

# Synthesis And Characterization Of Cadmium Doped Lithium Ferrite By Sol-gel Technique

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**Abstract.** Cadmium substituted lithium ferrite  $\text{Li}_{0.5-x/2}\text{Cd}_x\text{Fe}_{2.5-x/2}\text{O}_4$  were prepared by sol-gel method. Saturation magnetization versus composition shows a maximum  $M_s = 80$  emu/g at for = 0.3. In all samples, dielectric constant decreases with increasing frequency while dielectric loss tangent first increases and attains a maximum value followed by a decrease. Dielectric constant is in the range of  $10^5$  for sample  $x = 0.1$  & 0.3 with a low dielectric loss. High dielectric constant and low dielectric loss are essential requirement of ferrite for power applications.

**Keywords:** Magnetic properties; saturation magnetization; dielectric constant.

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## INTRODUCTION

Mixed lithium ferrites are of much interest because of their application in microwave devices such as isolators, circulators, gyrators and phase shifter [1]. There are reports on microstructure, electrical and magnetic behavior of lithium cadmium ferrite prepared by solid-state method [2, 3]. The present work reports the effect of  $\text{Cd}^{2+}$  substitution on the microstructure, dielectric and magnetic properties of lithium cadmium ferrites prepared by sol-gel technique.

## EXPERIMENTAL

Fine particles of  $\text{Li}_{0.5-x/2}\text{Cd}_x\text{Fe}_{2.5-x/2}\text{O}_4$  have been prepared by sol-gel technique [4]. The pre-sintering of the samples was carried out at 650 °C for 7 h. Circular pellets of dimensions were then prepared. Final sintering was done at 1200 °C for 10 h in air. The structural characterization was carried out by the X-ray diffraction (XRD).

Magnetic measurements were made using a vibrating sample magnetometer (Lake-Shore 7305). The dielectric measurements were taken in the range 1 KHz to 20 MHz by a HP4192A impedance analyzer.

## RESULTS AND DISCUSSION

Pure lithium ferrite sample is an inverse spinel phase having main diffraction planes [211], [220], [311], [400], [422], [333] and [440] with maximum diffraction intensity from the [311] plane as shown in FIGURE 1. The substitution of cadmium ions in the series  $\text{Li}_{0.5-x/2}\text{Cd}_x\text{Fe}_{2.5-x/2}\text{O}_4$  affects the 1:3 cations ordering of the octahedral spinel

sublattice. The cation distribution of lithium ferrite having the inverse spinel structure is giving by  $[\text{Fe}^{3+}]_A[\text{Li}_{0.5}^{1+}\text{Fe}_{1.5}^{3+}]_B\text{O}_4^{2-}$ .  $\text{Cd}^{2+}$  preferably occupied tetrahedral site as  $[\text{Fe}_{1-x}^{3+}\text{Cd}_x^{2+}]_A[\text{Li}_{0.5-x/2}^{1+}\text{Fe}_{1.5+x/2}^{3+}]_B\text{O}_4^{2-}$ .

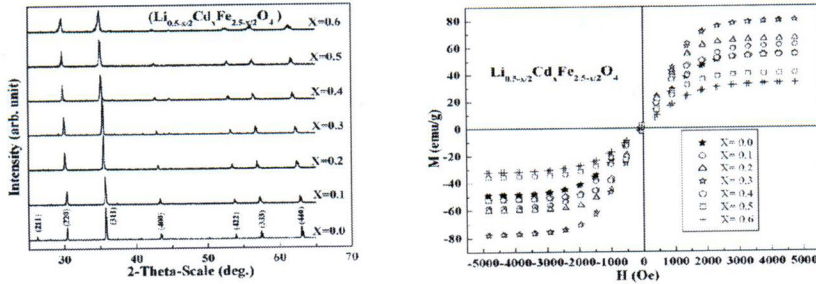


FIGURE 1. (a) X-ray pattern of  $\text{Li}_{0.5-x/2}\text{Cd}_x\text{Fe}_{2.5-x/2}\text{O}_4$ , (b) Hysteresis (M-H) loops of cadmium substituted lithium ferrites at room temperature

TABLE 1. Microstructure and magnetic data for  $\text{Li}_{0.5-x/2}\text{Cd}_x\text{Fe}_{2.5-x/2}\text{O}_4$ .

Composition	Lattice Constant (Å)	Grain Size (µm)	Saturation Moment (emu/gm)	Initial permeability	T <sub>c</sub>
$\text{Li}_{0.5}\text{Fe}_{2.5}\text{O}_4$	8.3330	5.1	55.1	95.78	670
$\text{Li}_{0.45}\text{Cd}_{0.1}\text{Fe}_{2.45}\text{O}_4$	8.3496	8.5	61.4	235.26	530
$\text{Li}_{0.4}\text{Cd}_{0.2}\text{Fe}_{2.4}\text{O}_4$	8.4100	12.2	66.1	274.98	410
$\text{Li}_{0.35}\text{Cd}_{0.3}\text{Fe}_{2.35}\text{O}_4$	8.4303	16.3	79.8	374.65	350
$\text{Li}_{0.3}\text{Cd}_{0.4}\text{Fe}_{2.3}\text{O}_4$	8.5016	14.1	54.3	415.12	240
$\text{Li}_{0.25}\text{Cd}_{0.5}\text{Fe}_{2.25}\text{O}_4$	8.5023	11.5	40.8	475.25	170
$\text{Li}_{0.2}\text{Cd}_{0.6}\text{Fe}_{2.2}\text{O}_4$	8.5266	6.8	33.4	700.02	110

FIGURE 1 (b) shows the M-H curves of all compositions of  $\text{Li}_{0.5-x/2}\text{Cd}_x\text{Fe}_{2.5-x/2}\text{O}_4$  at room temperature. It is clear that saturation magnetization  $M_s$  initially increases with cadmium concentration and attains a maximum value ( $M_s = 79.8$  emu/g) for  $\text{Cd} = 0.3$  ( $\text{Li}_{0.35}\text{Cd}_{0.3}\text{Fe}_{2.35}\text{O}_4$ ) concentration and begins to decrease by further substitution of cadmium. From the TABLE 1 it is evident that the grain size or the average grain diameter increases up to  $x = 0.3$ , then decreases. The initial increase in  $M_s$  with increased cadmium content may be due to the increase of resultant sub-lattice magnetic moment, which may be due to Neel's two sub-lattice model. The decrease in magnetization for  $x > 0.3$  can be explained with the three sub-lattice model suggested by Yafet and Kittel [5].

Table 1 shows the different values of measurement made for lattice constant, grain size and important magnetic properties of different composition samples. The variation of dielectric constant and loss tangent ( $\tan\delta$ ) with frequency is shown in FIGURE 2 & 3. A maximum value of  $\tan\delta$  is observed when the jump frequency of electron between  $\text{Fe}^{2+}$  and  $\text{Fe}^{3+}$  is equal to the frequency of the applied field [6]. From the plots of  $\tan\delta$  versus frequency, it can be seen that the curves for samples with  $x = 0.1, 0.2, 0.3, 0.4$ , shows maximum at frequency after  $10^5$  Hz. The samples with  $x = 0.5$  and  $0.6$  do not show any such maximum ( $f_{\text{max}}$ ) in frequency range  $10^3$  to  $10^6$  Hz.

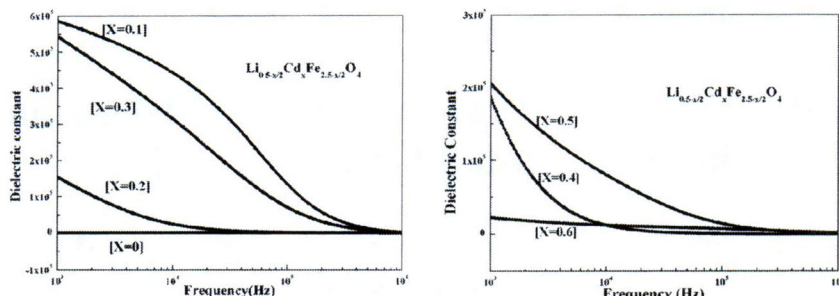


FIGURE 2. Variation of dielectric constant with log frequency in  $\text{Li}_{0.5-x/2}\text{Cd}_x\text{Fe}_{2.5-x/2}\text{O}_4$  for different compositions (a)  $x = 0.0 - 0.3$  (b)  $x = 0.4 - 0.6$  at room temperature.

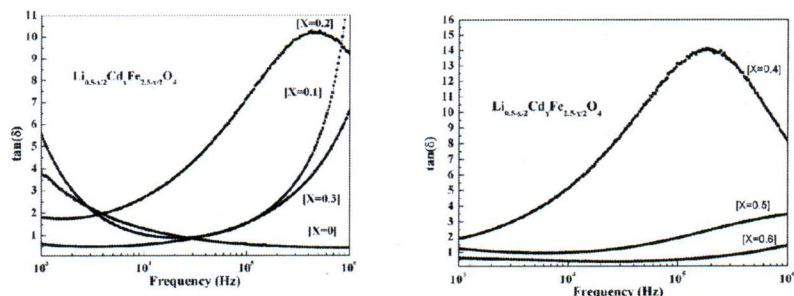


FIGURE 3. Variation of dielectric loss tangent ( $\tan\delta$ ) with log frequency in  $\text{Li}_{0.5-x/2}\text{Cd}_x\text{Fe}_{2.5-x/2}\text{O}_4$  for different compositions (a)  $x = 0.0 - 0.3$  (b)  $x = 0.4 - 0.6$  at room temperature.

It is interesting to observe that for  $x = 0.1, 0.2, 0.4$  the maximum shifts towards lower frequency side.

## CONCLUSIONS

$\text{Li}_{0.5-x/2}\text{Cd}_x\text{Fe}_{2.5-x/2}\text{O}_4$  has been prepared by sol-gel technique. The higher value of loss tangent is expected due to increase in the hopping mechanism between  $\text{Fe}^{2+}$  and  $\text{Fe}^{3+}$  ions present in the structure of lithium cadmium ferrites, which is responsible for maximum polarization.

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