SYNTHESIS, CHARACTERIZATION AND STUDY OF SOLID STATE PROPERTIES OF COBALT-ZINC FERRITES

A MSc. Dissertation report by:

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SYNTHESIS, CHARACTERIZATION AND STUDY OF SOLID STATE PROPERTIES OF COBALT-ZINC FERRITES ($Co_xZn_{1-x}Fe_2O_4$)

A DISSERTATION REPORT

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By
Ms. Shradha R. Thanekar

To the

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STATEMENT

I here by declare that the matter presented in this report entitled "***Synthesis, Characterization and study of solid state properties of Cobalt-Zinc ferrites"*** is based on the result of he investigations carried out by me in School of Chemical Sciences, Goa University under the guidance of Prof. Dr. Vidyadatta Verenkar, sir.

Miss. SHRADHA R. THANEKAR

School of Chemical Sciences

Goa-University

CERTIFICATE

This is to certify that the dissertation entitled "***Synthesis, characterization and study of solid state properties of Cobalt-Zinc ferrites***" is bonafied work carried out by Ms. Shradha Rajan Thanekar under my supervision and partial fulfillment of the requirements for the award of the degree of Master of Science in Chemistry at the School of Chemical Sciences, Goa University.

Prof. Dr. Vidyadatta Verenkar

Guiding Teacher

Dean of School of Chemical Sciences

Goa University

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1. INTRODUCTION:

Ceramic like ferromagnetic material which are mainly composed of ferric oxide α-Fe_2O_3, are called as “ferrites” [1]. Although the saturation magnetization of ferrite is a smaller amount half of ferromagnetic alloys, but they need advantages like applicability at high resistivity, cheaper price, higher frequency, greater heat resistance, and better corrosion resistance [2] . The growing interest of ferrites is due to their chemical stability, biological availability, and their easy preparation. In recent years, ferrites (MFe_2O_4, where M is a divalent cation) have been considered as important electronic material. [3] Magnetite, Fe3O4, which is a natural mineral, is a genuine ferrite, and it is said that ancient people had recognized its magnetism and that it was used as a mariner’s compass in China more than two millennia ago [1] . Public attention was thoroughly aroused as to the importance of ferrites after the 1950s, because new applications—such as radio, television, carrier telephony, computer circuitry, and microwave devices—were rapidly expanding. At the same time, physicists and electronics engineers worldwide became greatly interested in the unique magnetism and the expanded high-frequency applications of ferrites. Research scientists in chemistry, ceramics, and metallurgy also began to study ferrites, and they have been engaged in the development of new ferrites, enhancement of existing ferrite characteristics, and improvement of ferrite manufacturing processes.

Cobalt-Zinc ferrites due to their specific electrical, magnetic, and optical properties have been widely investigated. Because of their application in sensors, drug delivery, microwave absorption and magnetic resonance imaging they are gaining a wide attraction. There are several methods for preparation of Co-Zn ferrites like sol-gel, coprecipitation, auto combustion, microwave hydrothermal, solution combustion, modified citrate gel and combustion methods. Above all, methods coprecipitation was widely used as it is inexpensive and doesn’t require any harsh experimental condition.

Ferrites can be categorized into two classes on the basis of their magnetic coercivity: soft ferrites and hard ferrites.

Soft Ferrites: - Ferrites having low coercivity and low hysteresis losses are called as soft ferrites. Used in the cores of switched-mode power supply, RF transformers, and inductors. Manganese ferrite ($MnFe_2O_4$), Zinc ferrite ($ZnFe_2O_4$), Nickel ferrite ($NiFe_2O_4$), Copper ferrite (CuFe2O4), Lithium ferrite ($Li_{0.5}Fe_{2.5}O_4$) are some examples of soft ferrite.

Hard Ferrites: -The ferrites having comparatively high coercivity (2 kOe or higher) are called as hard ferrites. They are used in loudspeaker, automotive system, and so on, as permanent magnets. Barium ferrite ($BaFe_{12}O_{19}$) and cobalt ferrite ($CoFe_2O_4$) are some typical examples of hard ferrite.

1.1. CLASSIFICATION OF FERRITES BASED ON CRYSTAL STRUCTURE:

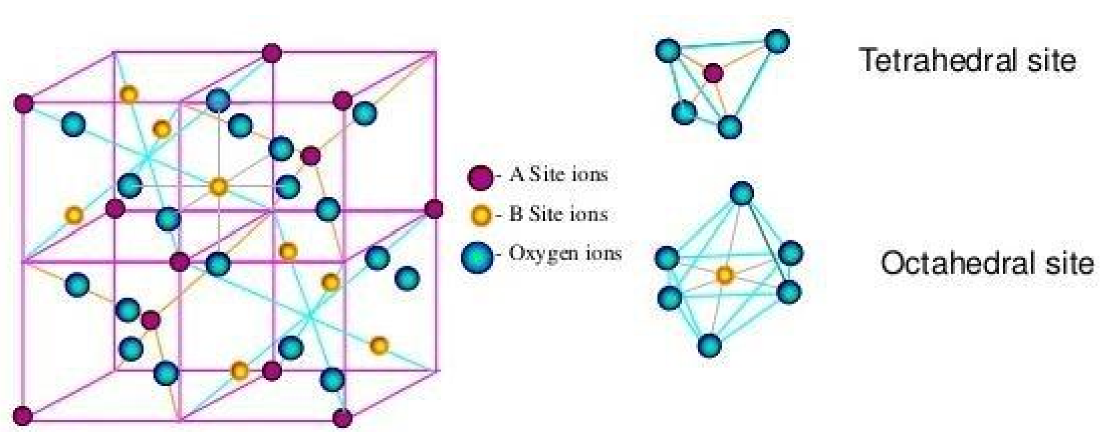
A. Spinel ferrites:

Spinel ferrites are magnetic materials that shows a wide range of application. They possess high electrical resistivity and low magnetic loss and thereby, magnetically soft. These ferrites are characterized by general formula MFe_2O_4 where M stands for divalent metal ion such as Cu, Ni, Mg, etc.

These ferrites are further classified as:

- Normal spinel ferrites
- Inverse spinel ferrites
- Random spinel ferrites

Structure of spinel ferrites:



B. Hexagonal ferrites:

Hexaferrites are also called as rhombohedral ferromagnetic oxides. It has high coercivity and therefore widely used as permanent magnet as its direction of magnetization cannot be changed easily. They are represented by general formula $MFe_{12}O_{19}$ where, M is element like Ba, Sr, Ca, etc.

C. Garnet ferrites:

Garnets ferrites are usually call as minerals that have dodecahedral sites in addition to octahedral and tetrahedral sites. They have wide application in microwave, acoustic, optical, and magneto-optical. They are magnetically hard and exhibit orthorhombic crystal structure.

D. Ortho ferrites:

Ortho ferrites have orthorhombic crystal structure and most are weakly ferromagnetic. They are used in communication techniques in sensors of magnetic fields and optical internet. They are structurally represented as $MFeO_3$, where M one or more rare earth elements.

1.2. HISTORY OF FERRITES IN DEVELOPMENT OF SCIENCE AND TECHNOLOGY:

Many reports have been given since 1940 on historical development of science and technology of ferrites. The first systematic study on relationship between chemical composition and magnetic properties of various ferrites was reported by Hilpert in 1909. At that, time he successfully prepared spinel ferrites such as, Cu, Co, Mg and Zn.

The second discovery occurred when the researchers mixed a large amount of normal spinel-type ferrites having practically no magnetization and inverse spinel-type ferrites having strong magnetization. As a matter of course, it was understood that such an attempt would result in a remarkable decrease in the magnetization of the mixed ferrites, and physicists would never have made such a strange mixture. Unexpectedly, Kato and Takei found that the permeability of the mixed ferrites had been multiplied more than several tens of times. This was the birth of the commercial ferrite core. The mechanism for the enhancement of magnetization by the addition of zinc ferrite was explained successfully by Nèel of France in 1948. Other French scientists also achieved great success, as exemplified by the accomplishments in the fundamental studies of orthoferrites by Forestier and Guoit-Guillain. Many Philips researchers in The Netherlands have been significant contributors to the development of the science and technology of ferrites. The work of Verway and Heilmann15onthe distribution of ions over the tetrahedral and octahedral sites in the spinel lattice has contributed to progress in the physics and chemistry of ferrites. Starting in 1935, Snoek devoted himself to preparing ferrites with both the highest possible permeability and lowest loss factor. The invention of hexagonal ferrite magnets such as the barium and strontium ferrite magnet by Wentetal.18in 1952 or the completion of ferroxplanna type hexagonal ferrites by Jonkeret al. In 1957—is a very important event in the history of ferrites. In the United States, many researchers were engaged in the study of ferrites from 1950 through 1970, and they attained remarkably fruitful results both in the fundamental research results both in the fundamental research. The first international conference on ferrites, ICF, was held in 1970 in Japan, and, to date, seven such conferences have been held. These conferences have contributed greatly to the advancement of the science and technology of ferrites. [1]

2. LITERATURE REVIEW OF COBALT-ZINC FERRITES:

There are relatively less reports available in the literature survey on the study of Co-Zn ferrites compared to Ni-Zn ferrites. Reports on synthesis of Co-Zn ferrites are not many, but there are reports on their properties and in different field. We shall now discuss the earlier work done related to my topic through literature survey before going to my research work.

Chan-Kong Kim, Jin-Ho Lee, Shunsaku Katoh, Riichi Murakami, Masahiro Yoshimura [3] synthesized Co-Zn ferrites by microwave and hydrothermal method. Co-Zn ferrites were prepared with nano size well-developed spinel phases by the coprecipitation and microwave-hydrothermal (M-H) methods. XRD and TEM showed that average particle size obtained is 10 mm. The lattice parameter of $M_{12-x}Zn_xFe_2O_4$ systems (M=Ni or Co, $0 \leq x \leq 1$) increased with an increase of Zn concentration. With increase in time and temperature of reaction, crystallization of spinel ferrites is promoted. The lattice parameters of Co-Zn ferrites are 8.369 Å. lattice parameter increase with increase in Zn content and it also depend on ionic radius of divalent metal ion. The TEM photographs of $Co_{12-x}Zn_xFe_2O_4$ particles obtained by the M-H method had nano size spherical morphology and uniform size. 8-12 nm particle size were determined from TEM. XRD peaks 9.1–10.4 nm for Co-Zn ferrite. Co-Zn ferrites were synthesized for the first time by the microwave-hydrothermal method. The application of the Microwave-Hydrothermal method to the ceramic processing is more advantageous than conventional methods.

M.H. Yousefia, S. Manouchehri, A. Araba, M. Mozaffari, Gh. R. Amiri, J. Amighian [4] prepared and characterized magnetic property of Co-Zn ferrites. Cobalt–zinc ferrite ($Co_{0.8}Zn_{0.2}Fe_2O_4$) was prepared by combustion method, using cobalt, zinc and iron nitrates. The crystallinity of the ash-burnt powder was developed by annealing at 7008^{0}C. Crystalline phase was investigated by XRD. Using Williamson–Hall method, 27nm size of nanoparticles crystals were determined before annealing and 37nm after annealing, the residual stress on the annealed particle were omitted out. The morphology was investigated by TEM of annealed sample and mean particles size was determined to be about 30nm. The final stoichiometry of annealed sample showed good agreement with the initial stoichiometry before annealing using atomic absorption spectrometry. Magnetic properties of the annealed sample such as saturation magnetization, remanence magnetization, and coercivity measured at room temperature were 70 emu/g, 14 emu/g, and 270 Oe, respectively. The Curie temperature of the sample was determined to be 3508^{0}C using AC-susceptibility technique. Combustion method is very simple, fast, and inexpensive for the preparation of cobalt-zinc ferrites nano powder. This method can be applied for a semi-large scale and even largescale preparation of ferrite nano powders. The saturation magnetization of the prepared nanosized sample was comparable with the bulk $CoFe_2O_4$and $Co_{0.8}Zn_{0.2}Fe_2O_4$. XRD pattern shows a nanostructure single phase $Co_{0.8}Zn_{0.2}Fe_2O_4$ with the mean crystallite size of around 37 nm after annealing. In addition, the strain factor has been reduced by annealing the sample.

M. Ichinose, S. Nakagawa, M. Naoe [5] synthesized by facing target sputtering system. Co–Zn ferrite films were deposited on glass ceramic disks of 1.89” in diameter by the facing targets sputtering, and their read/write characteristics were evaluated using a merged type of MR head. Specimen disk with (1 1 1) orientation, Disk (1 1 1), possessed larger perpendicular magnetization component than disk with (311) orientation. The linear recording density D_{50} increased with decrease of film thickness for both of these disks and the highest D_{50} was 136 kfrpi for Disk (1 1 1) and 86 kfrpi for Disk (3 1 1), respectively. The reason why higher recording density was attained for disk (1 1 1) seemed to be attributed to small $4\pi M_r\delta$ component. The transition noise of Disk (1 1 1) was almost constant with the increase in recording density, while that for Disk (3 1 1) increased. In consequence, Co–Zn ferrite disks with (1 1 1) orientation might be applicable as a semi contact type of recording layer even in longitudinal recording system.

Manju Kurian, Divya S. Nair [6] studied the efficiency of cobalt zinc ferrite nanoparticles for catalytic wet peroxide oxidation of 4-chlorophenol. Cobalt substituted zinc ferrite nanoparticles prepared by sol–gel auto combustion method are efficient catalysts for the wet peroxide oxidation of 4-chlorophenol in presence of hydrogen peroxide as oxidant. Complete degradation of 4-chlorophenol occurs within one hour with all catalysts under study. 90% of the target compound is removed with oxidant concentration as low as 1 ml. by changing the dosage, direct correlation between the amount of catalyst present and extent of 4-chlorophenol degradation is observed, by ruling out the heterogeneous-homogenous mechanism. Complete removal of 4-chlorophenol occurs at ambient temperature.

Misbah Ul Islam, Mazhar Uddin Rana, Tahir Abbas [7] studied the magnetic interaction of Co-Zn ferrites. Cobalt-zinc ferrites with compositions $Co_{0.5}Zn_{0.34}Fe_2O_4$, $Co_{0.37}Zn_{0.51}Fe_2O_4$, $Co_{0.3}Zn_{0.6}Fe_2O_4$, $Co_{0.2}Zn_{0.74}Fe_2O_4$, were prepared by ceramic techniques. The effects of compositional variation on porosity, coercivity, remanence, saturation magnetization, magnetic moments, and Y-K angles are reported. The coercivity exhibits almost similar behavior to that of porosity, whereas, the remanence decreases with increasing Zn-content. The saturation magnetization and magnetic moments exhibit decreasing behavior with increasing Zn-content, which may be due to the increase of the B-B interaction followed by the decrease in A±B interaction. The Y-K angles increase as the Zn concentration increase which is attributed to the presence of triangular-type spin arrangement on B sites.

Pratik A. Asogekar, Sanket K. Gaonkar, Arun Kumar, V.M.S. Verenkar [8] studied the influence of Co over magnetically benign Zn ferrite system and its structural, dielectric, superparamagnetic and antibacterial efficacy[6].Nano sized Co-Zn ferrite were synthesized by precursor combustion method in series, $Co_xZn_{1-x}Fe_2O_4$ (x =0.0, 0.1, 0.2, 0.3, 0.4, 0.5).By using techniques such as X-ray powdered diffraction, infrared spectroscopy, scanning electron microscopy, energy dispersive x-ray analysis, inductive coupled plasma-atomic emission spectroscopy, BET surface and measurement and X-ray photoelectron spectroscopy the phase purity, surface area, composition, and oxidation state of corresponding metal ion was confirmed. The transmission electron microscopy analysis revealed cuboidal shaped ferrite particles with 2030 nm size. The dielectric studies with change in temperature and frequency. And magnetization studies with change in applied field and temperature exhibited cobalt content in ferrites. The transition from para-magnetic to superparamagnetic nature with rising cobalt content was observed in our investigation based on magnetization and supported by Mossbauer studies. The ferrites which were synthesized have good antimicrobial activity against E. coli ATCC 8439 exhibited better result with the rise in Co^{2+} ion content in ferrites. The exact stoichiometry of ferrites was established based on ICP-AES analysis and the XPS studies verified the expected oxidation states of ll the corresponding elements in ferrites. The superparamagnetic nature was further confirmed from ZFC- FC measurements, wherein an increase in T_b and T_{irr} with the rise in the applied field and Co^{2+}ions was observed due to the anisotropy associated with cobalt in the ferrites. The A.C. susceptibility studies also revealed the rise in Curie temperature with cobalt content in the prepared ferrites.

Rania Ramadan, M. K. Ahmed, Vuk Uskoković [9] studied Magnetic, microstructural and photoactivated antibacterial features of nanostructured Co-Zn ferrites of different chemical and phase compositions. Here method based on urea decomposition and citrate combustion to synthesize four different compositions of cobalt and zinc ferrite, including monophasic $CoFe_2O_4$, $ZnFe_2O_4$ and $Co_{0.5}Zn_{0.5}Fe_2O_4$, and $CoFe_2O_4/ZnFe_2O_4$ nanocomposite. Zn nanoparticles were approximately of same size as that of the cobalt ferrites, but Zn ferrites were better dispersed, rougher, more crystalline and less pronouncedly faceted. The addition of Co ions to Zn-ferrite lattice to form the mixed, $Co_{0.5}Zn_{0.5}Fe_2O_4$ composition. After these mixed compositions formed vibrational spectroscopic analysis showed the down shifts of stretches long the metal oxide bond at both tetrahedral and octahedral sites and upon the addition of Zn ion to Co ferrites lattice to form same composition upshifts was observed. Expectedly, the highest saturation magnetization (66.3 emu/g) was detected in Co-ferrite and the lowest (2.8 emu/g) in Zn-ferrite. Co-ferrite also exhibited the highest magneto-crystalline anisotropy, remanence and hysteresis loop area, while the highest exchange bias and susceptibility were found in the mixed, $Co_{0.5}Zn_{0.5}Fe_2O_4$ composition. All the prepared 4 composition were biocompatible with human fibroblast, but they demonstrate different antibacterial activities against gram negative E coli and gram-positive S.aureus. Overall, these results demonstrate a very good potential of ferrites for antibacterial application in medicine.

Suman Halder,S. I. Liba, A. Nahar, S. S. Sikder, and S. Manjura Hoque [10] studied the surface modified cobalt zinc ferrite nanoparticles for application to magnetic hyperthermia. the influence of the annealing temperature and concentration of $Co_{0.5}Zn_{0.5}Fe_2O_4$nanoparticles as a heat generation material for hyperthermia therapy. Cobalt zinc ferrite ($Co_{0.5}Zn_{0.5}Fe_2O_4$) nanoparticles were synthesized by the chemical co-precipitation method and annealed at 200°C, 400°C, and 600°C for 3 h. The structural characterization was carried out using an x-ray diffractometer, and all samples exhibit a single-phase spinel structure. The M-H loop of the as-dried and annealed samples revealed a narrow “S” shaped hysteresis cycle, which exhibits the superparamagnetic behavior of all samples. The Mössbauer spectrum of all samples at room temperature observed as a doublet, which is the signature of the superparamagnetic nature, and it is in good harmony with the acquired M-H curves. Surface modifications of the annealed and as-dried nanoparticles were achieved by coating the nanoparticles with chitosan, and solutions of different concentrations (1 mg/ml, 2 mg/ml, 4 mg/ml, and 6 mg/ml) were prepared. Utilizing dynamic light scattering measurement, the hydrodynamic diameter of the chitosan-coated nanoparticles at 37°C was found out to be between 173 nm and 231 nm, and the polydispersity index was less than 0.30 for all concentrations. According to annealing temperature (6300°C>400°C>200°C>as-dried) and the solution of concentration (6 mg/ml>4 mg/ml>2 mg/ml>1 mg/ml) induction heating measurements stipulated that the heating efficiency of chitosan-coated nanoparticles increased.

H. Heli, N. Sattarahmady, G.R. Hatam, F. Reisi, R. Dehdari Vais [11] studied an electrochemical Geno sensor for Leishmania major detection based on dual effect of immobilization and electrocatalysis of cobalt-zinc ferrite quantum dots. In diagnosis and clinical studies of leishmaniasis identification of Leishmania parasites is important. Although clinical and epidemiological methods are available, they are not adequate for identification of causative agents of leishmaniasis. In the present study, quantum dots of magnetic cobalt-zinc ferrite ($Co_{0.5}Zn_{0.5}Fe_2O_4$) were prepared and characterized by physicochemical methods. The quantum dots were then utilized as an electrode modifier to immobilize a 24-mer specific single stranded DNA probe, and fabrication of a label-free, PCR-free and signal-on electrochemical Geno sensor for the detection of Leishmania major. Hybridization of the complementary single stranded DNA sequence with the probe under the selected conditions was explored using methylene blue as a redox marker, utilizing the electrocatalytic effect of the quantum dots on the methylene blue electroreduction process. The Geno sensor could detect a synthetic single stranded DNA target in a range of 1.0×10^{-11} to1.0×10^{-18}mol L^{-1} with a limit of detection of 2.0×10^{-19}mol L^{-1}, and genomic DNA in a range of 7.31×10^{-14} to 7.31×10^{-6}ngμL^{-1} with a limit of detection of 1.80×10^{-14}ng$\mu L^{-1}$with a high selectivity and sensitivity.

G.A.Petitt, D.W. Forester [12] studied Mossbauer of Cobalt-Zinc Ferrites. Samples of the cobalt–zinc ferrite series $Co_{1-x}Zn_xFe_2O_4$ have been studied by the Mossbauer effect technique at 4°K, in magnetic fields from 0to80kOe, covering the full range of zinc content. The cation distributions and the hyper fine fields at ^{57}Fe nuclei in A and

B sites have been determined as a function of Zn concentration. Canted spin structures associated with Fe^{3+} ions are observed for all samples at O°K . At large values of x there solved spectral features provide distinct evidence of localized spin canting with a distribution of canting angles determined by the statistical distribution of nonmagnetic (Zn^{2+}) neighboring ions. For several samples temperature dependence of the hyperfine magnetic field has been determined. For samples with x=0.4 and x=0.6, the Neel temperatures are found to be (513±5) and (322±5)°K, respectively. For low concentrations of nonmagnetic ions, distribution of hyperfine field is necessary for good approximation, independent of distribution of canting angles. These spectra are examined in terms of super transferred hyperfine field from neighboring ions.

Xiaogu Huang, Jing Zhang, Weifeng Rao, Tianyi Sang, Bo Song, Chingping Wong [13] studied tunable electromagnetic properties and enhanced microwave absorption ability of flaky graphite/cobalt zinc ferrite composites. These were synthesized by the coprecipitation method. The XRD results manifested that the flaky graphite/cobalt zinc ferrite composites can be procured and there is no impurity when the graphite weight ratio is less than 20 wt %. The FE-SEM results exhibited that the flaky cobalt zinc ferrite composites possessed flake-like shape with high aspect ratio. Moreover, by varying the graphite weight ratio electromagnetic properties could be tuned. In the series flaky graphite/cobalt zinc ferrite composites make ready, the sample with 10 wt.% graphite possessed excellent impedance matching performance. As a result, the it exhibited the best microwave absorption properties. The reflection loss was less than -10 dB in frequency range of 10.3-13.5 GHz and the maximum reflection loss was reach to -33.85 dB at 11.7 GHz when the coating thickness was 2.5 mm. Moreover, the electromagnetic analysis demonstrated that the electromagnetic loss properties and the electromagnetic impedance matching performance should be both satisfied to obtain the excellent microwave absorption properties. This study was meaningful to design the ferrite/carbon composites-based microwave absorbers.

Deepika Chahar, Shilpa Taneja, Shalini Bisht, Shubhi Kesarwani, Preeti Thakur, Atul Thakur, P.B. Sharma [14] studied photocatalytic activity of cobalt-zinc ferrite for the degradation of methylene blue dye under visible light irradiation. Cobalt-zinc ferrite with composition $Co_xZn_{1-x}Fe_2O_4$(x=0.0, 0.1, 0.2, 0.3, 0.4 and 0.5) was synthesized using citrate precursor method and the prepared samples were characterized by using X-ray powder diffractometry (XRD), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Fourier Transform Infrared Spectroscopy (FT-IR) techniques. Single phase spinel structure was confirmed by the XRD patterns having (311) characteristic peak. SEM images showed the agglomeration of the powdered samples of cobalt-zinc ferrite. TEM images record an average crystallite size of 52 nm. Visible range light was used for the photocatalytic degradation of methylene blue by creating a Fenton-type system. It was observed that the degradation of methylene blue was enhanced with an increase in cobalt concentration. The degradation efficiency reached a maximum (77%) for x=0.5 while it was the smallest (~65%) for x=0.0 in 1 h under visible light irradiation. Hence, we conclude that cobalt-zinc ferrite can be used as a potential material for purification of water and its degradation efficiency increased with an increase in cobalt concentration. FT-IR spectroscopy showed the stretching vibration of metal ions at tetrahedral and octahedral sites which is consistent with spinel crystal structure of the synthesized ferrites. Also, the samples were found to follow pseudo-first-order kinetics for the degradation of methylene blue. The results showed that cobalt zinc ferrite can be used as an effective photocatalyst for the degradation of methylene blue dye without having any hazardous effect on the environment.

A.-H. El Foulani, A. Aamouche, F. Mohseni, J. S. Amaral, D. M. Tobaldi and R. C. Pullar [15] studied the effect of surfactants on the optical and magnetic properties of cobalt-zinc ferrite $Co_{0.5}Zn_{0.5}Fe_2O$ Nanoparticles of zinc-cobalt spinel ferrite $Co_{0.5}Zn_{0.5}Fe_2O_4$ (CZFO) were prepared by co-precipitation route, and the effect on magnetic and optical properties were investigated after the addition of various surfactants (ethanol, CTAB, PEG and acetic acid; surfactant: metals = 0.5:1). Such surfactant additives have shown great potency in controlling and improving nucleation and growth stages, leading to an optimization of crystallite size, porosity and specific surface area (SSA). The addition of ethanol in particular helped to optimize the physicochemical properties of the material, giving the lowest crystallite size of 11.7 nm, and highest porosity and SSA values of 0.65 cm^3/g and 32.37m^2/g, respectively. The sample made using ethanol also had a small grain size of 50-100 nm. The CZFO made with ethanol surfactant also had greater coercivity (H_c) and saturation magnetization (M_s) values compared with the other surfactants, of 22 kA m^{-1} and 81.19 A m^2 kg^{-1}. All samples made with surfactant additives had two distinct absorption edges in the visible region, around 550 nm and 700 nm this was shown by UV-vis diffuse reflectance spectra (DRS). Two optical band gap (E_g) values were acquired for direct allowed transitions for these CZFO samples, with E_{g1} values in the range of 1.99-2.06 eV, equivalent to that expected for $ZnFe_2O_4$, and E_{g2} in the range of 1.60-1.66 eV, as expected for $CoFe_2O_4$. The CZFO had highest E_g value in both cases when made using ethanol. In this study, to improve the microstructural, optical and ferromagnetic characteristics of our material, the effect of adding different families of surfactants (alcohol, polymer and carboxylic acid) were evaluated.

M Veverka, Z Jirák, O Kaman, KKnízek, M Marysko,E Pollert, K Z áveta, ALancok,M D louhá and S V ratislav [16] studied distribution of cations in nanosized and bulk Co–Zn ferrites. The structural and magnetic properties of $Co_{1-x}Zn_xFe_2O_4$ferrites (Co–Zn ferrites) are scrutinized in a narrow compositional range around x=0.6, which is of focus, because of applications in magnetic fluid hyperthermia. The study by x-ray and neutron diffraction, Mossbauer spectroscopy and magnetization measurements is done on nanoparticles prepared by the coprecipitation method and bulk samples sintered at high temperatures. In spite of the known preference of $Zn^{2+}$for tetrahedral (A) sites and $Co^{2+}$for octahedral [B] sites, the cations are distributed nearly evenly over the two sites of spinel structure and there is also a changeable number of [B] site vacancies, making cobalt ions trivalent. In particular for x=0.6, the cationic distribution is refined to $(Co^{3+}_{0.22}Zn^{2+}_{0.31}Fe^{3+}_{0.48})$ $[Co^{3+}_{0.16}Zn^{2+}_{0.26}Fe^{3+}_{1.43}]$ $O_4$and $(Co^{2+}_{0.15}Zn^{2+}_{0.46}Fe^{3+}_{0.39})$ $[Co^{2+}_{0.08}Co^{3+}_{0.16}Zn^{2+}_{0.13}Fe^{3+}_{1.57}]$ $O_4$for the 13 nm particles (T_C=335 K) and bulk sample (T_C=351 K), respectively. The long-range ordered ferrimagnetic moments find out by the neutron diffraction appear to reflect the differences of cationic distributions in nanosized and bulk samples, though their absolute values are quenched, which indicates a large divergence of individual spins in both the (A) and [B] sublattices from the collinear arrangement.

J. López, L.F. Gonza lez-Bahamo n, J. Prado, J.C. Caicedo, G. Zambrano,M.E. Gomez, J. Esteve, P. Prieto [17] studied magnetic and structural properties of ferrofluids based on cobalt–zinc ferrite nanoparticles. Ferrofluids are colloidal systems composed of a single domain of magnetic nanoparticles with a mean diameter around 30 nm, dispersed in a liquid carrier. Magnetic $Co_{(1-x)}Zn_x Fe_2O_4$ (x=0.25, 0.50, 0.75) ferrite nanoparticles were prepared via co-precipitation method proceed through aqueous salt solutions in an alkaline medium. The composition and structure of the samples were characterized through Energy Dispersive X-ray Spectroscopy and X-ray diffraction, respectively. Nano particle size determination was permitted by Transmission Electron Microscopy (TEM); grain size of nanoparticle conglomerates was determined via Atomic Force Microscopy (AFM). The magnetic behavior of ferrofluids was characterized by Vibrating Sample Magnetometer (VSM); and finally, a magnetic force microscope was used to visualize the magnetic domains of Co(1-x) $Zn_xFe_2O_4$nanoparticles. X-ray diffraction patterns of $Co_{(1-x)}$ $Zn_xFe_2O_4$show the presence of the most intense peak corresponding to the (311) crystallographic orientation of the spinel phase of CoFe2O4. The bonds associated with the spinel structures particularly for ferrites was confirmed by Fourier Transform Infrared Spectroscopy. The mean size of the crystallite of nanoparticles established from the full-width at half maximum of the strongest reflection of the (311) peak by using the Scherrer approximation diminished from (9.570.3) nm to (5.470.2) nm when the Zn concentration increases from 0.21 to 0.75. The size of the Co–Zn ferrite nanoparticles acquired by TEM is in good agreement with the crystallite size calculated from X-ray diffraction patterns, using Scherer's formula. The magnetic properties were scrutinized with the aid of a VSM at room temperature confer super-paramagnetic behavior, decided by the shape of the hysteresis loop. In this study, we demonstrated that the coercive field of $Co_{(1-x)} Zn_xFe_2O_4$ magnetic nanoparticles, the crystal and nanoparticle sizes determined by X-ray Diffraction and TEM, respectively, decrease with the increase of the Zn percentage. Finally, our magnetic nanoparticles are not very hard magnetic materials stated that the hysteresis loop is small and for this purpose $Co_{(1-x)} Zn_xFe_2O_4$nanoparticles are contemplated as soft magnetic material.

A.V. Ramana Reddy, G. Ranga Mohan, B.S. Boyanov, D. Ravinder [18] studied the electrical transport properties of zinc-substituted cobalt ferrites. Electrical conductivity ([Equation]) and thermoelectric power(ş) studies of zinc-substituted cobalt ferrites are undertaken as a function of composition and temperature. The ferrites under investigation have been classified as n-type and p-type semiconductors on the basis of the Seebeck coefficient (*S*). As the temperature increased with a change of the slope at magnetic transition T_c electrical conductivity of all the ferrites increases. The activation energy in the ferrimagnetic region is normally less than that in paramagnetic region. The values of charge carrier, concentration and mobility on the contrary computed and discussed as a function of composition and temperature.

N. MATSUSHITA, K. NOMA, S. NAKAGA WA and M. NAOE [19] studied control of magnetocrystallline anisotropy of cobalt-zinc ferrites sputtered film. Co ferrite and Cobalt-Zinc ferrite films were deposited on SiO_2/Si substrates and quartz disks under various preparation conditions using the facing targets sputtering apparatus and their crystallographic, magnetic and read/write characteristics have been investigated. Co ferrite films deposited at partial oxygen gas pressure P_{02} below 0.2 m Torr at various substrate temperature revealed (311) orientation and quasi in-plane magnetic anisotropy. High Ts above 500°C and P_{02} of2.0 m Torr were necessary to obtain well (111) orientation which had isotropic orientation of magnetization and was suitable for high recording density media. On the other hand, Co-Zn ferrite films deposited at Ts up to 250°C and P_{02} of 0.01 m Torr had (111) orientation and possessed moderately large 47tMs of about 3.7 kG and almost the same in-plane and perpendicular coercivity of about 2.0 kOe. The (111) oriented Cobalt-Zinc ferrite disk exhibited high linear recording density D_{50} as high as 136 kfrpi.

A. Tawfik [20] studied electromechanical properties of $Co_{0.6}Zn_{0.4}Fe_2O_4$ ferrite transducer. $Co_{0.6}Zn_{0.4}Fe_2O_4$ferrite has been prepared by the general ceramic method. As a function of mechanical stress, the resonance frequency of the disk for the radial and thickness mode was investigated. The increase of the resonance frequency of the transducer is attributed to domain wall motion inhibition. The increase of ultrasonic velocity can be explained due to retarding the oscillation of the ferrimagnetic domains under applied high-frequency electric field with increasing mechanical stress. The induced strain increases the resonance frequency. The high values of the electromechanical coupling factor for the radial mode K_p and thickness mode, K_t, indicate that this composition is useful for producing high-frequency ultrasonic waves that can be used in modern technology.

Poorbafrani, A. Kiani, E. [21] studied enhanced microwave absorption properties in cobalt–zinc ferrite-based nanocomposites. In an attempt to find a solution to the problem of the traditional spinel ferrite used as the microwave absorber, the $Co_{0.6}Zn_{0.4}Fe_2O_4$-Paraffin nanocomposites were investigated. Co-Zn ferrite powders, synthesized chemically through PVA sol-gel method, were combined with differing concentrations of Paraffin wax. The nanocomposite samples were characterized employing various experimental techniques including X-Ray Diffraction (XRD), Field Emission Scanning Electron Microscopy (FESEM), Alternating Gradient Force Magnetometer (AGFM), and Vector Network Analyzer (VNA). The saturation magnetization and coercivity were enhanced utilizing appropriate stoichiometry, coordinate agent, and sintering temperature required for the preparation of cobalt-zinc ferrite. The complex permittivity and permeability spectra, and Reflection Loss (RL) of $Co_{0.6}Zn_{0.4}Fe_2O_4$-Paraffin nanocomposites in the frequency range of 1-18 GHz were measured. The microwave absorption properties of nanocomposites indicated that the absorbing composite containing 20 wt.% of paraffin manifests the strongest microwave attenuation ability. The composite exhibited the reflection loss less than -10 dB in the whole C-band and 30% of the X-band frequencies.

Xiaogu Huang, Jing Zhang, Wei Wang, Tianyi Sang, Bo Songb, Hongli Zhu,Weifeng Ra, Chingping Wong [22] studied effect of pH value on electromagnetic loss properties of Co–Zn ferrite prepared via coprecipitation method. the cobalt zinc ferrite was prepared by coprecipitation method at different pH conditions. The influence of pH values on the coprecipitation reaction was theoretically analyzed at first. The calculated outcome showed that to form the stable precipitation the pH values should be controlled in the range of 9–11. The XRD examination was used to further confirm the formation of the composite on specific pH values. In addition, the morphological study revealed that when the pH value increased from 9–11 the average particle size of the composite decreased from 40 nm to 30 nm. The variation of microstructure plays a crucial role in managing the electromagnetic properties. From the electro-magnetic analysis for the composite synthesized at pH of 9, the dielectric loss factor was 0.02–0.07 and magnetic loss factor was 0.2–0.5, which dramatically improved dielectric loss and magnetic loss properties than the samples prepared at pH of 10 and 11. The as-prepared cobalt zinc ferrite are highly encouraging to be used as microwave absorption materials. TEM images revealed that with the increase of pH value the particle size decreased. The electromagnetic properties analysis also demonstrated that complex permittivity and complex permittivity were significantly modified by varying the pH values. The reasons can be ascribed to the well-performed interfacial polarization loss and magnetic hysteresis loss. Due to these unique characteristics, the as-prepared cobalt zinc ferrite can be potentially used as microwave absorption materials. The effects of pH values are beneficial to improve its dielectric and magnetic properties with the increase of pH value.

Murli Kumar Manglam, Jyotirekha Mallick, Suman Kumari, Rabichandra Pandey, Manoranjan Kar [23] have studies the crystal structure and magnetic property of Cobalt Zinc ferrites composites. The composites of Co-Zn ferrites with different percentage have been synthesized by using high energy planetary ball mill technique. The powder that obtained was characterized by employing X-ray diffraction, Energy dispersive X-ray analysis techniques, and Field Emission Scanning Electron Microscope. The Rietveld refinement analysis of XRD peaks used to fine lattice parameter and phase percentage. By making use of Vibrating Sample Magnetometer (VSM) the magnetic hysteresis loop has been recorded. The magnetic interaction has been investigated by plotting the loop width versus magnetization and the shape of this curve changed with different weight percentage of Co-Zn ferrite composite.by increase in concentration of Co-Zn ferrite composite the saturation of magnetization increased and coercivity decreased. Vegard's law is used for comparing the experimental and theoretical magnetic parameter.

Tatarchuk, Tetiana, Shyichuk, Alexander et al. [24] Studied the simple green synthesis of cobalt-zinc ferrites nanoparticle and characteristic of super magnetic Co-Zn ferrites nanoparticles for Pb (II) adsorption and hyperthermia application. To investigate the structure and morphology of the obtained spinel structure XRD, SEM/EDX, TEM, Mossbauer and FTIR techniques have been carried out. The crystallite size obtained here is 14±2 nm. During the transition from Co ferrite to Zn ferrite the inversion degree of the Fe cation decreases from δ =0.89 to δ =0.00of characteristic peak of the M_A-O (at~450cm^{-1}) M_B-O (at~650 cm^{-1}) vibration as well as the vibration of the functional groups of the honey residual was shown by IR. $ZnFe_2O_4$ sample exhibits the highest absorption capacity (289 mg/g) towards lead cation. This result is described in terms of surface acidity of sample under study, estimated from the variation of ionic-covalent bond parameter. the efficiency of heat released by the $Co_x Zn_{1-x}Fe_2O_4$ magnetic nanoparticles for magnetic hyperthermia was also investigated. The registered induction heating curves depend on Zn content in the samples. The Zn content controls the magneto-crystalline anisotropy and super magnetic/ferromagnetic state of obtained particle through Mossbauer spectra of Co-Zn ferrites.

S. RAMANA MURTHY and T. SESHAGIRI RAO [25] studied the magnetic field and temperature on the elastic behavior of cobalt-zinc ferrites. A study of the dependence of the elastic behavior of polycrystalline mixed cobalt-zinc ferrites on temperature and magnetic field has been made employing a composite oscillator method. Because the temperature is increased the Young's modulus attains a minimum at a temperature below the Curie temperature. Thereafter it exhibits a positive temperature coefficient up to the Curie temperature and reduces with further increase of temperature. This anomalous behavior has been explained in terms of magnetic anisotropy energy. Within the case of cobalt ferrite and $Co_{0.6}Zn_{0.4}Fe_2O_4$ the Young's modulus is found first to decrease and later to extend with increasing magnetic flux, finally becoming constant at the saturation field. In contrast, within the case of $Co_{0.4}Zn_{0.4}Fe_2O_4$ and $Co_{0.2}Zn_{0.8}Fe_2O_4$ the Young's modulus doesn't show an initial decrease but increases with increasing magnetic field. The observed AE effect within the case of cobalt ferrite has been interpreted in terms of two domain processes, i.e., domain rotation against uniaxial strain anisotropy and also the movement of 90" boundary walls. A study of the effect of the simultaneous application of temperature and magnetic field on the elastic behavior of mixed cobalt-zinc ferrites has also been performed.

A. N. Hapishah · M. M. Syazwan· M. N. Hamidon [26] synthesized and characterized the magnetic and microwave absorbing properties in polycrystalline cobalt- zinc ferrites. The method used here is high energy ball milling along with sintering for the preparation of this $Co_{0.5}Zn_{0.5}Fe_2O_4$ composition of cobalt-zinc ferrites. Phase characteristic using XRD analysis of the prepared compound shows that the high crystalline ferrite has been formed with the help of thermal energy by sintering at 1250 ^oC which afterwards changes the magnetic properties of ferrite. From ferrite high permeability and losses was obtained with zinc content. The alteration of cation distribution between A and B sites in spinel which contribute to higher magnetic properties was observed on substitution of Zn in cobalt ferrite. Especially $Co_{0.5}Zn_{0.5}Fe_2O_4$ provides electromagnetic wave absorption characteristics. Cobalt zinc ferrite sample is highly potential for microwave absorber which showed the highest reflection loss (RL) value of − 24.5 dB at 8.6 GHz was found out from this research work. Their application as filters in prepared composite that is applied for microwave absorbing material is due to their potentiality to minimize the EMI interference in the measured frequency. The better value of electromagnetic wave absorbing properties is the result of good compatibility of dielectric and magnetic properties.

Vinuthna, C. H. Chandra Babu Naidu, Kadiyala et al. [27] Studied the antimicrobial ani magnetic property of Co-Zn ferrites prepared by citrate gel method and further calcined at 600^{o}C. Using the X-ray diffraction pattern the single-phase cubic spinel structure of CZF was confirmed. 22-29 nm range was the average crystallite size. Using the scanning electron microscopy (SEM), and transmission electron microscopy (TEM) the surface morphology was scrutinized. By using TEM study, the average particle size of $Co_{0.6}Zn_{0.4}Fe_2O_4$ was determined to be 19 nm which is supporting the average crystallite size measured from the X-ray diffraction studies. The two strong absorption bands in the series of ferrites between 4500 and 500 cm−1 are revealed from the Fourier-transform infrared spectra and also these are responsible for the characteristic of spinel ferrites. The elemental spectral signals of energy dispersive spectroscopy confirmed the presence of elements of Cu, Co, and Zn of CZF. At room temperature, based on hysteresis curves (M-H curves) the magnetic measurements of pure $ZnFe_2O_4$ and $Co_{0.6}Zn_{0.4}Fe_2O_4$ were evaluated. The results indicate that the addition of nonmagnetic Zn^{2+} ions increase the magnetic behavior in the mixed CZF samples. Against harmful microbes the antimicrobial activity of the $ZnFe_2O_4$ and $Co_{0.6}Zn_{0.4}Fe_2O_4$ nano ferrites was tested.

Ansari, Leyla, Sharifi, Ibrahim et al. [28] studies the synthesis, characterization and MRI application of Co-Zn ferrites nanoparticles coated with DMSA (dimarcaptosuccinic acid) and their efficiency as a contrast agent in in vivo MR imaging of rat liver. Synthetization Co–Zn ferrite NPs was done by the thermal decomposition method and stabilized by DMSA. To study their physical and magnetic properties the NPs were characterized by different analyses and were injected into 6 adult male rats. Measurement of the signal intensity at different times was performed by Liver MRI. The average nanoparticle size was approximated at about 8 ± 1 nm using transmission electron microscopy (TEM). About result, the synthesized Co–Zn ferrite NPs stabilized by DMSA are appropriate agents for increasing the contrast in both T_2 and T_2* weighted based on MR imaging in rat liver.O. Raina • Rakkiyasamy Manimekala studies the photocatalysis of Co-Zn ferrites under solar light [29] . $Co_{0.7}Zn_{0.3}Fe_2O_4$ nanorods were synthesized from hydrazine precursor by co-precipitation technique. Infrared and thermogravimetric–differential thermogravimetric curves of the precursor indicated the bridging bidentate nature of hydrazine and three-step thermal decomposition. The as-synthesized cobalt zinc ferrite nanorods were characterized by powder X-ray diffraction, scanning electron microscopy, energy dispersive spectroscopy, transmission electron microscopy, vibrating sample magnetometry and UV–diffuse reflection spectroscopy which proposed the phase structure, morphology, magnetic and optical properties. $Co_{0.7}Zn_{0.3}Fe_2O_4$ nanorods showed a sensible photocatalytic activity on Congo red, Malachite green, Methylene blue, Methyl red, Rhodamine B and Rose bengal under solar light at different time intervals and were magnetically separated. The formula fixation was done by data observed from EDS, IR and TG–DTA of the precursor. Three step decomposition was observed in TG-DTA which led to formation of $Co_{0.7}Zn_{0.3}Fe_2O_4$ photocatalyst. The sharp and intense peaks in XRD suggested the photo crystalline nature and from the Debye–Scherrer formula crystallite size calculated as 14nm was confirmed by TEM. Agglomeration of nanorods was observed in SEM images while EDS showed presence of the expected elements. Soft magnetic nature of photocatalyst was shown by VSM hysteresis loop.

3. CONCLUSION:

Over the years, different types of ferrites have emerged as a strong platform in the field of magnetic material. Ferrites have been extensively used in biomedical field for cancer cure and MRI and also have tremendous electronic application like, transformer, transducer, and inductors. And ferrites are also used in making magnetic fluids, sensors, and biosensor. As reviewed above Co-Zn ferrites are synthesized by various method with different nanoparticle size. Co-Zn ferrites quantum dots have been used in detection of Leishmania *major.* Also removed the toxicity from water by photocatalytic degradation of dye and adsorption using Co-Zn ferrites nano catalyst. Meanwhile ferrites are also effective in degradation of many potential organic contaminants. Co-Zn ferrites also shown to be increasing the electrical conductivity by increasing the metal content. From the eco-friendly perspective, it would be crucial in future to give importance for using green solvents and reagents for their synthesis and other development processes. Finally, I would like to describe my view on the future aspects of ferrites, certainly without any question the production of ferrites will continue to increase each year. As well the advancement in electronic technologies. If researchers and engineers who are anxious about ferrites should take a deep look to its future aspect and devote themselves to the subject of great value. The future of ferrites will experience a steady and more advancement prosperity in science and technology.

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