Synthesis and structural properties of copper ferrite

Rahul Upalaikar,

Assistant professor,
Department of Physics,
H.P.T Art's and R.Y.K. Science College, Nashik, India, 422005

Abstract- Powdered sample of spinel copper ferrite was synthesized by using sol-gel method. Structure of spinel copper ferrite was confirmed by using X-ray diffraction. Average crystalline size and lattice parameter of powdered sample is calculated using X- ray diffraction.

Keywords – Copper ferrite, X-ray diffraction

I. Introduction

Ferrite nanoparticles are a large group of magnetic particles that have piqued the interest of many researchers due to their numerous applications ranging from biomedical to industrial. Because of their physiochemical properties such as surface functionalization feasibility and high surface to volume ratio [1]. properties like strong magnetic anisotropy, high coercivity at room temperature, moderate saturation magnetization, good mechanical hardness, chemical stability & high resistivity makes the family of ferrites is promising material for various industrial purpose such as sensors, memory devices, refrigeration, quality filter circuit, high frequency transformers, wide band transformers, high frequency electronic circuitry, microwave applications, multilayer chip conductor, electromagnetic wave absorber.[2]–[6]

Spinel ferrites have face centered cubic structure and characterized by MFe_2O_4 formula where M denotes the divalent metal ions like Zn, Cu, Al. Spinel ferrites can have normal spinel structure, inverse spinel structure or mixed spinel structure. In spinel structure, all metal ions occupy tetrahedral sites, whereas all Fe^{+3} occupy octahedral sites. In inverse structure, all metal ions occupy octahedral site while Fe^{+3} ions are distributed over both tetrahedral & octahedral sites [7]. Among family of ferrites, copper ferrite ($CuFe_2O_4$) having inverse spinel structure is imperative due its wide applications in sensors, photo catalyst, lithium ion batteries, water treatment, biomedical applications [8]–[10] as it shows low saturation magnetization, high resistivity properties. For synthesis of copper ferrite, many methods like co precipitation[11], hydrothermal[12], electrochemical[13], sol gel [14] are used.

In this paper, our work leads to synthesis of copper ferrite using sol gel method & structural properties of it studied using X-ray diffraction.

II. Materials & methods

Materials

For synthesis of copper ferrite analytical grade copper nitrate (Cu $(NO_3)_3.6H_2O$), & ferric nitrates (Fe $(NO_3)_3.9H_2O$), reagents are used without further purification. Double distilled water is used throughout the synthesis & citric acid is used as reducing agent.

Method

Separate solutions of copper nitrate and ferric nitrate are prepared in stoichiometric amounts in double distilled water to make copper ferrite. These solutions were combined in a beaker, which was kept constantly stirring and heated to 150°C. As a reducing agent, citric acid is added to the beaker. Evaporation converts the solution

into a viscous gel after 3 hours. The gel was then heated to 250°C to achieve self-sustaining combustion, yielding burned brownish copper ferrite fluffy powder. This burned fluffy brownish powder is annealed in a furnace at 900°C for 4 hours before being used for further characterization.

III. Results and Discussion

Structural properties

X-ray diffraction (XRD) pattern of copper ferrite powder is shown in figure 1. From X-ray diffraction pattern, phase, crystalline size and lattice parameter of the powdered sample is obtained. The XRD pattern shows spinel structure having Fd3m space group having peaks (2θ) at 18.6°, 30.05°, 35.68°, 57.93°, and 62.38°. Most intense peak (2θ) is at 35.68°. Average crystalline size is calculated using Debye-Scherer formula $D = \frac{0.9\lambda}{\beta cos\theta}$ where λ is the wavelength of X-ray radiation, β is full width half maxima for most intense peak, θ -Bragg's angle for the most intense peak. Lattice parameter is calculated by using formula $a = d_{hkl}\sqrt{h^2 + k^2 + l^2}$, where d_{hkl} is inter-planner spacing & hkl are Miller indices. Using given formula calculated value of lattice constant & average crystalline size are 8.33 °A and 7.191 nm.

IV. Conclusion

Copper ferrite is synthesized using the sol-gel method in this paper, and the spinel structure of copper ferrite is confirmed using X-ray diffraction. The calculated values of lattice constant and average crystalline size from X-ray diffraction were 8.33 °A and 7.191 nm, respectively.

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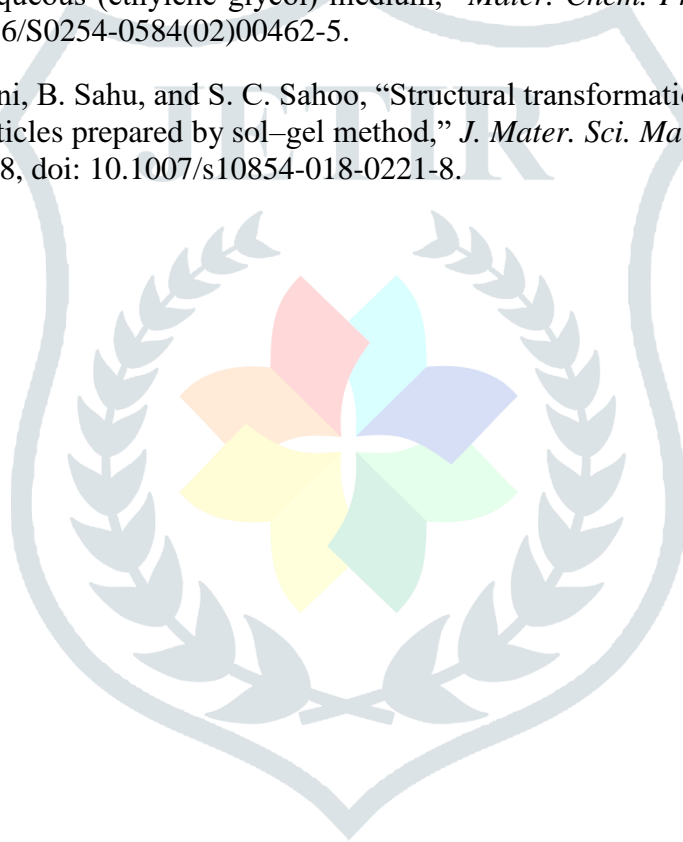
Figure 1