

FTIR Study of Diamagnetic Mg^{2+} Substituted Ni_2Z Hexaferrite

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Abstract— FTIR spectrum of $Sr_3Mg_xNi_{2-x}Fe_{24}O_{41}$ Z-type Hexaferrite heated at 1250 °C was recorded in the mid IR range (4000 cm^{-1} to 400 cm^{-1}). The spectra obtained specify the band position with respect to substituted cations. The band position at about 441 cm^{-1} and 609 cm^{-1} attributed to the vibration of octahedral and tetrahedral cluster respectively. Broad absorption band found in the spectra describe the complex nature of the Z-type hexaferrite. Shoulders observed in the spectra evidenced for presence of Fe^{2+} in the hexaferrite. Variation in the intensities of absorbed bands attributed to the change in the dipole moment with Mg^{2+} substitution.

Keywords— FTIR, Z-Type, Ceramic, Band Positions, Atomic Weight

1. INTRODUCTION

Infrared spectroscopy is used to determine local symmetries in crystalline, non crystalline solids and ordering phenomenon in spinel [1]. From the IR spectra the optical, oscillator parameter as well as effective ionic charges was computed by KK, DA, DA-KK methods by E. Z. Katsnelson 1989 [2]. The absorption bands in ferrites mainly arise from lattice vibration of oxide ions with cation producing varies frequencies of the unit cell. The frequencies of vibration depend on various factors such as atomic mass, unit cell parameters, cation oxygen bonding [1]. Thus IR study help to illustrate cationic arrangement, bonding strength as well bonding frequency of vibration of hexaferrite.

In the present study, the IR spectra of Mg^{2+} substituted Ni_2Z hexaferrite were investigated for first time to study the ordering in Z-type hexaferrite as a function of content of Mg^{2+} ions and probable evidence of Fe^{2+} ions.

2. EXPERIMENTAL

In this paper we present FTIR spectra of $Sr_3Mg_xNi_{2-x}Fe_{24}O_{41}$ ($x = 0, 0.2, 0.4, 0.6, 0.8, 1, 1.2, 1.4, 1.6, 1.8, 2$) hexaferrite prepared by solid state reaction at 1250°C for 6 h using AR grade oxides and carbonate. These pallets of compositions were first heated at 900°C for about 5 hr and then cooled at room temperature. Then the temperature of furnace was set to 1250°C and kept it constant for 6 hr. The furnace is then cooled slowly at the rate of 20°C per hour up to 1000°C and then allows the furnace cooled in natural way to room temperature. The formation of the Z hexaferrite was confirmed by X-ray diffraction studies carried out on powder samples by using $CuK\alpha$ radiation. All the samples showed single phase formation. The FTIR spectra of all prepared

hexaferrite were obtained by using Bruker, Germany 3000 Hyperion Microscope with Vertex 80 FTIR System in the range 4,000 cm^{-1} to 400 cm^{-1} .

3. RESULT AND DISCUSSION

Fig. 1 show FTIR spectrum of $Sr_3Mg_xNi_{2-x}Fe_{24}O_{41}$ Z-type Hexaferrite heated at 1250 °C recorded in the mid IR range (4000 cm^{-1} to 400 cm^{-1}). A small amount of $Sr_3Mg_xNi_{2-x}Fe_{24}O_{41}$ powder mixed with KBr powder and made in the form of a pellet for measurement. FTIR-spectrum of a power shows the characteristic bands have appeared at about 3440 and 2924 cm^{-1} . These bands are assigned to be hydroxyl group [3, 4].

The IR spectra of all hexaferrites show the two principle absorption bands in the range of 438-443 cm^{-1} and 606-610 cm^{-1} . These two vibration bands Fe-O and M-O are corresponded to the intrinsic lattice vibrations of octahedral and tetrahedral coordination compounds respectively [5, 6]. The normal mode of vibration of tetrahedral cluster is higher than that of octahedral cluster. The change in the band position is due to the change in the $Fe^{3+}-O^{2-}$ internuclear distances for the tetrahedral and octahedral sites [7–9]. The band positions are listed in Table 1. Variation in the ν_5 with increasing Mg^{2+} also due to the modified distribution of cations that present in B sites because of Fe or Ni ions replaced with Mg^{2+} ions at B site. Bands observed around 912 attributed to the stretching vibration of Sr-O. This band gives the confirmation of formation of a Strontium ferrite. [10]. The frequencies of the band near about 988 cm^{-1} was found to be increasing with increasing Mg^{2+} content. The absorption frequencies are depends on the mass of the atom along with strength and angle of connecting bands [11]. The atomic weight of the Mg^{2+} is smaller (24.31 g/mol) than that of the Ni^{2+} (58.70 g/mol). The absorption frequencies increase with decreasing atomic weight. Thus the band at about 988 cm^{-1} was due to the atomic weight of the substituted Mg^{2+} . The band around 1026 cm^{-1} was attributed to the Fe-O bending [12]. The broad band in the region 850 cm^{-1} to 1300 cm^{-1} was associated with the complex crystalline nature of the z-type hexaferrite. Shoulders were observed for all the Mg^{2+} substitution evidenced for the presence of Fe^{2+} ions in the samples formed during the sintering process. The intensities of the band depend on the ionic replacement and as a result on the magnetic dipole moment. Variation was observed in the intensities of the bands

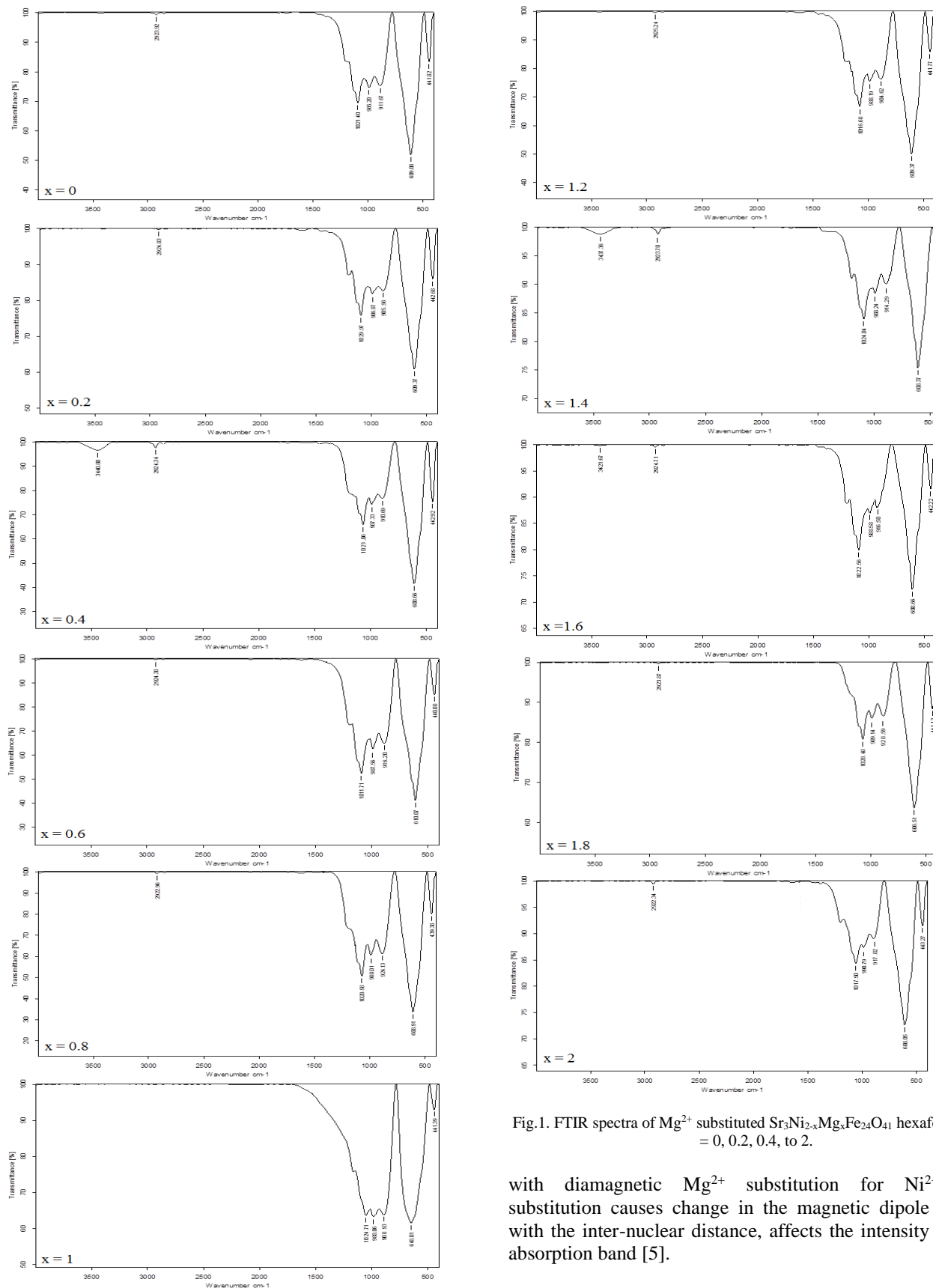


Fig.1. FTIR spectra of Mg²⁺ substituted Sr₃Ni_{2-x}Mg_xFe₂₄O₄₁ hexaferrite for x = 0, 0.2, 0.4, to 2.

with diamagnetic Mg²⁺ substitution for Ni²⁺. Such substitution causes change in the magnetic dipole moment with the inter-nuclear distance, affects the intensity E of the absorption band [5].

Table 1. Absorption frequencies of $\text{Sr}_3\text{Ni}_{2-x}\text{Mg}_x\text{Fe}_{24}\text{O}_{41}$ hexaferrite with Mg^{2+} concentration

x	Infrared Absorption Band (cm^{-1})				
	ν_5	ν_4	ν_3	ν_2	ν_1
0	1021.4	985.2	911.67	609.08	441.82
0.2	1029.97	986.87	905.98	609.37	442.68
0.4	1023.06	987.33	910.69	608.66	442.92
0.6	1011.71	987.56	916.2	610.07	440.08
0.8	1028.58	988.01	924.13	608.91	439.38
1	1024.71	988.06	908.93	648.01	441.39
1.2	1016.68	988.19	904.62	609.37	441.77
1.4	1024.04	988.24	914.29	608.37	438.79
1.6	1022.56	988.58	916.50	608.66	442.22
1.8	1028.48	989.14	928.59	606.51	441.13
2	1017.5	990.79	917.82	608.05	443.27

CONCLUSION

FTIR spectrum of $\text{Sr}_3\text{Mg}_x\text{Ni}_{2-x}\text{Fe}_{24}\text{O}_{41}$ Z-type hexaferrite prepared by standard ceramic method heated at 1250°C was recorded in the mid IR range (4000 cm^{-1} to 400 cm^{-1}) successfully. The band position obtained in the spectra at about 441 cm^{-1} and 609 cm^{-1} attributed to the vibration of octahedral and tetrahedral cluster in the hexaferrite respectively. Sr-O bond at about 912 cm^{-1} was conformed the formation of strontium hexaferrite. Broad nature of the absorption band observed in the spectra illustrated the complex nature of the Z-type hexaferrite. Shoulders observed

in the spectra evidenced for presence of Fe^{2+} in the hexaferrite for every substitution. Variation in the intensities of absorbed bands attributed to the change in the dipole moment with Mg^{2+} substitution.

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