Synthesis of Ni-Cs-Zn ferrite through solution combustion method and characterization

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Abstract

Ferrite materials with composition $Ni_{0.75-x}Cs_{0.25}Zn_xFe_2O_4$ (where 'x' varies from 0 to 0.5) have been synthesized through solution combustion method by using oxalyl dihydrazide (ODH) as a fuel. Solution combustion method has proven to be an efficient method for the synthesis of ferrite materials. By using this method nano-sized and single-phase ferrite materials can be synthesized at lower temperature (650^0C) and in shorter time. The synthesized ferrite materials have been characterized by using Fourier Transform Infrared Spectroscopy (FT-IR).

Introduction

Recently, ferrite materials have gained significant attention due to their promising magnetic and electrical properties, which lead to their applications in various fields [1-3]. These properties of ferrite materials have been attributed to the size and composition of the particles which in turn are dependent upon the method of synthesis of ferrite materials. These materials are extensively being used as they have low price, stable at high temperatures and are readily available [4-6]. Many researchers have adopted different methods for the synthesis of ferrite materials [7-10]. Properties of these materials can be enhanced by doping of some elements in the ferrite composition. Different methods like sol-gel, hydrothermal and spraying etc. are already being employed for this purpose [11-13]. In the present work, synthesis of Ni-Cs-Zn ferrites, $Ni_{0.75-x}Cs_{0.25}Zn_xFe_2O_4$, by solution combustion method and their characterization is reported.

Experimental

For solution combustion synthesis of Ni-Cs-Zn ferrites, $Ni_{0.75-x}Cs_{0.25}Zn_xFe_2O_4$, oxalyl dihydrazide has been used as a fuel.

Synthesis of oxalyl dihydrazide (ODH):

Oxalyl dihydrazide, $(CON_2H_3)_2$, has been synthesized by the reaction of diethyl oxalate and hydrazine hydrate. 1 mole of diethyl oxalate was added drop wise to 2 mole of hydrazine hydrate at 4^0C. Since the reaction was highly exothermic so this reaction mixture was kept in an ice bath. White coloured precipitates of ODH were obtained, which were then washed with cold water and dried in vacuum desiccator.

Synthesis of Ni-Cs-Zn ferrites:

Ferrite materials with composition $Ni_{0.75-x}Cs_{0.25}Zn_xFe_2O_4$ were synthesized by using solution combustion method. Series of ferrite compositions were prepared where x varies from 0 to 0.5 in steps of 0.1. Following procedure was adopted:

Step 1: Stoichiometric aqueous solutions were prepared form respective metal nitrates in minimum amount of distilled water.

Step 2: Different solutions were mixed in a single beaker.

Step 3: ODH paste was added slowly into the reaction mixture as reaction is highly exothermic.

Step 4: After complete addition of ODH, reaction mixture was concentrated on water bath.

Step 5: The concentrate was then subjected to heating in muffle furnace up to 650^0C to obtain the final ferrite powder.

The infrared spectra of $Ni_{0.75-x}Cs_{0.25}Zn_xFe_2O_4$ were recorded in the range of 4000- 400 cm^{-1} by using FTIR-8400S spectrometer, Shimadzu, using KBr pallets as reference.

Results and Discussion

FTIR spectra of ferrite samples (Fig. 1-6) with varying composition show two absorption bands in the range 600 cm^{-1} to 400 cm^{-1} for the tetrahedral (at higher frequency) and the octahedral (at lower frequency) sites respectively. These two absorption bands indicate the formation of spinel structure. Absorption band around 600 cm^{-1} is due to the metal-oxygen intrinsic vibrations for tetrahedral sites and band below 450 cm^{-1} is due to the octahedral metal-oxygen intrinsic vibrations. This difference in the frequencies of distinctive vibrations for tetrahedral and octahedral sites arises because of different bond lengths for the metal-oxygen ions in corresponding sites. [14, 15].

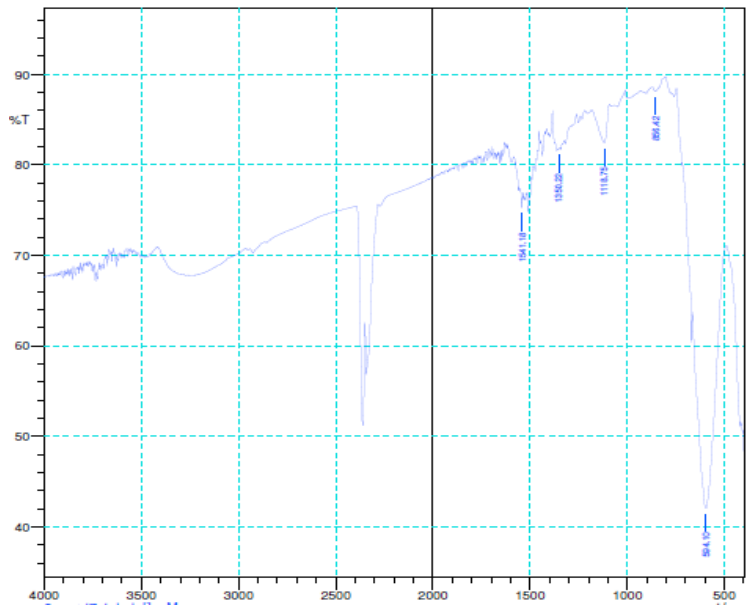

Fig.1 FT-IR spectrum of $Ni_{0.75-x}Cs_{0.25}Zn_xFe_2O_4$, where X=0

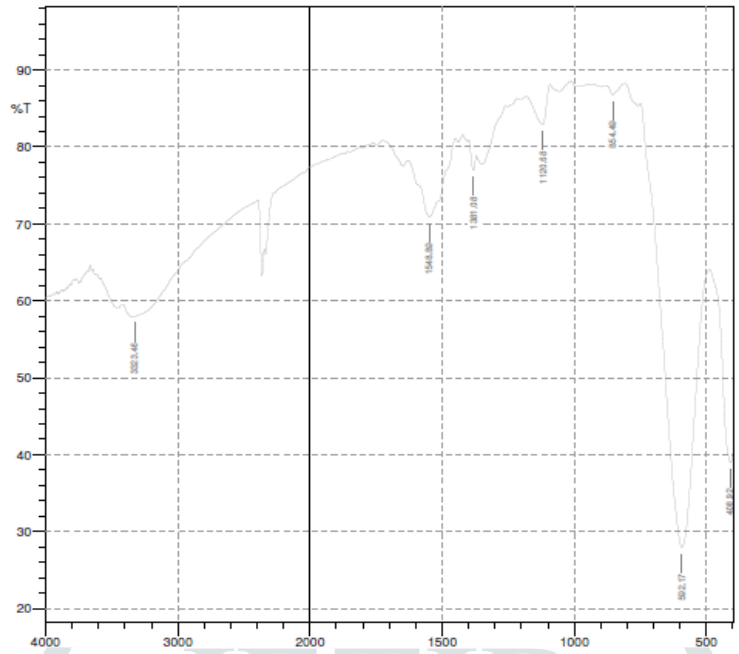

Fig. 2 FT-IR spectrum of $Ni_{0.75-x}Cs_{0.25}Zn_xFe_2O_4$, where X=0.1

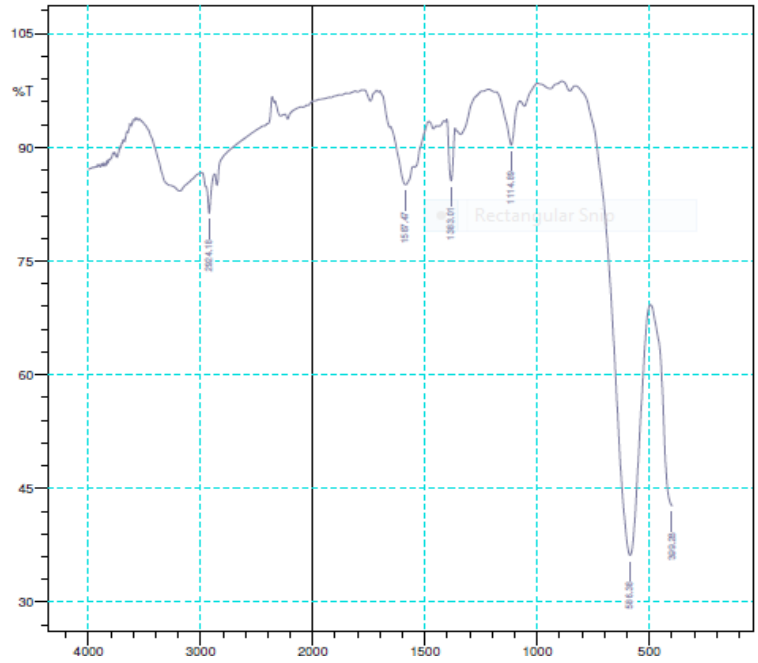

Fig. 3 FT-IR spectrum of $Ni_{0.75-x}Cs_{0.25}Zn_xFe_2O_4$, where X=0.2

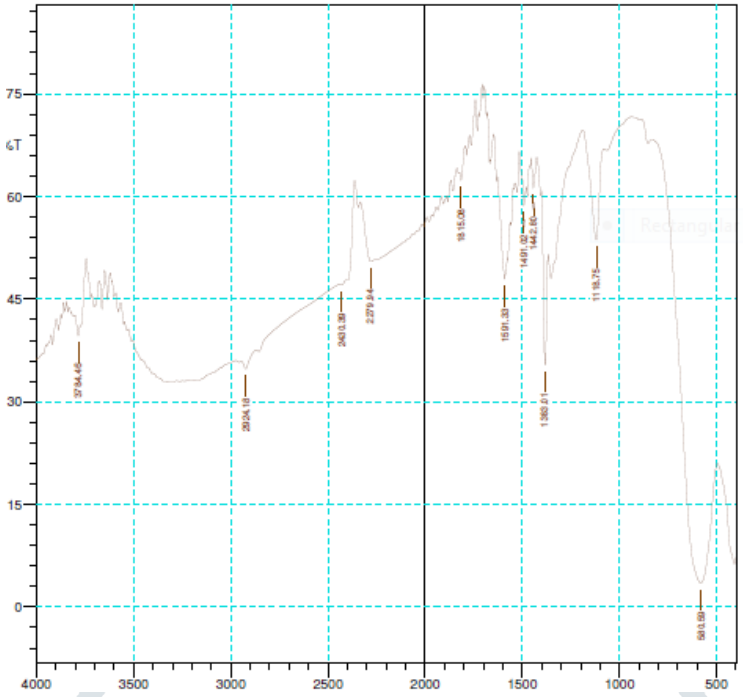

Fig. 4 FT-IR spectrum of $Ni_{0.75-x}Cs_{0.25}Zn_xFe_2O_4$, where X=0.3

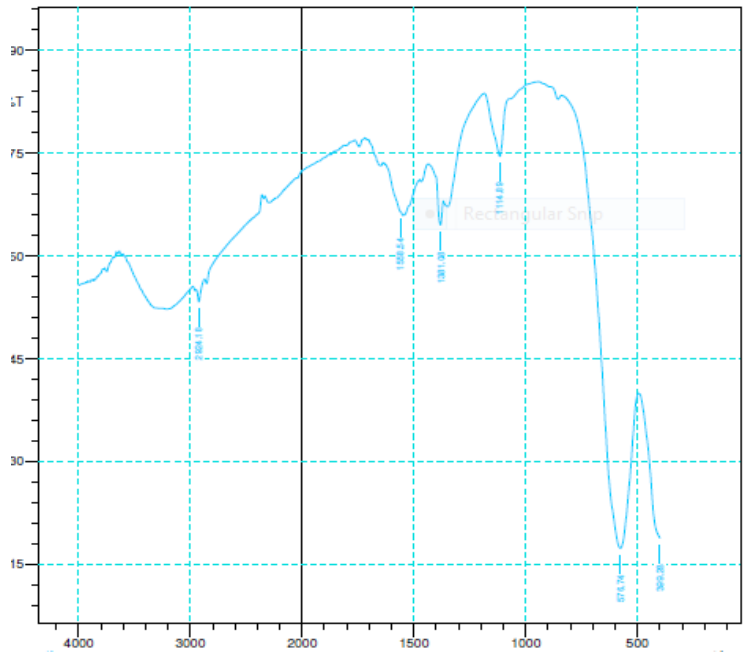

Fig. 5 FT-IR spectrum of $Ni_{0.75-x}Cs_{0.25}Zn_xFe_2O_4$, where X=0.4

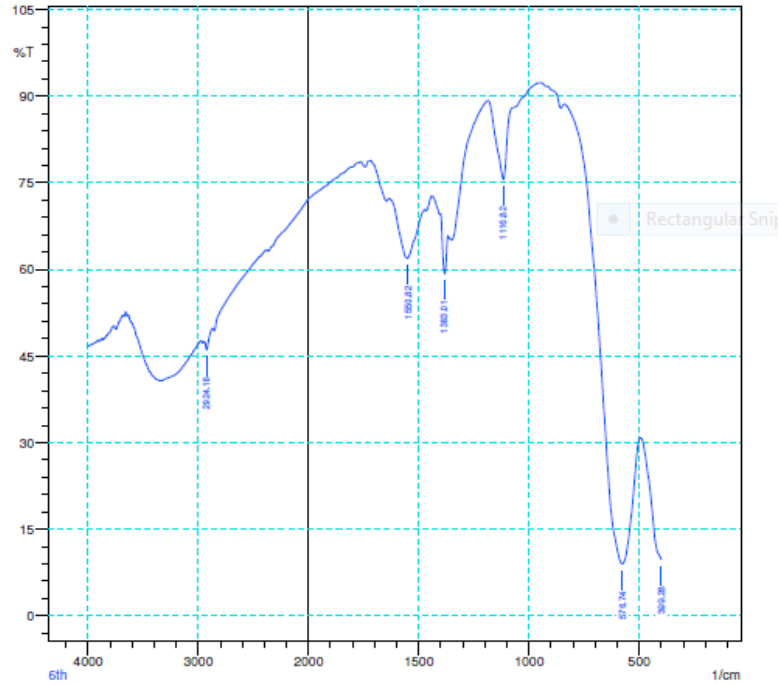

Fig. 6 FT-IR spectrum of $Ni_{0.75-x}Cs_{0.25}Zn_xFe_2O_4$, where X=0.5

Conclusion

Solution combustion method has many advantages over conventional ceramic methods as follows;

1. ODH acts as a fuel for combustion synthesis.
2. Ferrite materials are synthesized at lower temperature.
3. Ferrite materials are synthesized in shorter time.
4. Combustion process dissipates heat during combustion which prevents the aggregation of particles and nano particles can be synthesized.
5. Single phase ferrites are synthesized due to stoichiometric mixing of reactants.

Absorption peaks in FT-IR spectroscopy reveal the formation of tetrahedral and octahedral sites in spinel structure.

References

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