IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

Impact Factor: 6.252

Volume 2, Issue 4, April 2022

Synthesis and Characterization of Cobalt Zinc Ferrites by Coprecipitation Method

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Abstract: *Nanotechnology includes the development of man-made or engineered particles and molecular structures that have dimensions in the nanometer range (typically between 1-100nm in at least one dimension). Cobalt ferrite nano powder was obtained by coprecipitation method using NaOH. The metal chlorides such as zinc chloride, cobalt chloride and ferric chloride were used as source materials. The metal chloride to NaOH ratio was taken as 1:4 i.e. (300ml:1200ml).The pH of formed substance was maintained at 5.The prepared powder of cobalt Ferrite was used for characterization and investigation of structural and magnetic properties. X-ray diffraction (XRD) analysis and Fourier Transform Infrared (FTIR) were carried out to study the structural and magnetic properties respectively. The structural characterization of Zinc Cobalt Ferrite nanoparticles were done by XRD. The spinel structure and crystalline water absorption of $Co_{1-x}Zn_xFe_2O_4$ nanoparticles were studied by using FTIR. The coprecipitation method requires high temperature and more time. The size and properties of spinel ferrites nanoparticles are greatly depend upon pH, heating of compound, stirring time and speed, metal ferrite to fuel ratio (NaOH) etc. Ferrites are ferromagnetic oxides consisting of ferrite XRD. oxide and metal oxide Ferrites are ferromagnetic oxides consisting of ferric oxide and metal oxide. Ferrites are divided into three classes- hexagonal ferrite, spinel ferrite and garnet ferrite. In the last ten years research on Nano size spinel ferrite has been considerably increase due to their superior properties and applications in new fields like magnetic drug delivery, biomedical applications, etc. Among the different spinel ferrites Cobalt Zinc ferrite ($Co_{1-x}Zn_xFe_2O_4$) with inverse spinel structure has high electrical properties, high magnetic properties, good mechanical properties and chemical stability.*

Keywords: Coprecipitation method, Cobalt Zinc Ferrite ($Co_{1-x}Zn_xFe_2O_4$), Spinel Ferrite, FTIR.

I. Introduction

Ferrites are mixed oxide magnetic materials in which the iron oxide is main component. Ferrites have opened a new era in the physics of magnetic materials. Since they show high resistivity and negative temperature coefficient of resistance like semiconductors and are also good dielectrics[20]. If the high electrical resistivity of ferrites is controlled with useful magnetic properties, the resultant material could be suitable for high frequency applications. Many researchers have made efforts to synthesis the ferrite materials for various application. The first commercially available ferrite device the "UNLINE" manufactured by Caceade Research Corporation, California, USA in 1953. Since then, the study of ferrites has been subject of many research workers. The history of ferrites (magnetic oxides) and their applications have been known for several centuries ago. The loadstone (magnetite,Fe3O4), a natural non-metallic solid, may attract iron was first described in known Greek writings about 800 B.C. Much later, the first application of magnetite was as 'Lodestones' used by early navigators to locate magnetic North. That is the first scientific significance was appreciated, after the first technical magnetic material because it formed the first compass (Crangle, 1977). The first scientific study of magnetism named De Magnate was published by William Gilbert in 1600. Later, in 1819 Hans Christian Oersted observed that an electric current in a wire affected a magnetic compass needle. Naturally occurring magnetite is a weak 'hard' ferrite.

'Hard' ferrites possess a magnetism which is essentially permanent. Originally manufactured in a few select shapes and sizes, primarily for inductor and antenna applications, 'soft' ferrite has proliferated into countless sizes and shapes for a multitude of uses. Furthermore, ferrites are used predominately in three areas of electronics: low level applications, power applications, and Electro-Magnetic Interference (EMI) suppression. The breadth of application of ferrites in electronic circuitry continues to grow. The wide range of possible geometries, the continuing improvements in material characteristics and their relative cost-effectiveness makes ferrite components the choice for both conventional and innovative applications. Basically, ferrites are ceramic materials, dark grey or black in appearance and very hard and brittle. Ferrites may be defined as magnetic materials composed of oxides containing ferric ions as the main constituent (the word ferrite comes from the Latin “ferrum” for iron) and classified as magnetic materials because they exhibit ferromagnetic behaviour. The ferrites, in powder or thin film forms, can be prepared by high-temperature solid-state reaction method, sol–gel method, coprecipitation, pulsed laser deposition, high-energy ball milling and hydrothermal technique.et.al-[2].

The first application of magnetite was as ‘Lodestones’ used by early navigators to locate magnetic North. Naturally occurring magnetite is a ‘hard’ ferrite. ‘Hard’ ferrites possess a magnetism which is essentially permanent. In time, man-made ‘hard’ ferrites with superior properties were developed but producing an analogous ‘soft’ magnetic material in the laboratory proved elusive

II. Preparation of Ferrites

Materials used are Cobalt chloride, Zinc chloride, Ferric chloride, Sodium hydroxide and distilled water etc. Using distilled water for preparation of solution is important to reduce the chances of the presence of the impurities in the final product. The solution was prepared with the molar ratio of metal ferrite to NaOH at 1:4, where the stoichiometric amount of Cobalt chloride,Zinc chloride, Ferric chloride and NaOH were used The pH of the prepared solution was adjusted to 5 with the drop wise addition of NaOH along with constant stirring using vertical stirrer and the solution was heated up to 90 degree Celsius until the solution became viscous liquid. This solution was filtered out using whatmann filter paper so that brown gel was obtained. This compound was kept under dropwise addition by distilled water for about two days and the pH of filtered solvent was maintained at 5

Using pH paper. Obtained compound was heated in muffle furnace for about at 500℃ for 4 hours continuously in order to remove moisture from the mixture, granules of ferrite substance was obtained and then made to fine powder using pestle. The structural characterization was carried out by the X ray diffraction and FTIR technique at CFC centre of Shivaji University, Kolhapur Maharashtra.

III. Result and Discussion

3.1 Characterization of Ferrites by X-ray Diffraction Pattern

X-ray diffraction technique is used to understand the formation of desired materials and to understand its structural details. The X-rays could undergo diffraction by the crystals; the planes can acts as the grating for the X-rays, $2d\sin\theta = \mathbf{n\lambda}$, where, n = order of diffraction, λ= wavelength of monochromatic x-rays, d = inter planner distance, θ = glancing angle. Given equation is known as Bragg’s equation. There are three methods of x-ray diffraction, in which variation of θ and λ considered. Here we use powder method for the crystallization of the prepared zinc ferrite. In this method, wavelength of the radiation is fixed and the sample is rotating. The powdered sample consisting of crystals of different orientations and hence the diffractogram shows the peaks. The powder diffraction method has been used extensively, because of its accuracy and ability to identify the existence of the phases.

	Zinc content in cobalt ferrite			
hkl	**0.9**	**0.5**	**0.3**	**0.1**
220	29.8072	31.0313	32.2716	33.3218
311	33.4066	35.3699	35.1061	35.6542
400	40.6054	41.0963	40.7752	41.3008

Table 1: XRD characterization

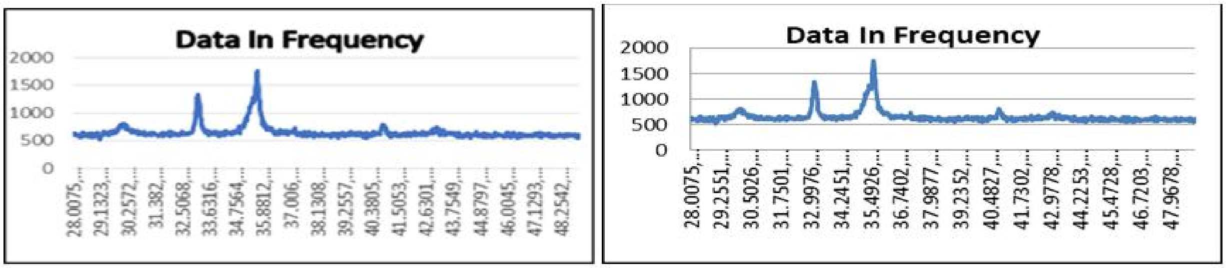

Figure 1: Shows the X-ray diffractogram of Cobalt Zinc Ferrite x=0.1,0.3

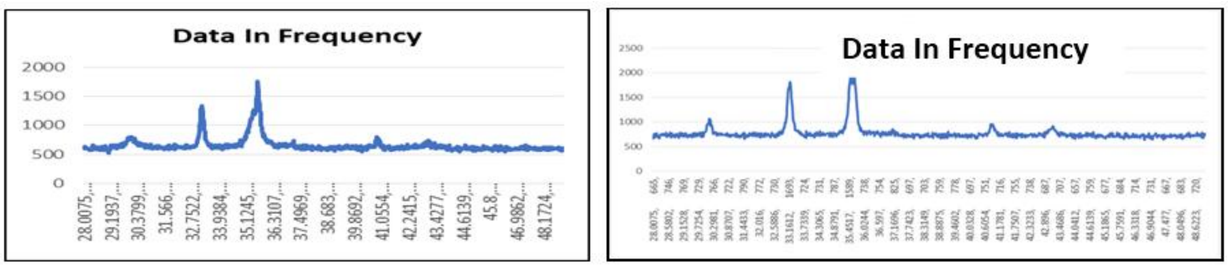

Figure 2: Shows the X-ray diffractogram of Cobalt Zinc Ferrite x=0.1,0.3

It is conclude that fig-1and 2 shows the X-ray diffraction pattern Zinc cobalt ferrite nanoparticles. All the peak belongs to cubic spinel structure and the analysis of XRD pattern prove the formation of spinel ferrite structure. XRD peak corresponding to most intense 311 peak of the XRD pattern.

3.2 Far Infrared Absorption Spectroscopy

Zn content in cobalt Ferrite	ϑ_1	ϑ_2	ϑ_3	ϑ_4
0.6	**3488.92**	**1520.13**	**1139.52**	**640.89**
0.2	**3474.71**	**1518.08**	**1139.12**	**723.55**

Table 2: FTIR characterization [12]

The FTIR characterization has been done to understand the bond formation and synthesis material is ferrite. It is rapid method of characterization. These methods help us to understand the structure of functional groups and their linkages. The results of IR absorption study help us to understand electrical and magnetic properties of ferrites. In this report, the IR absorption analysis of Zn substituted Co- ferrites have been discussed. The IR spectra of samples in present case were obtained from common facility Centre, Shivaji University Kolhapur Maharashtra.

It conclude that in present case from the IR spectra the frequency of absorption bands ϑ_1, ϑ_2, $\vartheta_{3,}$ and ϑ_4 obtained.

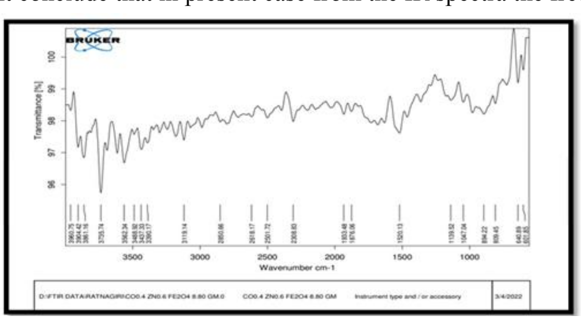

Figure 3: Infrared of $Co_{0.4}Zn_{0.6}Fe_2O_4$

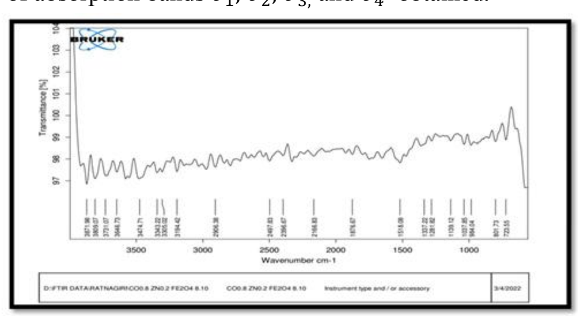

Figure 4: Infrared of $Co_{0.8}Zn_{0.2}Fe_2O_4$

IV. Discussion on Result

From characterization of XRD showed that the formation of spinel structure ferrite. The reflections observe are at 220, 311, 400, 422, Sand 511 here the spinel structure have highest intensity. The strongest reflection comes from the 311 plane, it denote spinel phase. The broad XRD line shows that particles are of Nano size range [13], [14]. FTIR characterization from fig. shows the formation of metal-oxygen bonds. The transmission wave bond ϑ_1 - ϑ_4 (3488.92-640.89) which corresponds to formation of oxygen bond and it confirms the formation of cobalt zinc ferrite. Bond length increases with increase in zinc concentration.

V. Conclusion

Preparation techniques suitable for preparation Co-Zn substituted ferrite nanoparticles using co-precipitation are reported. The formation of $Co_{1-x}Zn_xFe_2O_4$ using Co-precipitation method were confirmed by X-ray diffraction. The chemical structure bonds formed were with FTIR, which confirms the chemical structure of spinel ferrite of COF. The structural data of the present cobalt ferrite is in the reported range. The Cobalt Zinc Ferrites with high saturation magnetization can be synthesized for composition x=0.1, 0.2, 0.3, 0.5 & 0.9 by employing wet chemical Co-precipitation.

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VI. Acknowledgement

Our special thanks to D.D.Kulkarni sir (HOD), Aniket Nandiskar sir, our guide Vishwesh R. Joshi sir, for their right directional and valuable guidance. We sincerely thank our physics department staffs for providing us laboratory facilities and instruments which were very essential for our experimental work. We also thankful to chemistry department for providing us glass wears and muffle furnace and thanks to head of chemistry department Sathe Sir for giving permission to use the lab. We thankful to Mr. D. D. Kulkarni sir, whose very important spiritual blessings gives moral support during this work.

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