, a fluffy powder is formed which is a final product i.e. cobalt ferrite nanoparticles. The detail procedure of the sol-gel auto combustion synthesis technique is described in our previously reported articles.

Characterizations

Powder X-ray diffraction patterns were recorded at room temperature using Bruker D8 advance X-ray diffractometer (RUSA Center, Dr. B. A. M. University, Aurangabad). The samples in the form of pellet were Gamma irradiated using Co^{60} source.

III. RESULTS AND DISCUSSION

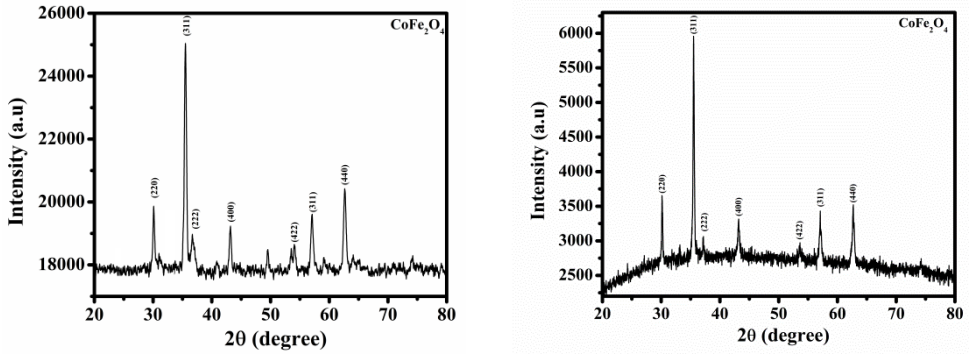

Fig. 1 X-ray diffraction patterns of cobalt ferrite nanoparticles before irrradiation (a) and after irradiation (b)

Fig. 1 (a-b) represents X-ray diffraction pattern of cobalt ferrite nanoparticles before and after irradiation respectively. The X-ray diffraction patterns were recorded at room temperature. Both the XRD pattern shows the reflections which belong to cubic spinel structure. The analysis of the XRD pattern reveals the formation of single phase cubic spinel structure. A careful observation of XRD patterns indicates that, the most intense peak (311) is slightly broader as compared to irradiated sample. The crystallite size calculated by using Scherrer's formula is of the order of 28.76 and 44.36 nm for unirradiated and irradiated samples respectively. The lattice constant calculated from the XRD data slightly decreases for gamma irradiated samples. Similarly, the latticeconstant dependent X-ray density and Unit cell volume both decreased after gamma irradiation. The values of crystallite size, lattice constant, X-ray density and Unit cell volume are listed in table 1. It is observed from their values that, gamma radiation influences the structural parameters.

Table 1 Crystallite size (t), Lattice constant (a), X-ray density (d_X) and unit cell volume for cobalt ferrite nanoparticles before and after gamma irradiation

Parameters	Before Irradiation	After Irradiation
Crystallite Size (t)	**28.76**	**44.36**
Lattice Constant(a) (Å)	**8.383**	**8.377**
Volume $(Å)^3$	**589.1**	**587.8**
X-ray density (d_X)	**5.331**	**5.342**

IV. CONCLUSIONS

Cobalt ferrite nanoparticles were successfully prepared by sol-gel auto combustion method. XRD patterns reveal the formation of single phase cubic spinel structure. The lattice constant, X-ray density, Unit cell volume all get decreased after gamma irradiation while the crystallite size increases after gamma irradiation.

ACKNOWLEDGEMENT

Author V. B. Raut is thankful to Director, Institute of Science, Aurangabad, for providing Gamma ray irradiation facility.

REFERENCES

[1]. A. Raut, R. Barkule, D. Shengule, K. Jadhav, Synthesis, structural investigation and magnetic properties of Zn2+ substituted cobalt ferrite nanoparticles prepared by the sol–gel auto-combustion technique, Journal of Magnetism and Magnetic Materials, 358 (2014) 87-92.
[2]. V. Kawade, G. Bichile, K. Jadhav, X-ray and infrared studies of chromium substituted magnesium ferrite, Materials Letters, 42 (2000) 33-37.
[3]. P. Hankare, R. Patil, U. Sankpal, S. Jadhav, P. Lokhande, K. Jadhav, R. Sasikala, Investigation of structural and magnetic properties of nanocrystalline manganese substituted lithium ferrites, Journal of Solid State Chemistry, 182 (2009) 3217-3221.
[4]. B. Toksha, S.E. Shirsath, S. Patange, K. Jadhav, Structural investigations and magnetic properties of cobalt ferrite nanoparticles prepared by sol–gel auto combustion method, Solid State Communications, 147 (2008) 479-483.
[5]. J.S. Kounsalye, P.B. Kharat, M.V. Shisode, K. Jadhav, Influence of Ti4+ ion substitution on structural, electrical and dielectric properties of Li0. 5Fe2. 5O4 nanoparticles, Journal of Materials Science: Materials in Electronics, 28 (2017) 17254-17261.
[6]. A.V. Humbe, J.S. Kounsalye, M.V. Shisode, K. Jadhav, Rietveld refinement, morphology and superparamagnetism of nanocrystalline Ni0. 70− xCuxZn0. 30Fe2O4 spinel ferrite, Ceramics International, 44 (2018) 5466-5472.
[7]. D.S. Mathew, R.-S. Juang, An overview of the structure and magnetism of spinel ferrite nanoparticles and their synthesis in microemulsions, Chemical engineering journal, 129 (2007) 51-65.
[8]. P.B. Kharat, S.B. Somvanshi, J.S. Kounsalye, S.S. Deshmukh, P.P. Khirade, K. Jadhav, Temperature dependent viscosity of cobalt ferrite/ethylene glycol ferrofluids, in: AIP Conference Proceedings, AIP Publishing, 2018, pp. 050044.
[9]. J.S. Kounsalye, A.V. Humbe, A.R. Chavan, K. Jadhav, Rietveld, cation distribution and elastic investigations of nanocrystalline Li0. 5+ 0.5 xZrxFe2. 5-1.5 xO4 synthesized via sol-gel route, Physica B: Condensed Matter, 547 (2018) 64-71.
[10]. A. El-Sayed, Influence of zinc content on some properties of Ni–Zn ferrites, Ceramics International, 28 (2002) 363-367.

IOSR Journal of Engineering (IOSRJEN) is UGC approved Journal with Sl. No. 3240, Journal no. 48995.

Vishnu B. Raut. "Synthesis and Gamma Radiation Effect on the Structural Properties of Cobalt Ferrite Nanoparticles." IOSR Journal of Engineering (IOSRJEN), vol. 09, no. 05, 2019, pp. 06-08.