Synthesis and characterization of Sn Substituted Zn ferrite

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Abstract

Sn substituted Zn ferrites have been synthesized with composition $Zn_{1-x}Sn_xFe_2O_4$ (where x varies from 0.0 to 0.5 in steps of 0.1) by using solution combustion method. For the solution combustion synthesis of ferrite samples, oxalyl dihydrazide has been used as a fuel. By using this method ferrite samples can be prepared at lower temperature and in shorter time. Identity of synthesized ferrite samples have been established by using FTIR and powder XRD studies. Spinel cubic phase structure has been observed for investigated ferrite materials.

Introduction

In last few decades, scientific have paid noteworthy attention in cubic spinel ferrites as these materials show remarkable properties as per their use in different applications. These ferrite materials find extensive applications in high frequency devices, transformers and quality filters due to their availability, stability and low price [1-3]. Properties of ferrite materials are largely dependent upon their chemical composition, method of preparation and sintering temperature. These properties can be easily altered/enhanced by variation in said parameters. Properties of Zn ferrite can be changed by substitution with Sn^{4+} ions. Many scientists have reported the studies on substitution of Sn ions [4-6]. Synthesis of Sn substituted ferrites by different methods have already been reported by various scientists [7-9]. In present investigation, pure and Sn substituted Zn ferrites have been synthesized through solution combustion method.

Experimental

1. Preparation of oxalyl dihydrazide (ODH)

Oxalyl dihydrazide, $(CON_2H_3)_2$ was synthesized by drop wise addition of one mole of diethyl oxalate to two moles of hydrazine hydrate at 0-4 degree Celsius temperature. The reaction between these two chemicals is highly exothermic and addition of diethyl oxalate was carried out by placing hydrazine hydrate in an ice bath. White precipitates of ODH were synthesized which were then washed with distilled water.

2. Preparation of ferrites:

The series of nano-crystalline $Zn_{1-x}Sn_xFe_2O_4$ ferrites (x = 0, 0.1, 0.2, 0.3, 0.4, 0.5) were synthesized by using ODH. ODH acts as a fuel in combustion method. The stoichiometric amount of metal nitrate/chloride were dissolved separately in minimum amount of distilled water and then all solutions were mixed thoroughly.

ODH was then added into the reaction mixture with continuous stirring. After addition of ODH the reaction mixture was concentrated on water bath. For the preparation of ferrite product concentrated mixture was combusted in muffle furnace up to 600^0C. Temperature of furnace was increased in steps and combustion product was allowed to stand at 600^0C for 3 hours. After that temperature of furnace was decreased in steps. Dark brown coloured ferrite powder was obtained in this process. Synthesized ferrite powder was then subjected to FTIR and XRD (powder) studies. The infrared spectrum of each product was recorded with FTIR-8400S Fourier transformer infrared spectroscopy, Shimadzu, in the range of 4000- 400 cm^{-1} using KBr pallets as reference. The X-ray powder diffraction patterns were observed at room temperature by using XPERT-PRO, PW -3071, at IIT Ropar by using Cu K-alpha radiation with wavelength value 1.5406 A^o.

Results and Discussion

FTIR spectra of ferrite samples are displayed in Figure 1-6 which show two distinct absorption bands below 600 cm^{-1}. These bands are assigned to tetrahedral (high frequency) and octahedral (low frequency) sites respectively in a spinel structure [10, 11]. These bands arise due to M-O bonding and present of these sites in ferrite samples confirm the formation of spinel phase.

Figure 7-12 show X-ray diffraction pattern of synthesized ferrite samples. These spectra reveal the formation of spinel phase ferrite materials. With increase in Sn substitution lattice parameter ‘a’ increases, which is attributed to larger size of Sn ions as comparted to Zn ions.

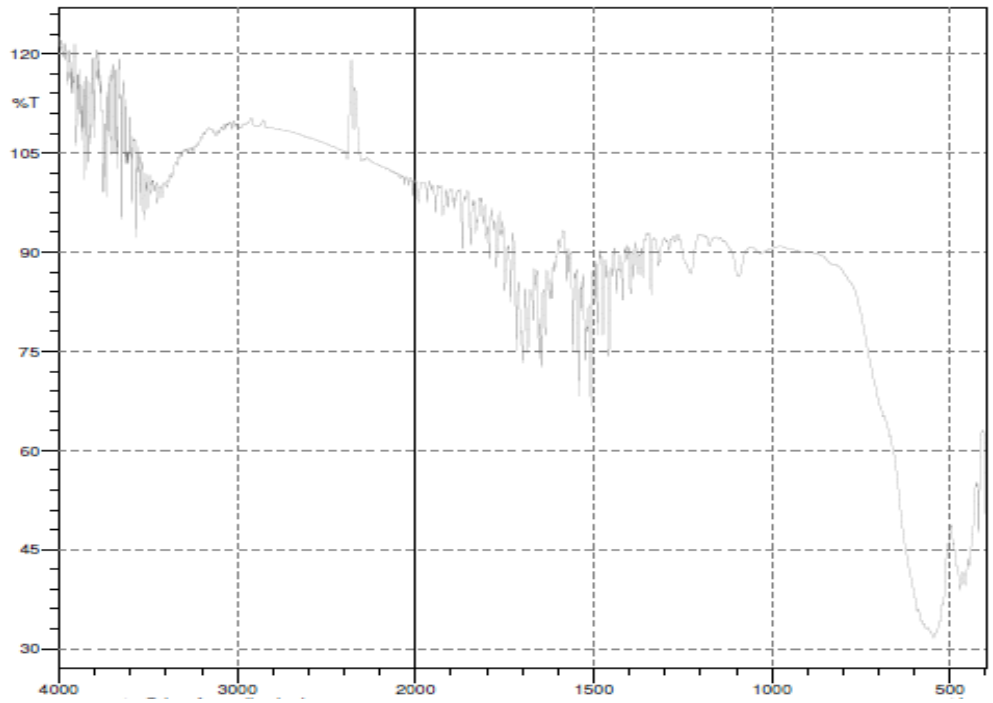

Figure 1. FTIR spectrum of $ZnFe_2O_4$ (X=0)

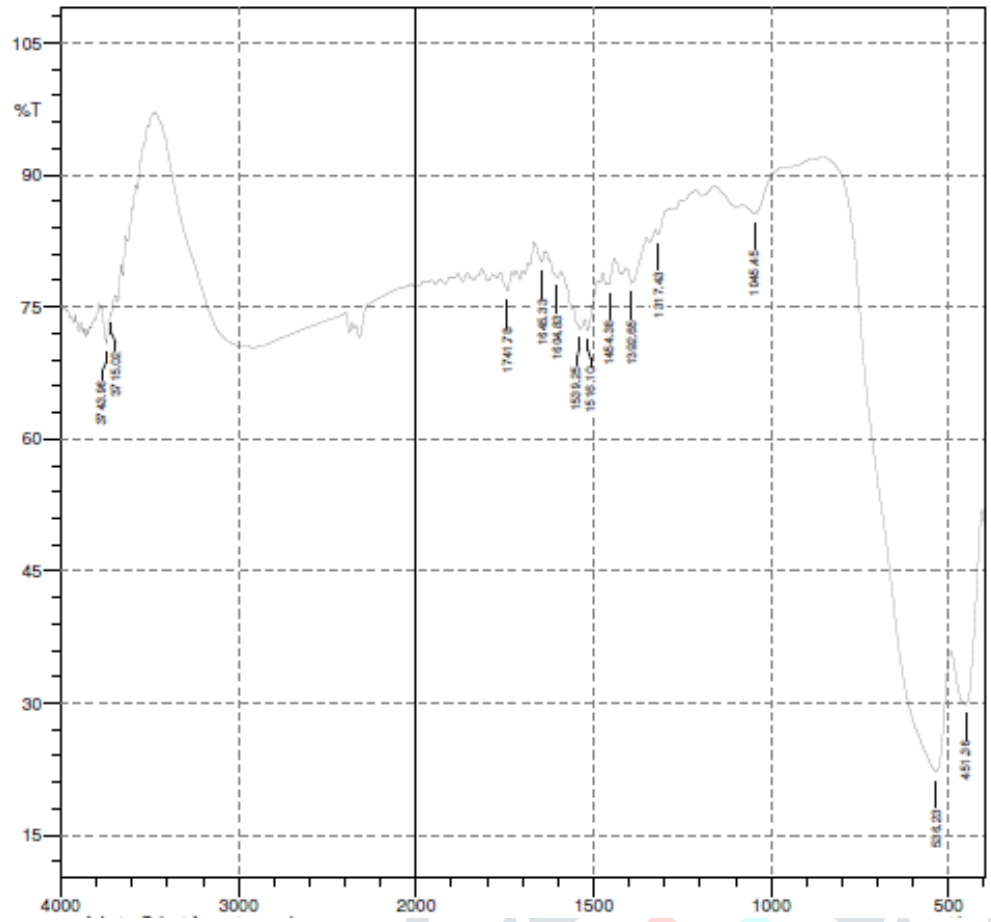

Figure 2. FTIR spectrum of $Zn_{1-x}Sn_XFe_2O_4$ (X=0.1)

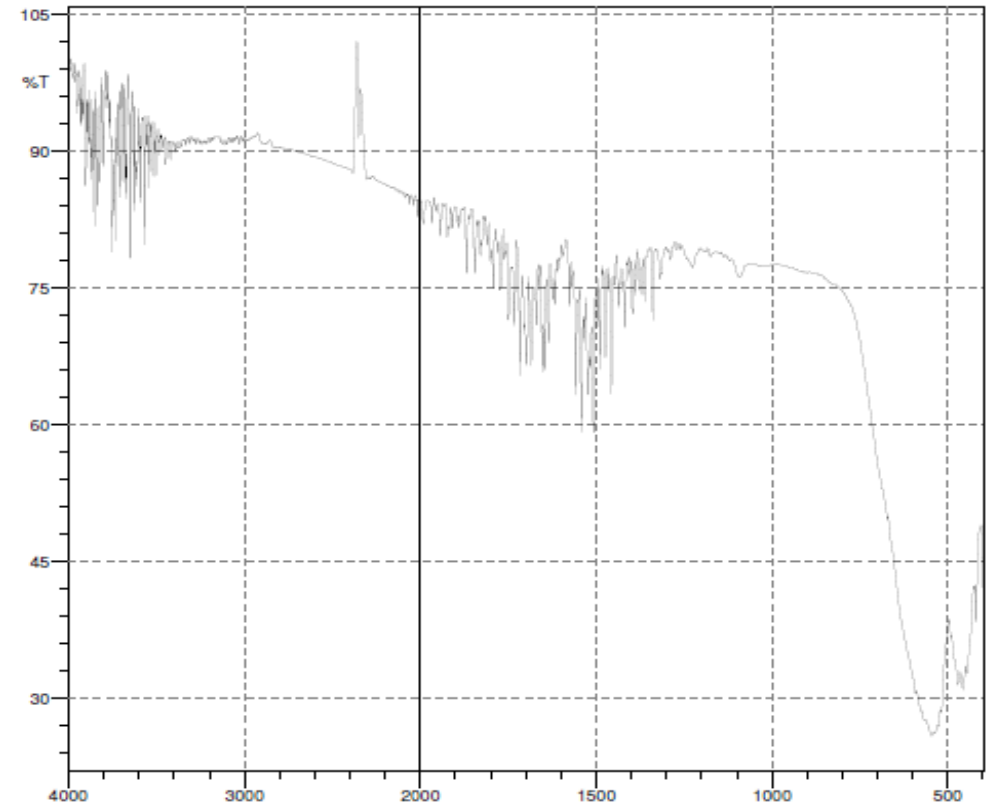

Figure 3. FTIR spectrum of $Zn_{1-x}Sn_XFe_2O_4$ (X=0.2)

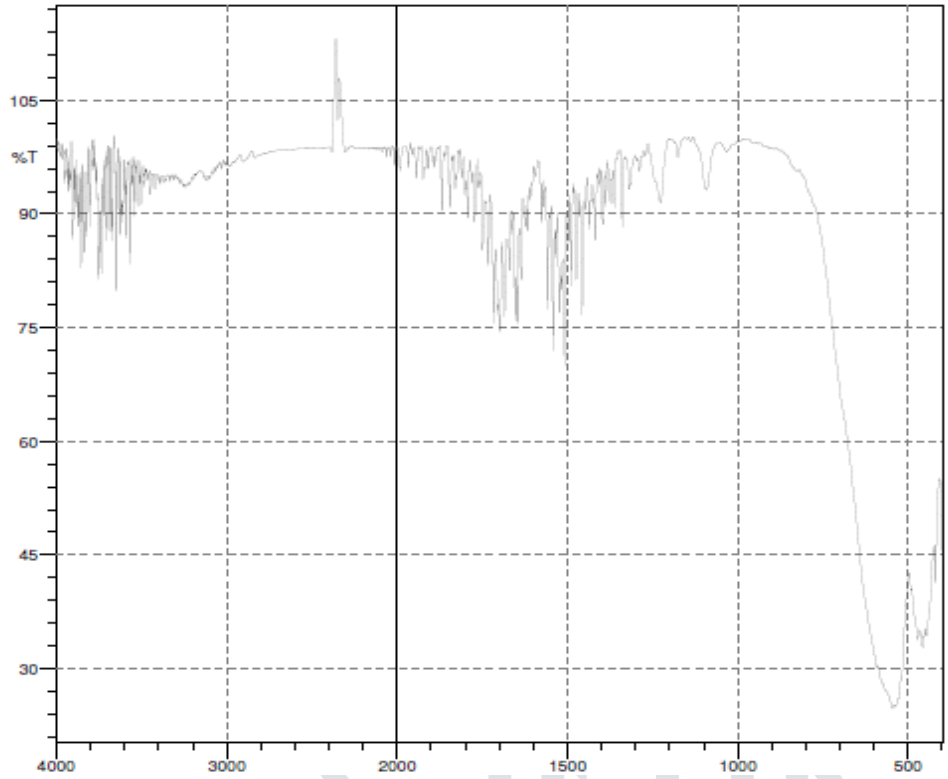

Figure 4. FTIR spectrum of $Zn_{1-x}Sn_XFe_2O_4$ (X=0.3)

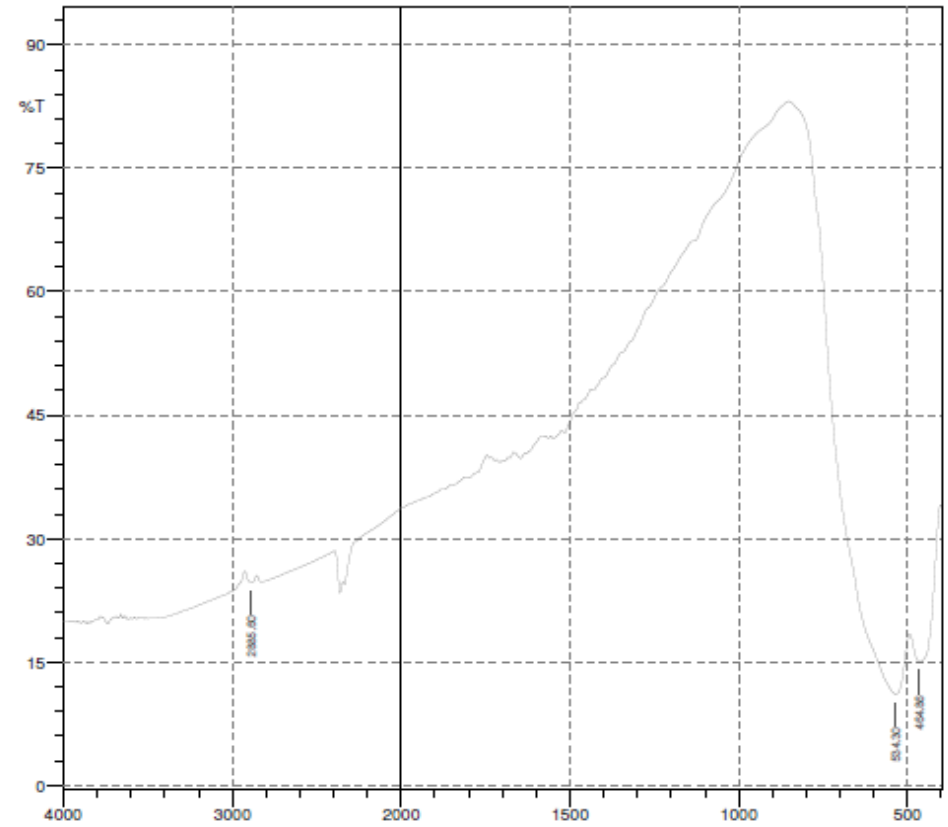

Figure 5. FTIR spectrum of $Zn_{1-x}Sn_XFe_2O_4$ (X=0.4)

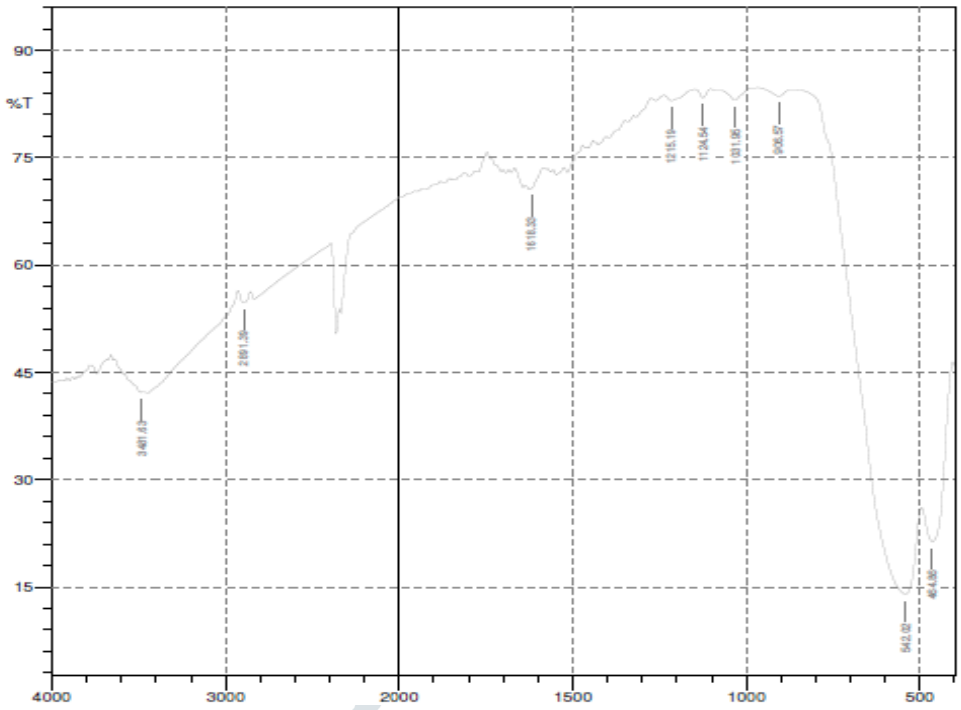

Figure 6. FTIR spectrum of $Zn_{1-x}Sn_XFe_2O_4$ (X=0.5)

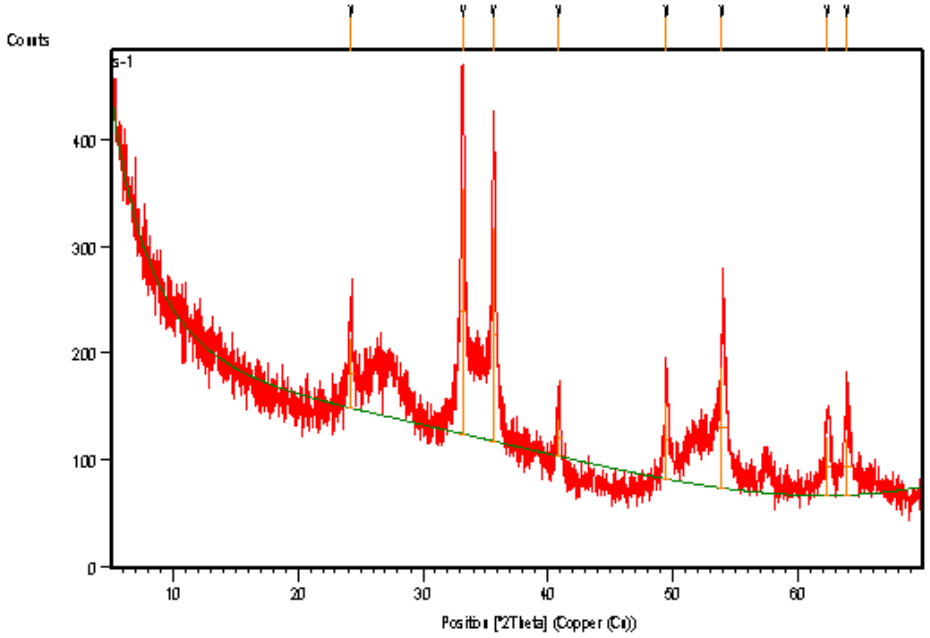

Figure 7. X-ray diffraction pattern for $ZnFe_2O_4$ (X=0)

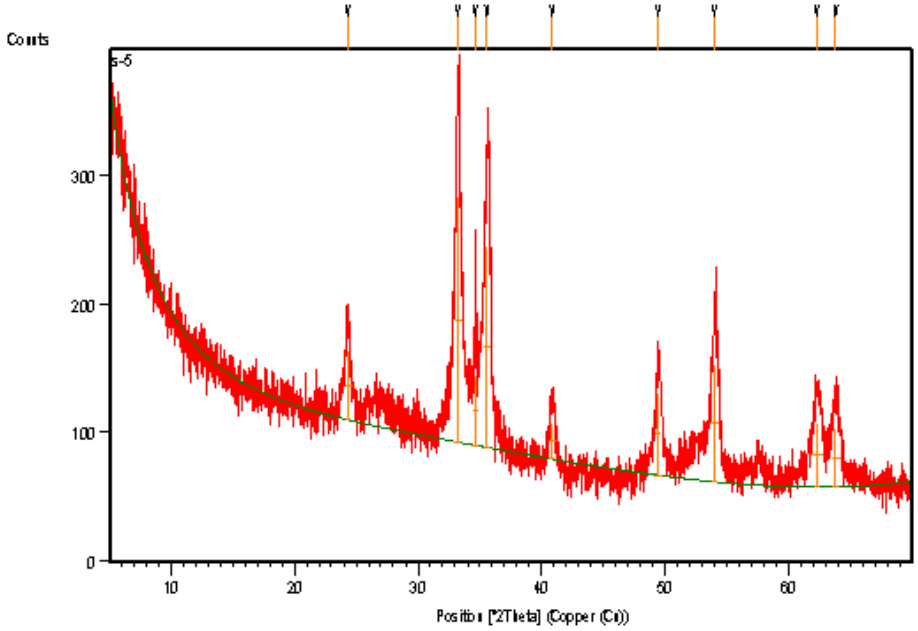

Figure 8. X-ray diffraction pattern for $Zn_{1-x}Sn_XFe_2O_4$ (X=0.1)

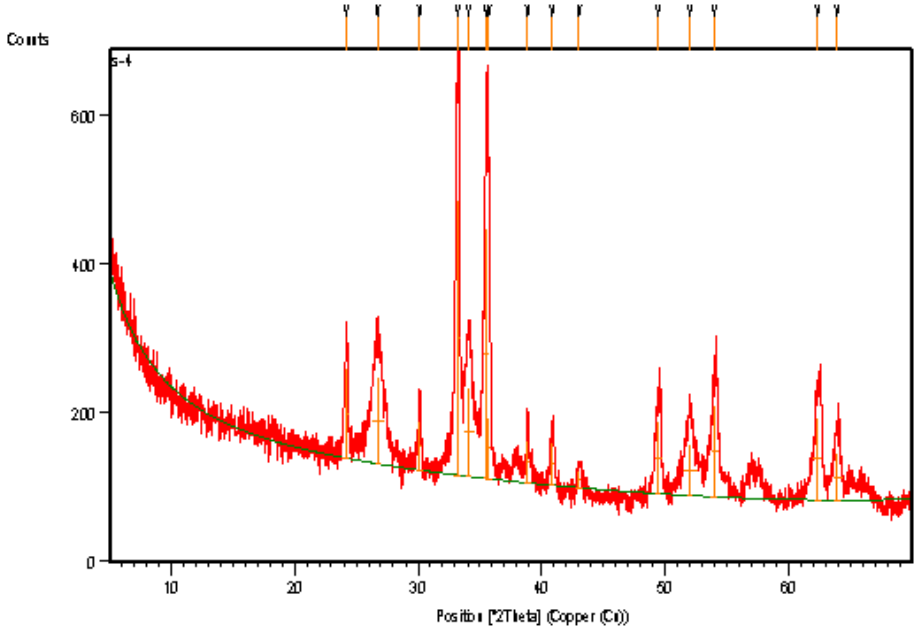

Figure 9. X-ray diffraction pattern for $Zn_{1-x}Sn_XFe_2O_4$ (X=0.2)

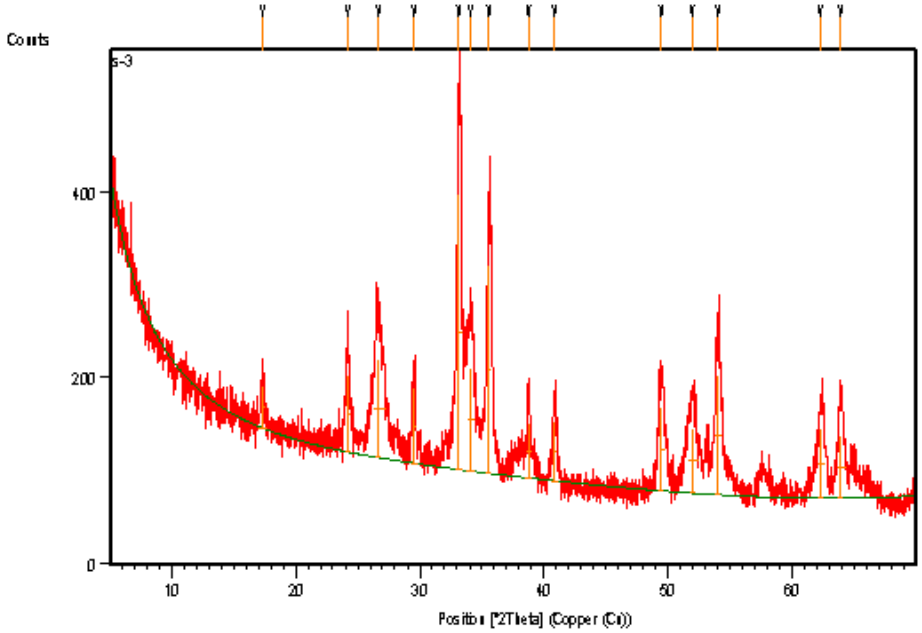

Figure 10. X-ray diffraction pattern for $Zn_{1-x}Sn_XFe_2O_4$ (X=0.3)

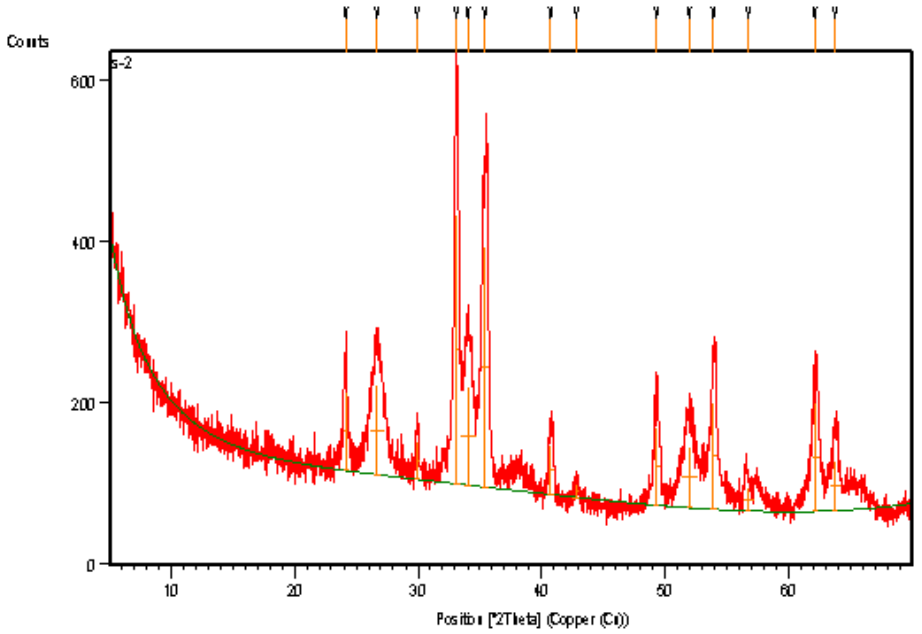

Figure 11. X-ray diffraction pattern for $Zn_{1-x}Sn_XFe_2O_4$ (X=0.4)

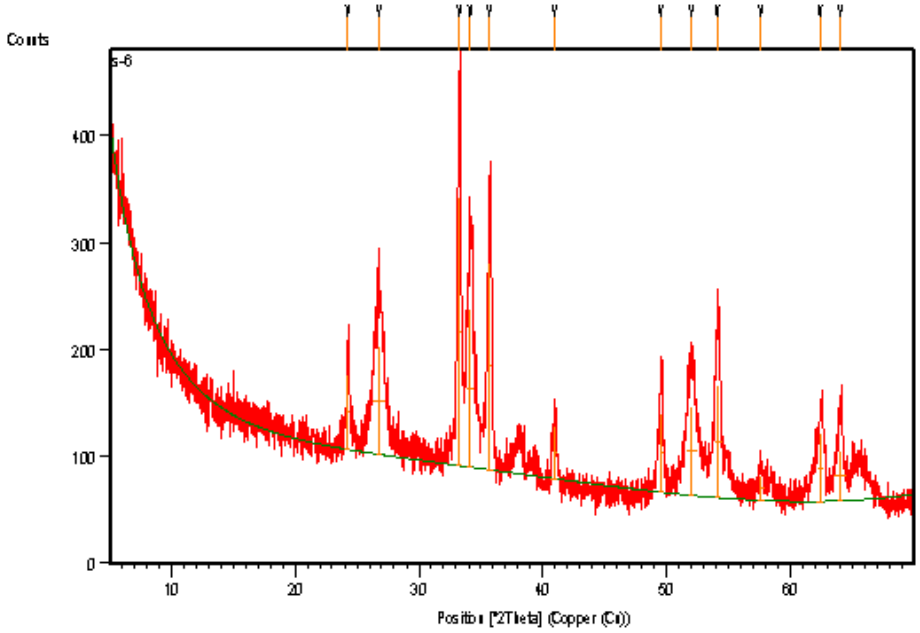

Figure 12. X-ray diffraction pattern for $Zn_{1-x}Sn_XFe_2O_4$ (X=0.5)

Conclusion

Solution combustion method for the synthesis of ferrite materials has many advantages over the other methods: simple reagents are used, no special equipment is required a doping can be done easily. Solution combustion method uses the energy produced from the exothermic decomposition reaction of a redox mixture of metal chlorides/nitrates with an organic compound (ODH). Oxalic dihydrazide has been employed as a fuel for this combustion synthesis. By using this method:

(i) As per result of atomic scale mixing of respective stoichiometric solutions, single phase spinel ferrites have been obtained.

(ii) Ferrite powders have been prepared at low temperature and in shorter time.

(iii) Nano-sized ferrite powders cab be synthesized by using solution combustion method.

FTIR and Powder X-ray diffraction studies confirm the formation of spinel ferrite materials.

References

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