

## STUDY OF INFRARED SPECTROSCOPY OF $MgZn_xTi_xFe_{2-2x}O_4$ SPINEL FERRITE SYSTEMS

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### ABSTRACT

**Objectives:** Infrared spectroscopy is the method of choice of qualitative analysis of organic material and it has wide application to inorganic substances as well. The infrared spectrum of a material has aptitude for the fingerprint, a unique property of that material and of its physical state.

**Materials and methodology:** The samples of  $MgZn_xTi_xFe_{2-2x}O_4$  spinel ferrite systems with varying x [x = 0.0, 0.1, 0.2, 0.3, 0.4, 0.5 and 0.6] were synthesized by double sintering ceramic method. A.R. grade oxides of magnesium, zinc, titanium and ferric were used for the preparation of  $MgZn_xTi_xFe_{2-2x}O_4$  ferrite [1]. The infrared spectra of all the samples of the present series were recorded at room temperature in the range  $200\text{ cm}^{-1}$ - $1000\text{ cm}^{-1}$  on a Perkin Elmer spectrometer (Model 783).

**Results:** The spectra have been used to identify the band positions. Two prominent bands are seen in the IR spectra. The high frequency band  $\nu_1$  is seen to be in the range  $592$  to  $620\text{ cm}^{-1}$  and the lower frequency band  $\nu_2$  is in the range  $427$  to  $425\text{ cm}^{-1}$ .

**Conclusion:** Two prominent absorption bands are seen in the IR spectra, which is the characteristic feature of spinel ferrite. Debye temperature obtained from IR data increases with composition 'x'.

**Key Words:** Ferrites, XRD, IR Spectroscopy.

### INTRODUCTION

All the synthesis powders were characterized by using X-ray diffraction (Philips X-ray diffractometer, Model PW3710) technique at room temperature. The X-ray diffraction patterns were recorded in the  $2\theta$  range of  $200$ - $800$  using  $\text{Cu-K}\alpha$  radiation [2]. IR spectra were recorded at room temperature using Perkin Elmer spectrometer by KBr pellet for samples 0.2, 0.3, 0.4

### Infrared spectroscopy

The spectrum is unique because it reflects the vibration between atoms within the molecule, and even slight changes in geometry or bond strength between atoms cause noticeable shift in the infrared absorption pattern.

To study the I.R. spectra of all the samples, about one gram of fine powder of each sample was mixed with KBr in the ratio 1:250 by weight to ensure uniform distribution in the KBr pellet. The mixed powder was then pressed in a cylindrical die to obtain clean disc of approximately 1 mm thickness. The IR spectra were used to locate the band position. The IR spectra were used to determine bond length  $R_A$  and  $R_B$ , in a cubic crystal for tetrahedral (A) and octahedral [B] site using formula and Using the analysis of the force constant  $K_0$  and  $K_t$  were calculated [3,4].

### MATERIALS AND METHODS

The samples of  $MgZn_xTi_xFe_{2-2x}O_4$  spinel ferrite systems with varying x [x = 0.0, 0.1, 0.2, 0.3, 0.4, 0.5 and 0.6] were synthesized by double sintering ceramic method [5]. AR grade oxides of magnesium, zinc, titanate and ferric were used for the preparation of  $MgZn_xTi_xFe_{2-2x}O_4$  ferrite. The presintering and final sintering of the samples was carried out at temperature  $950^\circ\text{C}$  (12 hours) and  $1100^\circ\text{C}$  (12 hours) respectively. The sintered samples in the form of pellet were furnace cooled to room temperature.

Powder X-ray diffraction technique has been employed in the present study to characterize the samples of  $MgZn_xTi_xFe_{2-2x}O_4$  at room temperature. The XRD patterns were recorded in the  $2\theta$  range of  $20^\circ$ - $80^\circ$  using  $\text{Cu-K}\alpha$  radiation [6].

IR spectra were recorded using Perkin Elmer spectrometer by the KBr technique. Spectra was recorded in the wave number of  $200$ - $800\text{ cm}^{-1}$ [7].

### RESULTS

The infrared spectra of the present series  $MgZn_xTi_xFe_{2-2x}O_4$  recorded at room temperature for typical samples x = 0.2, 0.3, 0.4.

According literature the high frequency band  $\nu_1$  is associated with the intrinsic vibration of the tetrahedral complexes and the low frequency band  $\nu_2$  is associated with the intrinsic vibrations of octahedral complexes [8,9]. The values of absorption bands  $\nu_1$  and  $\nu_2$  are given in table 1. The difference in the values of band positions is due to the differences in  $\text{Fe}^{3+}\text{-O}^{2+}$  distances for octahedral and tetrahedral sites. Our results on IR studies are similar to the literature reports [10,11].

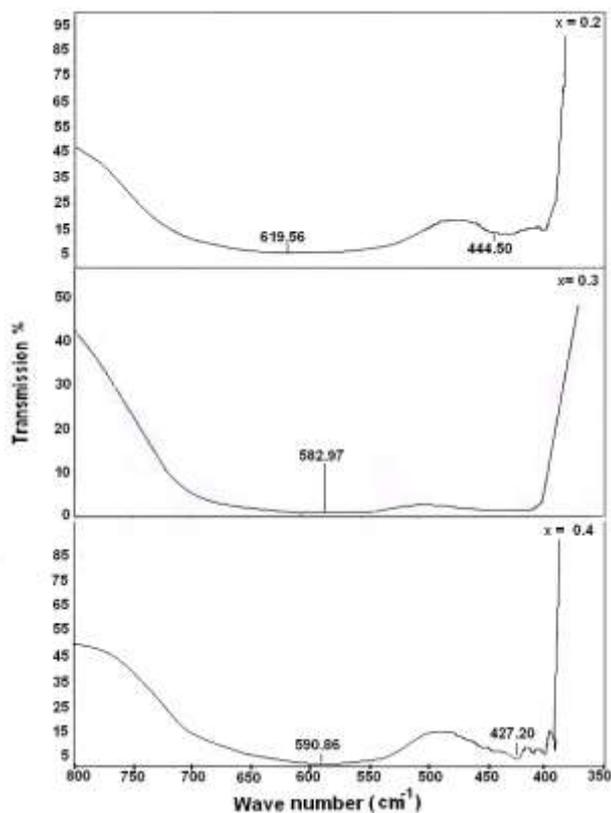
Using the values of band frequency  $\nu_1$  and  $\nu_2$ , the force constant  $K_t$  and  $K_0$  corresponding to tetrahedral A and octahedral B site were calculated and the values are given in table 1. The average values of the band positions were used to calculate the Debye temperature  $\theta_D$ . The Debye temperature was calculated using the relation

$$\theta_D = \lambda C \nu_{av}$$

The values of Debye temperature are also given in table 1 it is clear from the table that Debye temperature increases with Zn, Ti concentration 'x' [12]. The graphs are plotted between transmission percentage v/s wave number.

Table 1  
Vibrational band frequencies ' $\nu_1$ ' & ' $\nu_2$ ' and force constant ' $K_t$ ' & ' $K_0$ ' of the system  $MgZn_xTi_xFe_{2-2x}O_4$ .

Comp. x	$\nu_1$ $\text{cm}^{-1}$	$\nu_2$ $\text{cm}^{-1}$	$K_t \times 10^5$ dynes/cm	$K_0 \times 10^5$ dynes/cm	$\theta_D$ (K)
0.2	619.56	444.50	1.4242	1.1021	765
0.3	582.97	434.17	1.2541	1.1356	737
0.4	590.86	427.20	1.5456	1.0421	732



#### CONCLUSION

The analysis of X-ray diffraction patterns revealed the formation of single-phase cubic spinel structure of all the samples under investigation. The cation distribution data suggest that Ti ions occupy octahedral B site, Zn ions goes to tetrahedral A site, Mg and Fe ions prefers to occupy both tetrahedral A and octahedral B site.

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