Study of Magnetic properties of Mg-Mn Ferrites prepared by Chemical Co-precipitation Method.

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Abstract: Magnetic properties of $Mg_xMn_{1-x}Fe_2O_4$ (x = 0.00, 0.01, 0.03, 0.05, 0.07) ferrites prepared by chemical co-precipitation method were studied by the variation of the saturation magnetization and Curie temperature with increasing concentration of the Mg^{2+} ions. This variation can be explained by taking into account the basis of cation distribution and Neel's two sub-lattice models.

Introduction

An ideal ferrite with all its characteristics properties improved and is capable of covering a complete spectrum of applications is impossible to prepare. It is found that on substitution of impurity ions a few properties improved but some of other is adversely affected. Therefore, a compromise has to be made in improving one property at the expense of other by substituting suitable ions in various ferrites. The properties of ferrites are highly sensitive to the type and amount of impurity. A number of workers have studied the effect of divalent, trivalent, tetravalent impurities on their magnetic properties [1-4]. The Mg–Mn ferrites prepared by the chemical co-precipitation techniques have been studied by several workers [5-8]. These ferrites highly suitable for memory and switching circuits in digital computers and phase shifters as they have characteristic rectangular hysteresis loop, The magnetic properties of the Mg–Mn ferrites can be upgraded by preparing these ferrites by various preparation methods. The aim of present investigations is to study the variation in magnetic properties i.e. saturation magnetization and Curie temperature with respect to change in concentration of Mg^{2+} ion in Mg–Mn ferrite using vibrating sample magnetometer.

Experimental details

All the compositions of nanocrystalline $Mg_xMn_{1-x}Fe_2O_4$ (x = 0.00, 0.01, 0.03, 0.05, 0.07) system were prepared from Merck Germany GR grade chemicals viz. $Mg(NO_3)_2.6H_2O$,

$Fe(NO_3)_3.9H_2O$, $Mn(NO_3)_2.6H_2O$ and aqueous NH_3 (Merck India, 30%). The samples were prepared using stoichiometric quantities of $Mg(NO_3)2·6H_2O$ and $Fe(NO_3)_3·9H_2O$ then dissolving them separately in 100mL deionized water and adding simultaneously into a flask containing 200mL deionized water. Ammonia solution was added drop wise till the pH value 10 was attained. The solution was continuously stirred by a magnetic stirrer for 1 h and aged at room temperature overnight. The precipitates were filtered and washed with deionized water and then dried at 120 ^oC for 16 h in a hot air oven. The dried samples were calcined at 950^oC in air in a tube furnace programmed at a fixed heating rate of 5^oC/min for 8 h. The Mn doped derivatives of $Mg_xMn_{1-x}Fe_2O_4$system were also prepared by adding the appropriate stoichiometric quantities of dopant salt $Mn(NO_3)_2.6H_2O$ and following the same procedure as stated above. Magnetic properties like saturation magnetization were studied for the prepared samples using Vibrating Sample Magnetometer (EG & G Park Model 155**).** Curie temperature variation with concentration of dopant ion was studied using the experimental set up described by Soohoo [9].

Results and Discussion:

The variation of saturation magnetization as function of the concentration, of the Mg^{2+} ions is shown in Fig. 1. The initial rise in the, 4πMs, value is attributed to the fact that at low concentration, Mg^{2+} ions preferably tend to go to the A-site leading to a rise in the magnetic moment of the B-site, and only a slight decrease in the magnetic moment of the A-site, so that the net magnetic moment increases. When the concentration of the nonmagnetic Mg^{2+} ions exceeds beyond x = 0.02, these ions also go to B-site [1, 3]. The net magnetic moment, which is equal to difference of magnetic moment of the B-site and magnetic moment of the A-site, is reduced. It is attributed to the lower inter-granular porosity as well as an increase in the grain size [10, 11] in the prepared ferrite samples. Increased grain size results in a higher magnetic moment per unit volume. Fig. 2 shows variations in the Curie temperature of the ferrites with an increase in the Mg^{2+} ion concentration. Substitution of the diamagnetic Mg^{2+} ions results in changing the spin ordering from the Yafet–Kittel type to the Neel type. Since the energy required to offset the spin alignment in the Neel type is more than required in Yafet-Kittel type spin ordering which results in increase in Curie Temperature [12, 13].

Conclusion

Samples prepared using Co-precipitation method were studied for magnetic properties like saturation magnetization and Curie temperature variation with concentration of Mg^{2+} ion in $Mg_xMn_{1-x}Fe_2O_4$ (x = 0.01, 0.03, 0.05, 0.07). The saturation magnetization initially increases upto x = 0.02 and then decreased with the concentration of substituted Mg^{2+} ions. This observed variation have been explained on the basis of change in spin ordering from Yafet-Kittel type to Neel-type beyond x = 0.02. The increase in Curie temperature with increase in concentration of Mg^{2+} ions is also due to change in spin ordering from Yafet-Kittel to Neel type.

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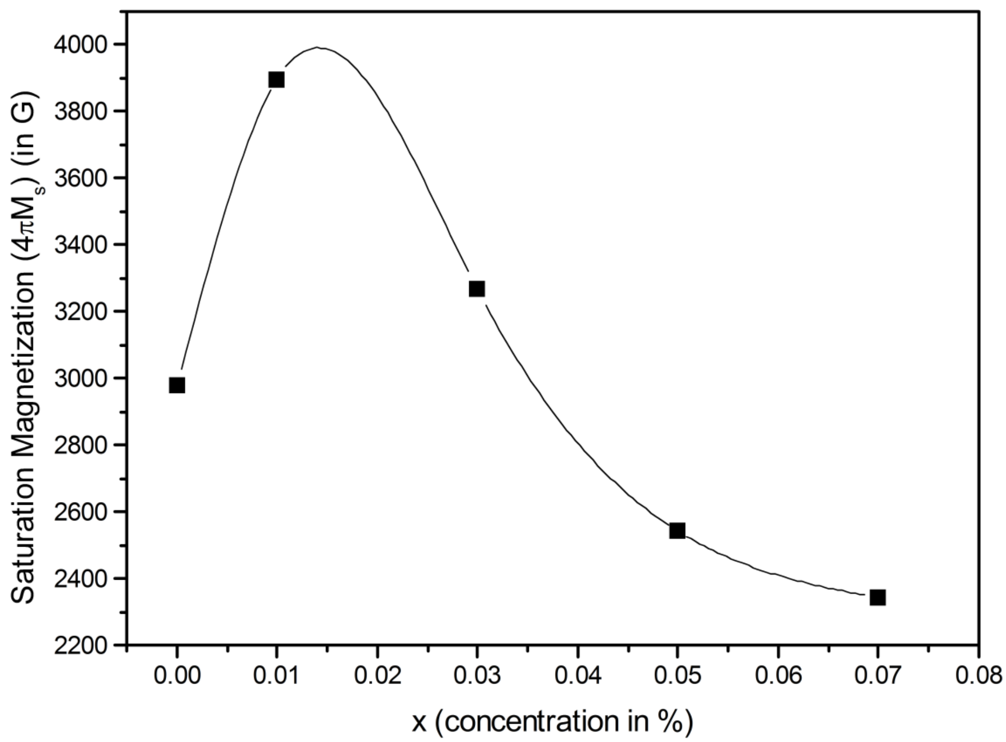

Figure 1. Variations of $4\pi Ms$ with concentration of Mg^{2+} ions in $Mg_xMn_{1-x}Fe_2O_4$ ferrites

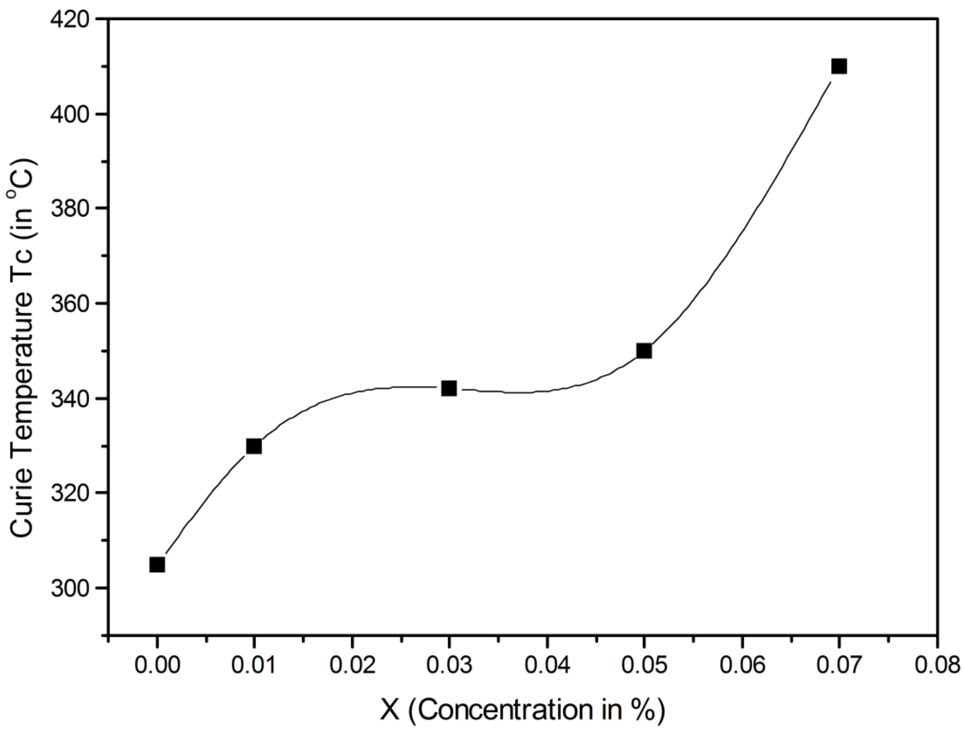

Figure 2: Variations of Curie temperature with concentration of Mg^{2+} ions in $Mg_xMn_{1-x}Fe_2O_4$ ferrites