A Short Review on Synthesis and Characterization of Mg-Mn Ferrites

Shweta [1], Anjana Sharma [2]

[1, 2] Department Of Physics, University Institute Of Sciences, Chandigarh University, Mohali, Punjab, India

Abstract

Nanotechnology is the study and control of matter at the nanoscale. It gives a recondite idea of new progress in many disciplines, including medicine, environmental research, and material science. Nanoparticles of ferrites have a mind-blowing significance to their substance. Nowadays, we are making materials for various applications like microwaves with the help of this technology. The magnetic characteristics and microstructure of Mg-Mn are extremely sensitive. The synthesis and characterization of Mg-Mn ferrites using diverse techniques were studied in this article. The separate researchers doped Mg-Mn ferrites with various cations, including cobalt in the case of the solution combustion approach. It rises with rising temperature and causes a low dielectric loss at high frequencies. The density of the x-ray and lattice parameters is increased in the case of the sol-gel method by doping silver in Mg-Mn ferrites. We observe that the magnetic and dielectric properties are improved with increasing cobalt concentration in the co-precipitation process used to synthesize cobalt-doped Mg-Zn ferrites. We can improve the electrical and appealing characteristics of magnesium manganese ferrite by doping with the appropriate cations.

Keywords: Mg-Mn ferrites, nanotechnology, cobalt, sol-gel, XRD (X-ray diffraction).

1. Introduction

Ferrites set up a significant convention of materials with a wide scope of uses because of their low dielectric losses and attractive properties. [1,2]. Since 1909, the study of ferrites has been investigated. Many scientists have worked on ferrites to find new ferrites with distinct magnetic and electrical properties. After 2000, research into the characterization and synthesis of nanoparticle systems exploded. The nanoscale material properties are often different from their bulk material. Mg-Mn ferrites address the significant class of spinel ferrites. Substituting these ferrites with In^{3+}, Al3+, and Co^{2+} ions gives them pleasant properties. Nishikawa and Bragg were the first scientists to determine the spinel structure of ferrites. Spinel ferrites are crucial components of microwave control segments. Microwave control segments include things like circulators, isolators, and stage shifters. Selections of cations together with Fe3p particles and their dispersion across octahedral and tetrahedral regions illustrate these electrical and attractive features of spinel ferrites. Compositions are extremely susceptible to impurities, preparation techniques, different kinds of microstructures, and the magnetic characteristics of magnesium and manganese. [3,4]. Magnesium manganese ferrites are discovered to have a very beneficial composition in switching devices and several other microwave applications. [5]. Due to their significant penetrability at high repetition rates, significant immersion polarization, and advanced dc electrical resistivity, ferrite compounds will increasingly be used as cathode materials in energy components, batteries of Li-particles, and super-capacitors. By selecting the most appropriate ready approaches for response climate and dopant particles in accordance with gadget application requirements, the fundamental, morphological, and attractive ferrite qualities are effectively advanced. We make use of distinctly attractive nonmagnetic metal dopant particles. The development of magneto-optical recording, detection, and hyperthermia therapeutic applications has largely relied on uncommon earth metal particles and development metal nanoparticles (NPs) of doped ferrite. There are various methods for the synthesis of Mg-Mn ferrite by conventional technique [5-7], but very little literature is available for non-conventional techniques [8]. In this review paper, we discuss the various synthesis processes, namely, the method of sol-gel, the co-precipitation method, and the characterization of magnesium manganese ferrites**.**

2. Synthesis of Magnesium Manganese Ferrites

The synthesis techniques assume a significant role in creating excellent materials of ferrite in terms of morphology, virtue, strength, and surface territory. The arrangement-based substance 56 Spinel ferrite nanostructure for storage of energy devices: engineered procedures give basic and amazing courses to nanocrystals**.** They are very general, permitting the readiness of a wide range of nanomaterials, and typically hold the upside of more prominent ability. As of now, different combination strategies are being utilized for the arrangement of ferrite materials, as every blend technique has its benefits and weaknesses. The top-down and base-up methodologies are isolated into two general classes of synthesis strategies. During "base up," the particles are artificially joined together to shape the particles, though, in the "top-down" course, materials are pummeled to shape small particles [9]. There are a few amalgamation methods considered the "base-up" alternative, which incorporate co-precipitation [10], warm deterioration, hydrothermal, solvothermal, sol-gel [11], solution combustion method, sonochemical, and so on; just the mechanical processing strategies and pulsed laser removal are under the "top-down" union class. Gagan Kumar et al. [12] synthesize the Mg-Mn ferrites by the technique of citrate precursor. In their study, they observed that with an increase in the content of cobalt, the magnetic and electric properties, for example, the resistivity of dc and Curie temperature, also increase.

2.1. Solution Combustion Method (SCM)

In the solution combustion method [13] we investigate the Mg-Mn by substituting cobalt.

Cobalt-subbed magnesium manganese nanoferrite has been set up by SCM with the compound Mg0.9Mn0.1CoxFe2xO4, in which x has 0.1, 0.2, and 0.3 values. In this current work, the substances utilized were Fe-nitrate, Mg-nitrate, Co-nitrate, and Mn-nitrate, and as a fuel, we utilized glycine, which has the formula(NH2CH2COOH). To get the forerunner solution, we broke down all the nitrates (mentioned previously) and glycine in refined water. Then the solution was warmed at 40 °C on a hot plate with constant mixing until the arrangement began to ignite with the opportunity of lots of warmth. Then, at 500 degrees Celsius, the powder that we acquired was calcined for 4 hours. Now, the calcined powder acquired for every nano-ferrite was then squeezed into pellets having a breadth of 10 millimeters and 2 millimeters of thickness under a squeezing variable of 3 to 5 tons passing by in treated steel. Then, at 700 degrees Celsius, the pre-arranged examples were sintered for 4 hours. The XRD study explored the singular nature stage of pre-arranged examples, which was done by radiation CuKα of frequency 1.54 angstrom utilizing Rigauku Denki XBD (x-Beam Diffractometer). By utilizing quanta 250 ffid 939 3, the microstructure of a multitude of tests was concentrated. With the assistance of Keithly (2611 instrument model), the temperature dependence of every sample of DC resistivity was concentrated. The properties (dielectric), for example, dielectric loss and constant, have been examined in the scope of 100 hertz to 1 mega Hz by utilizing Wayne Kerr (impedance analyzer 6500). Gagan Kumar et al. [14] prepared ferrites of Mg-Mn with cobalt doped by the technique of solution combustion. They noticed that the measured value of the dielectric loss rises with temperature and is very low at high frequencies**.**

2.2. Method of sol-gel

This technology is commonly used to create thin films and various nanostructured materials. We can transform the precursor solution into an inorganic solid catalyzed by water using this approach. We explore the Mg-Mn ferrite by doping it with scandium in this way.

Sc-doped Mg-Mn with the arrangement Mg0.9Mn0.1ScxFe(2-x)O4, where x has 0.1,...,0.3 values, is made by combining Mn-nitrate, Mg-nitrate, Sc-nitrate, and ferric or alkali arrangements. The unadulterated and scandium-doped Mg-Mn ferrite nanoparticles were created using a simple and low-cost sol-gel process. Because of its straightforward command over the arrangement of stoichiometry at low temperatures**,** this approach is used on other synthetic courses. At first, take AR Mg(II), Mn(II), Sc(III), and Fe(III) nitrates as precursors for the arrangement of molars in the required stoichiometry and blend them with attractive stirring. Metal nitrate acts as an oxidizing specialist, whereas citrus extract acts as a decreasing specialist due to its suitability for obtaining precursors of advancing metal oxides. A stoichiometric measure of a burning ingredient (fuel) is also added. By adding alkali, the pH of the arrangement is preserved at 7. This arrangement is allowed to rate on warming at 80 to 90 degrees Celsius to obtain a thick gel. After that, during the drying of the gel at 120 degrees Celsius, it goes through self-start, and the end result is an earthy-colored shading soft powder. Sintered re-arranged powder for 4 hours at 500 degrees Celsius to obtain the genuine stage arrangement [15]. Sol-gel synthesis is used by Jasrotia R et al. [16] to create silver-doped Mg-Mn ferrites. They discovered that adding silver ions (Ag+) and Mn2+ ions boosted the density of x-rays and the lattice characteristics.

2.3. Hydrothermal technique

The hydrothermal technique [17] measures the reactivity of heterogeneous dissolvable materials under high temperature and tension in the presence of fluid to re-crystallize and break down materials that are moderately insoluble under normal conditions. These types of preparation can be used to provide high virtue and homogeneity, precious stone balance, restricted molecule shape circulation, simple hardware, low energy prerequisites, quick response, or low home time, particularly for gem development with low dissolvability or polymorphic alterations. The aqueous approach is likely the most promising amalgamation strategy for the fabrication of various forms and sizes of ferrite materials. Ferrite nanoparticles with equations of Mn0.1Mg0.9Fe2O4, Mg-ferrite, and Mn0.1Mg0.9Fe1.9O4In0.1 were synthesized through aqueous union from metal nitrate hydrate combinations. Metal-nitrate hydrates, including nitrate of Mg-hexahydrate, nitrate of Mn (II) hexahydrate, nitrate of indium (III) hydrate, and nitrate of iron (III) nonahydrate, have been scientifically evaluated. All of these hydrates were used as raw materials. After that, stoichiometric measurements of insightful evaluation reagents were broken down in deionized water, and the arrangement of NaOH was dropped down into final arrangements until 12 pH. To obtain an impartial pH value, the precipitate (ppt) was washed with deionized water. Following that, a 45-mL Teflon-lined, tempered steel high-pressure autoclave reactor for the aqueous blend was run at 150 °C for 18 hours as the suspension setup was filled. Finally, the materials were properly cleaned and dried to produce magnesium ferrite.

2.4. Co-Precipitation method

The precipitation technique refers to obtaining a uniform synthesis in at least two cations in homogeneous arrangements by precipitation response, which is one of the important strategies for the amalgamation of composites including at least two different types of metal components.

Here we used a typical co-precipitation approach to create fine MgFe2O4 particles. The thorough examination of Fe(NO3)3·9H2O, Mg(NO3)2·6H2O, and NaOH revealed that they were combined in the appropriate molar proportion and added to an 8 M NaOH setup with consistent mixing at room temperature. With continual blending, the encourage was warmed to 80 degrees Celsius. After the reaction was complete, the precipitate was centrifuged for 20 minutes at 15,000 rpm before being repeatedly washed and sifted with purified water. At last, the precipitate was warmed to 90 °C for a day and a half. Temperatures between 200°C and 1400°C were used to sinter and pelletize the powder. X-beam diffraction and FTIR have been used to concentrate the growth of ferrites. The microstructure was studied using filtering electron magnifying lenses. An impedance analyzer was used to evaluate complex initial porousness and dielectric constants. A B-H circle tracer was used to consider B-H circles. Electrometers and heaters manufactured by research institutions have concentrated the temperature resonance of resistivity [18-19]. Rohit Sharma et al. [20] used the co-precipitation approach to create Mg-Zn doped with cobalt. They discovered that increasing the cobalt concentration improved the magnetic and dielectric characteristics.

3. Characterization

The characterization of Mg-Mn ferrite is finished by using different types of equipment, namely XRD, looking at the microscopy of the electron [21], the microscopy of the transmission electron (TEM), and the force of atoms amplifying the focal point. VSM, circles of hysteresis (M-H) charge, as well as electron-turn resonation (ESR) hysteresis circle assessments, are assumed to explain the alluring ferrite features. The X-shaft assessment has completed the process of using XRD.

Table 1. Advantages and disadvantages of different methods of Mg-Mn ferrite**.**

Synthesis	Temperature	Advantages	Disadvantages
Solution combustion method	40-700	Easy and dominant method. Less energy is required and a rapid reaction.	High temperature required.

Method of Sol-gel	30-200	Good shape and size. Cost is less and creates fine powders. Easy to perform in the library.	Take a longer time. High cost for fabrication Yield is medium.
Hydrothermal method	100-200	The manageable size and high yield.	High temperature and pressure are required for the reaction and long time process.
Co-precipitation method	40-1400	Simple and environmentally friendly process.	Poor crystallinity.
solid-state reaction	25	No toxic solvents are used.	The required temperature is high.

Table 2. Characterization table for different methods.

Author names	Methods	Structure	Lattice parameter	Magnetic property
Gagan Kumar et al.	SCM	Diffraction of X-ray (XRD), Scanning Electron Microscopy (SEM)….	With the increase in ions of Co2+, it also increases	With the increase in frequency dielectric loss and constant were observed to be decreasing
Meenakshi dhiman et al.	Sol-gel method	Diffraction of X-ray, Microscopy of Scanning Electron, Energy dispersive explication of x-rays, and VSM	Increase with rising in Sc3+ ion doping	Decreases and can be improved with dopant concentration
Sheikh Manjura Hoque et al.	Method of Co-precipitation	Diffraction of X-ray (XRD), microscopy of Scanning Electron(SEM)….	Increases rapidly during sintering	Increase with the degree of crystallinity of the sample
Sk Sharma et al.	Solid-state reaction method	X-ray diffraction	Increases	Magnetization decreases with a decrease in particle size
Gagan Kumar et al.	Method of Citrate precursor	Diffraction of X-ray technique and microscopy of Scanning Electron (SEM)	Increases	Permeability increases with an increase in temperature

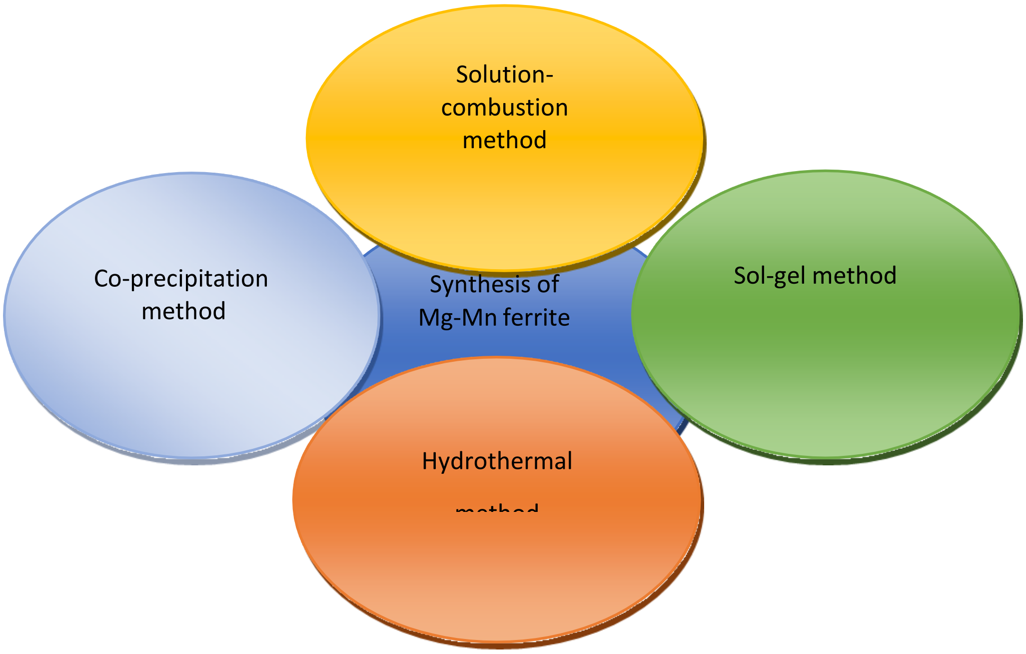

Figure 1. Different synthesis methods of Mg-Mn ferrites.

4. Conclusion

The synthesis of Mg-Mn ferrites has widely increased over the last some years due to its elegant properties in the class of delicate ferrites such as saturation magnetization, low coercivity, and high permeability. Due to these excellent properties researchers are interested in the preparation of these nano-ferrites. Here we reviewed some of the synthesis methods for Mg-Mn ferrites such as the sol-gel method, precipitation method, hydrothermal method, and SCM. Among all of these methods, the sol-gel method is mostly utilized for the preparation of ferrites. This method provides simple preparation for ferrites and is cost-effective. Reviewing the synthesis of Mg-Mn ferrites and understanding their properties in a good manner will lead to great development in the future.

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