Review of synthesis, characterization of cobalt nano ferrite

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***Abstract*—Magnetic materials are much more important in science, specifically ferrites have lots of applications in various fields. Ferrites are basically the ferromagnetic oxides containing proper proportions of iron oxide and metal oxides.**
The spinel cobalt ferrite (CoFe2O4) has unique features. The synthesis of Cobalt ferrite nanoparticles was done using various methods such as co-precipitation method, ball milling method, auto combustion method, sol gel methods, spray pyrolysis technique, precursor technique, hydrothermal technique, solid state method, etc. The review also observes the challenges and opportunities for further research and development in this area, emphasizing the need for optimization of the synthesis parameters.
Cobalt ferrite has many applications in various fields which are highlighted in this review.

***Index Terms*—Cobalt Ferrite, Spinal, Oxides, Synthesis.**

I. INTRODUCTION

In 1940 the magnetic material ferrite was developed. Ferrite is a ferromagnetic metal oxide. Electric properties of ferrites show that the resistivity of magnetic materials in a single metal or alloy is less than a ferrite. It also has high magnetic permeability.
Based on the magnetic coercivity ferrites are classified into two groups, Hard ferrites and Soft ferrites. Hard ferrites have very high coercivity and Soft ferrites have low coercivity.
Ferrite nanoparticles are belonging to a group of magnetic nanoparticles and they have received a considerable amount of attention due to their wide applications in various fields, which ranges from biomedical to industrial. The standard formula for FNPs is AB2O4, which is a metal oxide with a spinel structure. The metallic cations A and B are located at two distinct crystallographic sites: the tetrahedral (A site) and octahedral (B site). In both sites, the cations are coordinated to oxygen atoms tetrahedral and octahedral, respectively (fig 1). Iron (III) must be present in the chemical formula for the substance to be called ferrite, at the very least. The majority of ferrites exhibit superparamagnetic (SPM) characteristics at sizes below or around 20 nm in diameter, such as MFe2O4 (where M = Mn, Fe, Co, Ni, Cu, and Zn) [5]. The spinel ferrites are thermally and chemically stable materials desirable for various applications. The nanometer sized ferrite particles have been studied and synthesized by various methods. It also focuses on both fundamental and applied research with an emphasis on their size-dependent properties. Using the standard structural characterization methods to determine the degree of dispersion of the ions in the tetrahedral and octahedral positions is challenging. Nuclear magnetic resonance (NMR) in solid states is a potent method for learning about local structural differences. However, utilizing NMR to evaluate magnetic materials is very challenging [7].

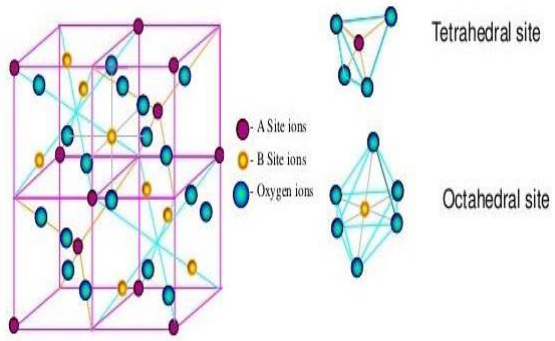


Figure 1 Schematic diagram of spinel ferrites
In this review, the synthesis and structural and optical characteristics of the CoFe2O4
nanoparticles were studied.

II SYNTHESIS METHODS

In the synthesis of cobalt ferrite, methods such as sol-gel method, thermal decomposition technique, ball milling method, ceramic method, co-precipitation method, hydrothermal technique, flash combustion technique, solid state reaction etc. Have been used. The brief explanation of production of cobalt ferrite is given below.

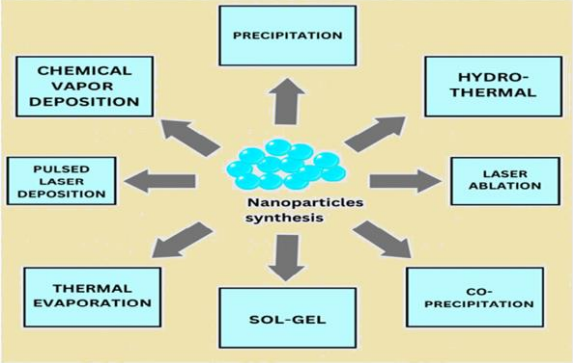


Figure 2 Schematic diagram of synthesis of nanomaterial

Sol-Gel Method:

The sol-gel method is a straightforward and reasonably priced wet chemical synthesis technique. Four crucial preparation stages are included in this process: hydrolysis, polycondensation, drying, and thermal breakdown. This procedure uses ethylene glycol, citric acid, and other chelating agents to dissolve the metal oxide precursors in stoichiometric proportions in double-distilled water. The process of evaporation creates gel. Both the qualities of the synthesized sample and the reactions that occur during preparation are more controlled using this procedure [1].

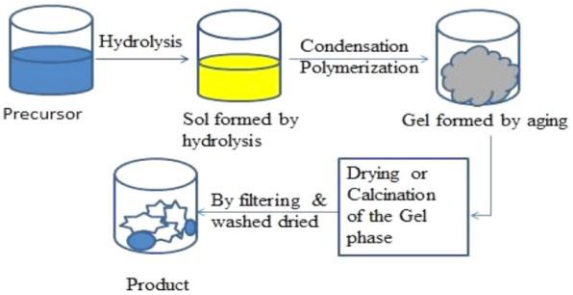


Figure 3 Schematic representation of Sol-gel method

Anugraha et al., [2] synthesized cobalt ferrite by substituting copper via sol gel method. The average size of the crystal was 18nm. Structural properties and confirmation of phase formation was studied by X-ray diffraction method. The particle size and the saturation magnetization decrease as the concentration of Cu into cobalt ferrite increases.

Kadam et al., [4] were synthesized cobalt ferrite with chromium substitution by using sol-gel auto-combustion method. The infra-red spectroscopy (IR), transmission electron microscopy, X-ray diffraction (XRD), vibrating sample magnetometer and scanning electron microscopy were used to study the magnetic, morphological and structural properties of the crystal. The formation of single-phase cubic spinel structure of chromium substituted cobalt ferrite was studied by X-ray diffraction (XRD) technique. The nanocrystalline nature of the sample was confirmed by transmission electron microscopy (TEM) and scanning electron microscopy (SEM).

Hussain et al., [6] synthesized cobalt ferrite by sol-gel method. X-ray diffraction study confirmed the cubic structure and phase purity of nanoparticles with average size of 24−75 nm. The magnetic behavior of the prepared sample was studied by VSM characterization and by SEM morphological properties was studied.

Jeevananthama et al., [14] Cobalt ferrite nanomaterial were prepared by sol gel method. Homogeneous structure was form due to this method. The average size of the crystal was 43nm.

Ball milling method:

A ball milling is a very simple technique for grinding. It is used for silicate products, cement, fireproof materials, new type building materials, ceramics, chemical fertilizers, black and non-ferrous metals, glass, etc. It can grind ore or other materials which can be ground by either dry or wet processes [7].

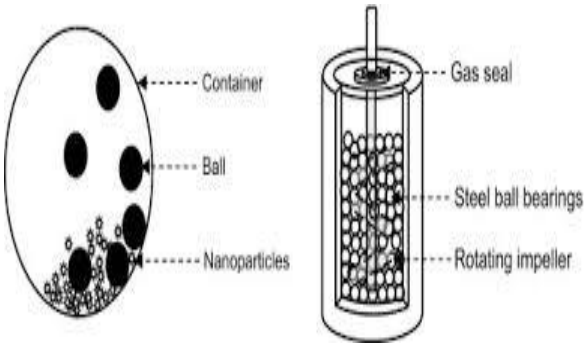


Figure 4 Schematic representation of ball milling method

Ceramic method:

It is a very simple method. For the preparation of ferrite particles, the ceramic method requires a very high temperature. This method contains oxides as a

starting precursor by mixing together to form a powder. Synthesis process contains two phases. To achieve the desired sample, the mixture must first be pre-calcined at a very high temperature and then undergo further heat treatment.

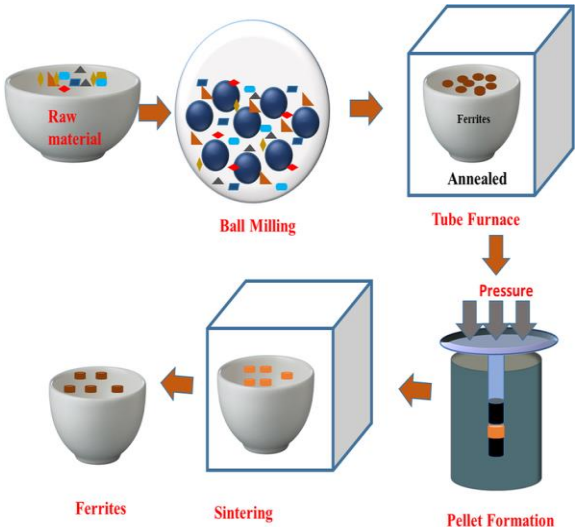


Figure 5 Schematic representation of ceramic method

Tamanna Mariam et al.,[3] synthesized zinc substituted cobalt ferrite by using a double sintering Ceramic method. Cubic spinel structure and high-quality crystal was confirmed by X-ray diffractometer. By increasing the quantity Zn in cobalt ferrite grain size decreased and Dielectric properties and resistivity of the sample increased by substituting 10% of Zn in place of cobalt.

Co-precipitation method:

This is a wet chemical method which is used for synthesis of cobalt ferrite. Co-precipitation method consists of metal salt mixed with normal solvent. By addition of a precipitate agent a desired pH is obtained to prepare homogeneous inorganic and single phase solid.

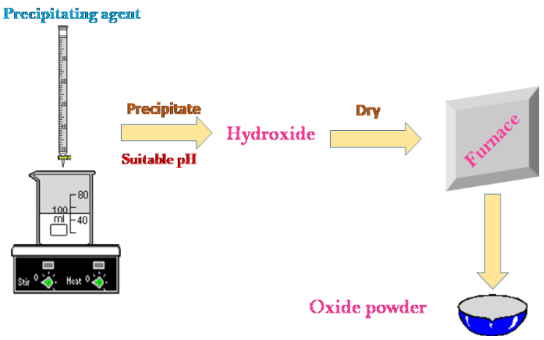


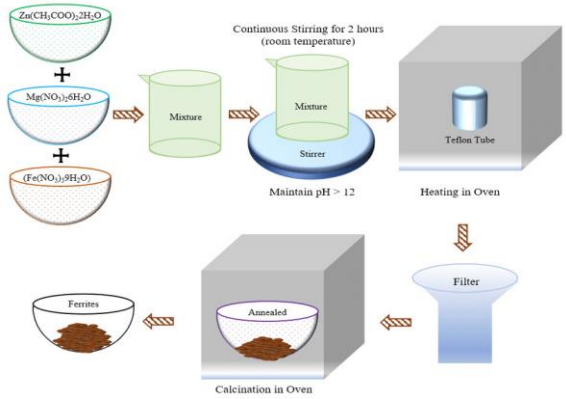
Figure 6 Schematic representation of Co-precipitation method

Afshari et al., [13] Ferrite nanoparticles were synthesized by co-precipitation method. This method consists of aqueous solutions involving the mixture of divalent and trivalent transition metals, which are mixed together in the ratio of 1:2, respectively. This method consists of control of pH in order and careful adjustment for the preparation of the super quality of ferrite nanoparticles. Size of the nanoparticle confirmed was 25nm.

By using sodium hydroxide solution or ammonium solution pH is adjusted. For example, Cobalt ferrite synthesized by Co-precipitation method having particle size of 15 to 25 nm respectively [11,12].

Hydrothermal technique:

High-quality crystals with more control over their composition are created using the hydrothermal technique. The ability of metal salts to dissolve in hot water under high pressure is the primary determinant of single crystal formation via the hydrothermal pathway.



Ayub etal., [8] Using hydrothermal technique cobalt ferrite nanoparticles were synthesized. The structural properties were synthesized by X-ray diffraction technique.

Zalite etal., [9] Cobalt Ferrite nanoparticles were prepared by hydrothermal synthesis method. The average size nanoparticles of range 20nm were produced by this method. Using this method Single phase cobalt ferrite nanoparticles were obtained. Magnetic properties and crystalline size were confirmed by this method.

Refat etal., [10] Spherical Cobalt Ferrite nanoparticles were synthesized by hydrothermal synthesis method, with the average size of 12nm. Spinal crystalline structure was obtained by using this method. Structural properties were confirmed by x ray diffraction method.

III CONCLUSION

An extensive research was done on Synthesis, structural, magnetic, physical properties of cobalt ferrite. This review explained morphology, size and structure of cobalt ferrite by substituting the materials in various way.

IV ACKNOWLEDGMENT

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