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Synthesis and Studies of Zinc Doped Copper Ferrites

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Copper Zinc Ferrites were synthesized by Combustion method at 450oC using Polyethylene Glycol (6000 mw) as fuel. XRD powder patterns for all compositions indicate single phase spinel cubic structure formation. The nano-size particles were obtained. The FTIR Spectra Shows two broad bands and designated as ν1 (Tetrahedral) and ν2 (Octahedral). The first primary band ν1 in the range 500- 800 cm-1 and lower frequency band ν2in the range 500-250 cm-1.

1. Introduction

Since 19th century, there is a rapidly growing interest in the systematic study of chemical composition and various properties of ferrites. They have many applications ranging from simple function devices to sophisticated devices in the electro-electronic industry. The technical importance of ferrites is due to their high electrical resistivity, low dielectric constant, high magnetization, high permeability and low cost. These properties make them suitable for microwave devices, transformers, magnetic components, phase shifters and electric generator storage devices. To most people ferrites are completely unknown, yet they touch the lives of everyone, every day and contribute significantly to improve their lifestyle.Among all the ferrites, Cu-ferrites are considered as good dielectric materials, having very high dielectric constants which are useful in designing good microwave devices as insulators, circulators, etc. By introducing non-magnetic Zn^{+2} ions in Cu ferrite, the significant influence on several properties such as electrical and dielectric phenomena are studied.

The subject of magnetic nanostructures is wide and several articles are published. The Cu-Zn ferrites, constitute a special niche of nanoparticles because of the attraction of the scientific community towards soft ferrites.

Generally, ferrites are prepared by the ceramic process involving high temperature solid state reactions between the constituent oxides/carbonates. Since 19th century, there is a rapidly growing interest in the systematic study of chemical composition and various properties of ferrites. They have many applications ranging from simple function devices to sophisticated devices in the electronic industry. The technical importance of ferrites is due to their high electrical resistivity, low dielectric constant, high magnetization, high permeability and low

cost [1,2]. These properties make them suitable for microwave devices, transformers, magnetic components, phase shifters and electric generator storage devices [2]. To most people ferrites are completely unknown, yet they touch the lives of everyone, every day and contribute significantly to improve their lifestyle. Among all the ferrites, Cu-ferrites are considered as good dielectric materials, having very high dielectric constants which are useful in designing good microwave devices as insulators, circulators, etc[2]. By introducing non-magnetic Zn^{+2} ions in Cu ferrite, the significant influence on several properties such as electrical and dielectric phenomena are studied.

Researchers infer that by substitution of various non-magnetic ions and transition metal ions in spinel ferrites leads to improvement of their crystalline structure, magnetic properties and antibacterial activity[3-5].

The synthesis techniques such as the sol-gel [9], co-precipitation [10] and many others are discussed for the synthesis of Cu-Zn mixed ferrites.

2. SYNTHESIS OF Cu-Zn FERRITE BY COMBUSTION TECHNIQUE:

Zinc doped Copper Ferrite were prepared by combustion synthesis method. The precursors CuO, ZnO and Fe_2O_3 all AR grade are taken in stoichiometric ratio. The amount of precursors taken for synthesis of 10gm of samples were listed in table 2.1. these precursors are well ground in agate mortar and pestle for 1 hr. Polyethylene Glycol (PEG) of molecular weight 6000 which acts as a fuel for Combustion synthesis is mixed with the precursor mixture in the precursor to PEG ratio 1:2 in weight. This mixture was further ground for 2 hr to get fine powder. Precursor and PEG mixture was taken into silica crucible and heated at the rate of 3^0C per minute up to 450^0C in Muffle Furnace and kept at 450^0C for 1 hr.

The PEG ignites on heating ~420^0C, thus, undergoing combustion resulting in formation of fine nanoparticle product. Apparently, nucleation of the Cu-Zn ferrite occurs as a result of the heat generated due to high exothermicity of the decomposition of PEG in the precursor. Further decomposition of the precursor is self-sustained resulting in complete decomposition giving Cu-Zn ferrite product.

The samples were labelled as CuZF0, CuZF2, CuZF4, CuZF6, CuZF8 and CuZF10 respectively.

The crystallite size can be calculated using the angle θ in the Debye Scherrer equation given by,

$D_{hkl} = 0.89\lambda/\beta \cos\theta$

Where λ is the incident wavelength of X-Ray Radiation, is the full-width at half-maximum and θ is the diffraction angle.

Another important physical parameter of spinel ferrite, is the theoretical or X-Ray density which is calculated using the value of lattice parameter in the formula,

$\rho = 8M/Na^3$

Where M is the molecular weight of the sample, N is the Avogadro's number=$6.023x10^{23}$ unit

and a is the lattice constant.

Thus, the use of X-Ray technique helps in phase identification, determination of lattice parameter, crystallite size, densification etc.

FTIR STUDIES:

The goal of absorptionspectroscopy techniques (FTIR, ultraviolet-visiblespectroscopy, etc.) is to measure how much light a sample absorbs at each wavelength. The most straightforward way to do this, the "dispersive spectroscopy" technique, is to shine a monochromatic light beam at a sample, measure how much of the light is absorbed, and repeat for each different wavelength.

3. RESULTS AND DISCUSSION:

Data obtained from analytical methods and the instrumental techniques used in the present investigation are presented below. Interpretations from these results are also discussed.

3.1 X-Ray Diffraction Analysis:

X-Ray diffraction studies were carried out to examine the structure as well as to determine interplanar distance and the lattice constants. The samples of Cu-Zn ferrite prepared were analysed for its crystal structure by powder X-Ray diffraction method using reflection angles in the range from 20^0 to 80^0. XRD powder patterns for all the samples, indicate single phase cubic spinel structure formation for all the compositions. X-Ray spectra of these samples are given in fig 3.1.

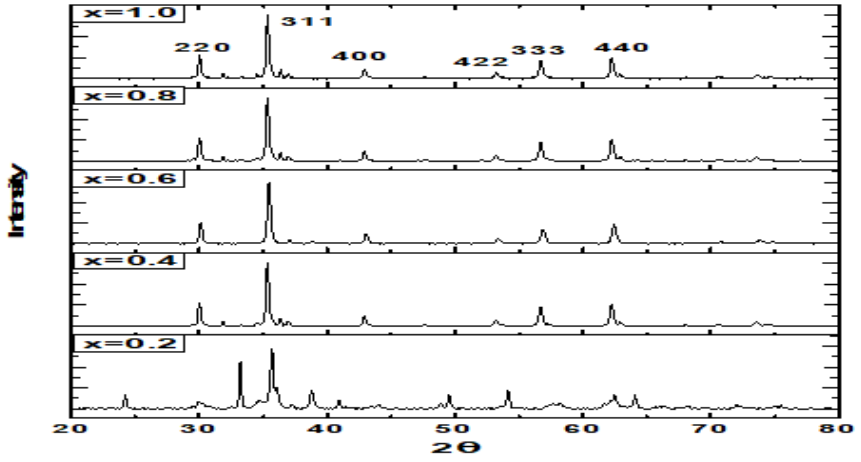

Fig 3.1 X-Ray Diffraction patterns of $Cu_{1-x}Zn_xFe_2O_4$

Particle size using X-Ray analysis:

As the particle size decreases, the peaks in the XRD patterns get broadened due to the incomplete destructive interference. This broadening caused by the fine crystallites is related to the size of the grains by the Scherrer formula.

The particle size is an important parameter in the ferrite materials with regard to their applications. The particle size values calculated by Scherrer formula show that the size of Cu-Zn ferrite particles formed were in the nanometer range. The values are given in table 3.2.

Table 3.2. particle size of Cu-Znferrite

Sl. No.	Samples	Particle size (nm)
1	CuZnFe2	49.77
2	CuZnFe4	80.99
3	CuZnFe6	63.98
4	CuZnFe8	73.09
5	CuZnFe10	84.97

FTIR Studies:

IR radiation is passed through the sample and is absorbed and transmitted by the sample. The resulting spectrum represents the molecular absorption and transmission, creating a fingerprint of the sample. Fig 3.2 shows FTIR Spectra having two broad bands and designated as ν_1 (Tetrahedral) and ν_2 (Octahedral). The first primary band ν_1 in the range 500- 800 cm^{-1} and lower frequency band $\nu_2$in the range 500-250 cm^{-1}.

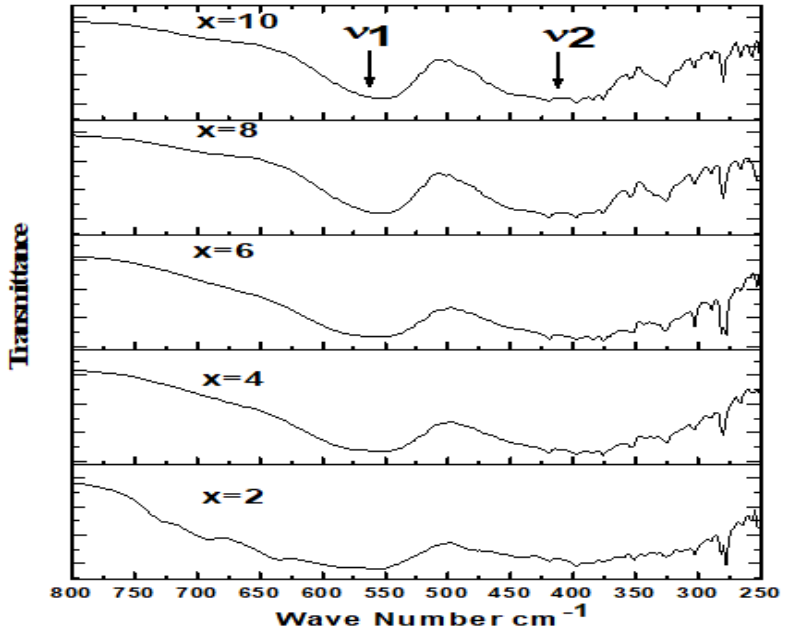

Fig 3.2 FTIR patterns of $Cu_{1-x}Zn_xFe_2O_4$ samples

4. Conclusion

Copper Zinc Ferrites having general formula, $Cu_{1-x}Zn_xFe_2O_4$ where x=0.2, 0.4, 0.6, 0.8 and

1.0 were synthesized by Combustion synthesis method at 450^0C using Polyethylene Glycol of molecular weight 6000 as fuel. XRD powder patterns for all the samples indicate single phase cubic spinel structure formation for all the compositions. The nano-size particles were obtained. The FTIR Spectra Shows two broad bands and designated as ν_1 (Tetrahedral) and ν_2 (Octahedral). The first primary band ν_1 in the range 500- 800 cm^{-1} and lower frequency band $\nu_2$in the range 500-250 cm^{-1}.

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