Preparation of Cobalt doped Zinc nano-ferrites by sol-gel technique

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ABSTRACT
This paper describes the preparation of nitrate-citrate gel from nitrates and citric acid by sol-gel method in order to synthesize Cobalt doped zinc nano-ferrites Co$_x$Zn$_{1-x}$Fe$_2$O$_4$ due to simple, low cost and application oriented. The composition was prepared by nitrates of Fe(NO$_3$)$_3$.9H$_2$O , Zn(NO)$_3$.6H$_2$O , Co(NO$_3$)$_2$.6H$_2$O in the presence of citric acid and the gelling agent ethylene glycol. Solution prepared at 90⁰C with final pH value of 7 and synthesized powder was annealed at 600⁰C for 4 hours. The phase purity of synthesized nano-ferrites was characterized by X-Ray Diffraction (XRD) analysis and studied for various applications.

Keywords
Nitrates, gelling agent, citric acid, nano-ferrites, sol-gel, XRD
1. INTRODUCTION

Ferrites are the ceramic materials, which are seen as dark gray or black in colour and these are very hard and brittle. Basically ferrites composed of oxides containing ferric ions and defined as magnetic materials. They exhibit ferromagnetic behavior due to their magnetic property. The magnetic property arises from interactions between oxygen ions and metallic ions which are occupying at particular positions [1-3]. Ferrites are commonly used because of their many practical applications, such as magnetic devices in optical, electronic and microwave installations [4]. Ferrites to be the most important materials due to their applicability at higher frequency, greater heat resistance, higher corrosion resistance and lower price. Ferrites are used in television circuits, VCRs and in radios. Nano-ferrites are chemical compounds in the form of nano sized powder with ferromagnetic properties. Nano-ferrites are the subject of interest because of their various applications in research as well as in industrial areas. Doping of nano-ferrites with various metals like cobalt, zinc, copper, chromium, and manganese are commonly used to enhance their magnetic and electrical properties. Cobalt doped zinc nano-ferrites are the technological important ferrites. Cobalt ferrite is the most important magnetic material that has remarkable chemical stability, large magnetic anisotropy, and mechanical hardness which makes the best candidate for recording media [5]. Cobalt doped zinc nano-ferrites are prepared by sol-gel technique because some properties of nano-ferrites depend upon the synthesis technique. The other chemical techniques are co-precipitation, hydrothermal, citrate precursor. Sol-gel technique is one of the best technique due to their remarkable effects on prepared powder. Low temperature processing, nano-particle size and sintering at low temperature also possible. Better homogeneity and phase purity are possible in sol-gel technique compared to the other methods.

2. MATERIALS AND SYNTHESIS

2.1 MATERIALS:
Zinc (II) nitrate, Cobalt (II) nitrate, Iron (III) nitrate, Citric acid, Ammonia, Ethylene glycol, Ethanol

2.2 SYNTHESIS:
Cobalt doped zinc nano-ferrites with chemical formula Co$_x$Zn$_{1-x}$Fe$_2$O$_4$ were prepared using sol-gel method. The actual method for the sample preparation consists of various steps.

**Step: 1**

In the first step the stoichiometric amounts of individual nitrates, i.e., Iron nitrate, Zinc nitrate and Cobalt nitrate were mixed together and dissolved in suitable amount of distilled water. All the solution was mixed at 90°C temperature followed by the constant stirring with magnetic stirrer.

**Step: 2**

In the second step the molar ratio of nitrates to citric acid was 1:1. The suitable amount of citric acid was taken in another beaker and dissolved in ethanol. The obtained solution was heated using hot plate at 80°C-90°C with stirring.

**Step: 3**

Both solutions were mixed carefully and after 45 minutes ammonia was added drop wise to control the pH value. The pH was attained 7 with the help of ammonia (base). The final solution was constantly stirred for 20 minutes and then gelling agent was added.

**Step: 4**

Ethylene glycol was the gelling agent and added into the solution drop wise until the solution was transform into the gel. The gel was formed at a given temperature then dried the gel at 110°C in hot air oven for 24 hours.

**Step: 5**

The dried gel grinded into the powder using electrical grinder to obtained the nano-sized particles. After that, the powder was annealed at 600°C for 4 hours in muffle furnace under air atmosphere. Finally, cobalt doped zinc nano-ferrites were synthesized with the help of sol-gel technique.
Fig.1. Schematic of the preparation of Co-Zn powder

3. CHARACTERIZATION

X-Ray diffraction technique is very common for the study of crystal structure of synthesized nano-ferrites powder. The phase purity of synthesized nano-ferrites was characterized by X-Ray Diffraction (XRD) analysis and studied for various applications.

4. RESULTS

Cobalt doped zinc nano-ferrites were synthesized by sol-gel method and hence, the PH was attained 7.

5. CONCLUSION

The sol-gel technique was successfully used to synthesized cobalt doped zinc nano-ferrites Co$_x$Zn$_{1-x}$Fe$_2$O$_4$ due to their small and homogeneous nano-particle size, high purity, simple, energy saving, low cost, minimum evaporation loss and have many advantages in research areas. The X-Ray Diffraction analysis confirmed the phase purity of synthesized powder.

6. REFERENCES


