CHAPTER 7

SUMMARY AND CONCLUSIONS

7.1: INTRODUCTION:
Spinel cobalt ferrite nanoparticles have attracted much attention in the recent years because of their unusual, interesting and superior properties compared to their bulk materials. The cobalt spinel ferrite exhibits electrical as well as magnetic properties that are unique and useful for several technological applications.

The important electrical and magnetic properties are sensitive to various parameters like synthesis methods, synthesis conditions, synthesis parameters, cation distribution etc. All these parameters can be varied to obtain the highly stable, homogeneous, single phase materials.

In the literature, various synthesis methods have been used to prepare cobalt spinel ferrite particles with nanometer dimension. These methods include co-precipitation, micro-emulsion, sol-gel, hydrothermal, ball-milling etc.

These methods are cost effective, easy and produce homogenous particles of nano-meter dimensions. Among these methods the sol-gel method is widely studied for the preparation of nano-particles.
In sol-gel process pH, metal nitrate to fuel ratio, annealing temperature, fuel etc. Synthesis parameters are of great importance in modifying the properties of cobalt ferrite nanoparticles. Various workers have studied some of these parameters.

7.2: PRESENT STUDY

In the present thesis cobalt ferrite nanoparticles were prepared by standard sol-gel method with a view to obtain nanoparticles for the applications in many fields.

The synthesis parameters like fuel and annealing temperature have been chosen to understand their effect on the structural, morphological, electrical, dielectric and magnetic properties of cobalt ferrite nanoparticles.

The fuels like citric acid were commonly used for the synthesis of cobalt ferrite nanoparticles. L-ascorbic acid and tartaric acid were used for the first time in our study for the synthesis of cobalt ferrite nanoparticles.

The annealing of the prepared nano-particles of cobalt ferrite is important for better crystallization and for the study of structural, morphological and other properties.
An attempt is made to understand the effect of varying annealing temperature on the structural, morphological, electrical, dielectric and magnetic properties of cobalt spinel ferrite.

The structural characterizations were carried out using X-ray diffraction, scanning electron microscope and infrared spectroscopy techniques.

The electrical, dielectric and magnetic properties were studied through two-probe technique and pulse field hysteresis loop technique.

7.3: RESULTS

EFFECT OF FUEL

Using L-ascorbic acid, tartaric acid and citric acid cobalt ferrite nanoparticles were prepared at low temperature with nanometer dimensions. The single phase nature of the prepared samples was confirms through X-ray diffraction method. The Particle size (Crystallite size) obtained by Scherrer’s formula exhibit nanocrystalline nature of the prepared samples with particle-size 38 nm, 42 nm and 43 for citric, L-ascorbic and tartaric and acid respectively.

The lattice constant for citric acid, L-ascorbic acid and tartaric acid used cobalt ferrite nanoparticles is of the order of 8.363 A.U.,
8.357 A.U., and 8.395 A.U. respectively. The greater value of lattice constant is observed for tartaric acid as a fuel.

The grain size determined through scanning electron microscopy (SEM) technique is of the order of 76.2 nm, 72.4 nm and 75.7 nm for citric acid, L-ascorbic and tartaric acid as a fuel respectively. The surface morphological studies show that uniform grain growth and less agglomeration for all these fuels.

The infrared spectra recorded at room temperature of all the samples under investigations exhibit normal characteristic feature of spinel ferrite.

The magnetic properties of the cobalt ferrite samples were found to be enhanced as compared to the bulk material. The values of saturation magnetization (Ms) for cobalt ferrite nanoparticles for fuels citric, L-ascorbic and tartaric acid are of the order of 62.04 emu/gm, 80.21 emu/gm and 52.84 emu/gm respectively.

The values of coercivity (Hc) for citric, L-ascorbic and tartaric acid are 3520 Oe, 2444 Oe and 2167 Oe respectively.

These values of magnetic parameters show that the fuels used in the synthesis of cobalt ferrite strongly influences magnetic properties.

The electrical and dielectric properties were also influenced by L-ascorbic, tartaric and citric acid used as a fuel.
Thus, the different fuels L-ascorbic, tartaric and citric acid used in the synthesis of cobalt ferrite samples shows more or less same effect from the structural, morphological, electric, dielectric and magnetic properties.

However, it can be observed from the experimental results that L-ascorbic acid and tartaric acid both can be suitably used as a fuel in the synthesis of cobalt ferrite nanoparticles. L-ascorbic acid used as a fuel shows better magnetic properties compared to other fuels in the present work.

**EFFECT OF ANNEALING TEMPERATURE**

Cobalt ferrite nanoparticles synthesized by sol-gel auto-combustion technique using L-ascorbic acid as a fuel. The prepared samples were annealed at 600°C, 800°C and 1000°C. The single phase nature of the prepared samples was confirms through XRD. The Particle size (Crystallite size) obtained by Scherrer’s formula exhibit nanocrystalline nature of the prepared samples and increases with increase in temperature.

The analysis of SEM image shows that the microstructures of the nanoparticles were almost regular in shape and dispersed uniformly. The agglomeration of particles at 600 °C that is for sample CF6 is more as compared to CF8 and CF10.
It is observed from spectra that the absorption band shift towards lower wave number due to increase in annealing temperature.

The saturation magnetization increases whereas coercivity and remanence magnetization decreases with increasing annealing temperature.

The dc electrical resistivity of cobalt ferrite nanoparticles decreases with increase in temperature for all the samples. The dc electrical resistivity of cobalt ferrite nanoparticles decreases with the annealing temperature.

The dielectric parameters ($\varepsilon'$, $\varepsilon''$ and $\tan \delta$) decreases with increase in frequency. The dielectric parameter increases with increase in annealing temperature.