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# Curie Temperatures of $\text{Co}_x\text{Mg}_{1-x}\text{Fe}_2\text{O}_4$ Ferrite System By Loria Technique

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**ABSTRACT:** The ferrite samples  $\text{Co}_x\text{Mg}_{1-x}\text{Fe}_2\text{O}_4$  with ( $x=0.0, 0.2, 0.4, 0.6, 0.8$  and  $1.0$ ) were synthesized by ceramic technique. The formation of single phase spinel structure of samples were confirmed by XRD patterns. Curie temperatures of the samples were determined by Loria technique. Curie temperatures obtained from this technique were in good agreement with the values obtained by dc conductivity and ac susceptibility studies. It was observed that the Curie temperatures increase continuously and linearly with increasing cobalt content. This can be explained firstly on the basis of super exchange (A-B) interaction and secondly on the basis of domain behavior in these ferrite samples.

**KEYWORDS:** Curie temperature, ceramic technique, Loria technique, super – exchange interaction, domain behavior.

### I. INTRODUCTION

Curie temperature ( $T_c$ ) is a temperature at which a ferromagnetic or ferrimagnetic state of a material changes to paramagnetic state. It is also called as disordering temperature because the magnetic ordering is destroyed above this temperature. Curie temperature is one of the important property for the selection of ferrites for microwave applications [1]. The Curie point is the measure of the strength of the magnetic order (the exchange energy) which is eventually destroyed by thermal randomization at Curie temperature ( $T_c$ ). Since ferrites are generally used at temperature far below the Curie temperature ( $T_c$ ), there is no danger of losing the magnetic moment entirely through the heating effects normally encountered. There are various methods to determine the Curie temperature of magnetic materials. One of the method is Loria technique [2]. Recently M Raghassudha [3] have been reported Curie temperature of Mg-ferrite by Loria technique. The present research work reports the Curie temperatures of  $\text{Co}_x\text{Mg}_{1-x}\text{Fe}_2\text{O}_4$  with  $x=0.0, 0.2, 0.4, 0.6, 0.8$  and  $1.0$  ferrite system.

### II. RELATED WORK

The Curie temperature ( $T_c$ ) is investigated by many researchers in case of magnetic materials such as Cu-Ni-Zn mixed ferrites [3],  $\text{CaCl}_2$  doped Cu-zn ferrites [4], Li –Cd –Cu ferrites [5],  $\text{Cr}^{3+}$  Mg-Cd ferrites [6], composite materials [7],  $\text{Sm}^{3+}$  and  $\text{La}^{3+}$  substituted Mg-Cd ferrites [8] etc. by employing Loria technique. Recently M.Raghassudha [9] and R.Shridhar [10] are used to determine Curie temperature of Mg- and Ni- nano ferrites respectively by using Loria technique. Most of the investigators are explained the Curie temperature on the basis of magnetic A-B interaction and domain structure in the ferrites.

### III. EXPERIMENTAL

The ferrite samples  $\text{Co}_x\text{Mg}_{1-x}\text{Fe}_2\text{O}_4$  with  $x=0.0, 0.2, 0.4, 0.6, 0.8$  and  $1.0$  were synthesized by the standard ceramic technique. High purity ferric oxide ( $\text{Fe}_2\text{O}_3$ ), Cobalt oxide (CoO) and magnesium oxide (MgO) were taken in calculated molar proportions and mixed thoroughly in the acetone medium in agate mortar. The pre-sintering was carried out at  $800^\circ\text{C}$  for 10 hours and samples were cooled at the rate of  $80^\circ\text{C}$  per hour.

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To prepare pellets, approximately 1gm of pre-sintered powder was taken and subjected to a pressure of about 5 tons per square inch for two minutes by keeping it in a die of 1 cm diameter. The pellets were again sintered at 1250°C for 40 hours and cooled at the rate of 80°C per hour.

For characterization of the samples, X-ray diffraction (XRD) technique performed on a diffractometer (Philips pw 1820) using Fe-K<sub>α</sub> radiation ( $\lambda=1.936 \text{ \AA}$ ) was used .

## IV. RESULTS AND DISCUSSION

The XRD patterns of the ferrite samples  $\text{Co}_x\text{Mg}_{1-x}\text{Fe}_2\text{O}_4$  with  $x=0.0, 0.2, 0.4, 0.6, 0.8$  and  $1.0$  are shown in Fig. 1. The diffraction maxima have been indexed in the light of crystal structure of the natural spinel  $\text{MgAl}_2\text{O}_4$ . The observed reflections in the present case are in conformity with natural spinel  $\text{MgAl}_2\text{O}_4$ . The diffraction patterns for present case show that there is no impurity phase present in the samples except for some cobalt riched samples ( $x = 0.8$  and  $1.0$ ).

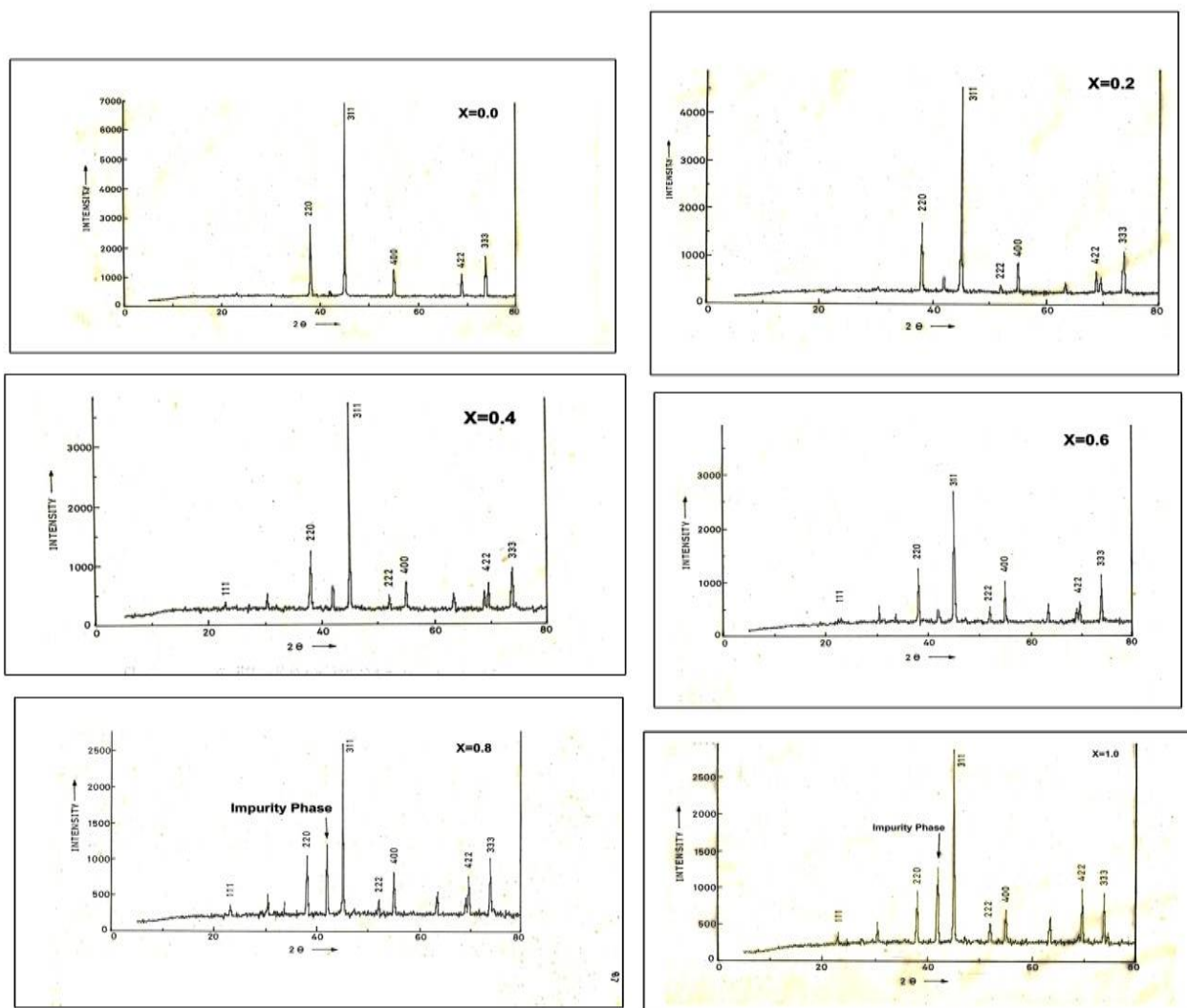


Fig.1: XRD patterns of the ferrite samples  $\text{Co}_x\text{Mg}_{1-x}\text{Fe}_2\text{O}_4$  with  $x=0.0, 0.2, 0.4, 0.6, 0.8$  and  $1.0$ .

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The Curie temperature ( $T_c$ ) of the ferrite samples were determined by Loria technique (gravity method) [2] . A schematic diagram of the experimental set up of Loria technique is as shown in Fig. 2 For the determination of the Curie temperature ( $T_c$ ) by Loria technique, a soft iron rod of diameter less than the diameter of furnace was introduced in the furnace from the upper end. It forms the core of the electromagnet. The rod was magnetized by passing a current through a coil of copper wire. The pellet was stuck to the lower end of the magnet and then it was heated.

The ferrite sample remained in contact with the electromagnet till the Curie temperature was attained. As soon as the Curie temperature was reached, ferrite sample loses its magnetization so that the ferrite sample lose its contact with the magnet and fell under gravity. The temperature at this moment was recorded with the help of a thermocouple. The error in the measurement of Curie temperature was kept minimum (2%).

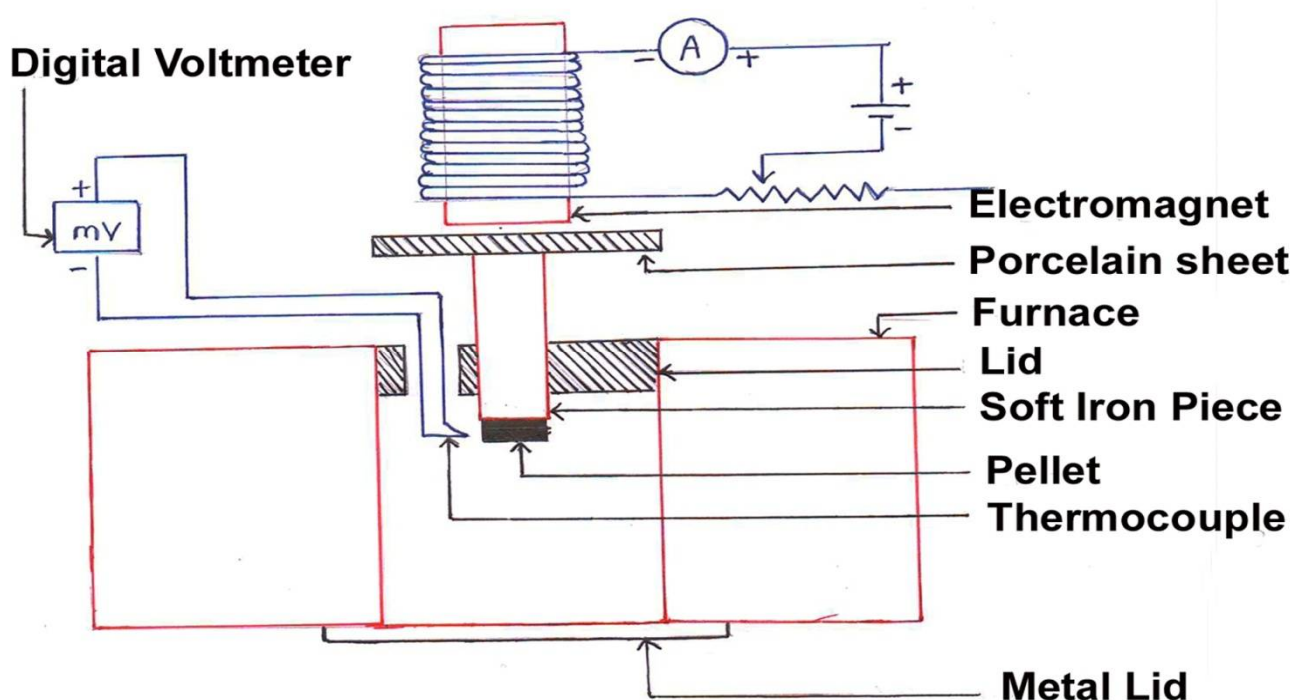


Fig. 2 Experimental set – up for Loria Technique

The Curie temperature of the ferrite samples  $Co_xMg_{1-x}Fe_2O_4$  with  $x=0.0, 0.2, 0.4, 0.6, 0.8$  obtained from Loria technique are listed in Table 1. along with literature values[4],[5].

Table 1: CURIE TEMPERATURES OF  $Co_xMg_{1-x}Fe_2O_4$  FERRITES.

COMPOSITION X	CURIE TEMPERATURE ( $T_c$ °C)		
	Loria technique	dc resistivity expt. [4]	ac susceptibility expt. [5]
0.0	388	439	437
0.2	428	452	450
0.4	482	468	469
0.6	496	479	482
0.8	515	496	495
1.0	527	521	520

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From table 1. It is observed that the Curie temperatures increase continuously and linearly with increasing cobalt content. In Mg- ferrite , the strong exchange interaction is between  $Fe^{3+}$  (A) and  $Fe^{3+}$  (B) ions while B –B interaction is assumed to be small. Also there is no super exchange interaction between  $Mg^{2+}$  (A) and  $Fe^{3+}$  (B) ions because  $Mg^{2+}$  ion do not have any magnetic moment. The presence of  $Co^{2+}$  in Mg ferrite results in an increases in the magnitude of the super exchange interaction. Under these situations , increases in the Curie temperature is expected and is found as cobalt contents is increased.

Secondly as reported earlier [5] Mg-ferrite contains multi-domain (MD) grains whereas Co-ferrite contains single domain (SD) grains. The presence of cobalt ions in Mg-ferrite hinders the formation of MD grains and hence Curie temperature increases as cobalt content is increased. Regular increasing trend in Curie temperature indicates that the cobalt ions have entered into the lattice of Mg-ferrite. The Curie temperatures obtained from Loria technique are in good agreements with those obtained from dc resistivity measurements [4] and ac susceptibility measurements [5].

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