Synthesis, Characterization and Effect of Manganese Substitution on Properties of Mg Ferrites

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Abstract: Manganese substituted magnesium ferrites having stoichiometric composition Mg1-xMnxFe2O4 with x ranging from 0.0 to 1.0 were prepared by Sol-gel method. X-ray diffraction was used to characterize the structure and phases present respectively. It was found that of all ferrite compositions at 900°C led to cubes of the ferrite grains and that there was single phase spinel structure. The X-ray diffraction patterns revealed the presence of (311) peak as the most intense one. The crystallite size was found to be within the range of 21-48 nm. Activation energy of resultant samples decreases from 0.45 ± 0.02 eV (x = 0.0) to 0.35 ± 0.02 eV (x = 1.0).

***Index Terms*: Ferrites, Chemical Synthesis, X-ray Diffraction, Scanning Electron Micrograph, D.C. electrical resistivity.**

I. INTRODUCTION

Studies of spinel ferrites are highly relevant to modern technologies, so the synthesis and sintering of ferrites have become an important part of modern research [1-3].Polycrystalline spinel ferrites are most important materials due to their interesting electrical properties i.e. low eddy current and dielectric losses. These spinel ferrites find applications in a wide range of frequencies extending from microwave to radio [4]. These are also applicable in many magnetic devices. The order of magnitude of conductivity greatly influences the dielectric and magnetic behavior of the ferrites and depends on the type of preparative method. Structural and magnetic properties of spinel ferrites depend upon the method of preparation, nature of dopant and dopant concentration [6]. The properties of spinel ferrites are strongly dependent on the distribution of the different cations among tetrahedral (A) and octahedral (B) sites [7]. The cation distribution in magnesium ferrite has been studied by various authors and was found to be strongly temperature dependent [8]. Mg-Mn ferrite was prepared by the coprecipitation method. In chemical method of preparation particles with desired physical properties, chemical properties and composition flexibility are achieved. Also, it allows a good control on size and shape distribution during synthesis. Due to this co-precipitation method is widely used for preparation of ferrites.

II. EXPERIMENTAL

Manganese substituted magnesium ferrite $Mg_{(1-x)}Mn_xFe_2O_4$ (where x=0.0, 0.25, 0.50, 0.75 and 1.0) samples were prepared by sol-gel auto combustion method [19]. The A.R. Grade chemicals used in the synthesis of materials were $C_6H_8O_7.2H_2O$, $Mg(NO_3)_2.6H_2O$, $Mn(No_3)_2.4H_2O$, $Fe(NO_3)_3$ H_2O and NH_3. The metal nitrates were dissolved in deionised water and equal quantities of citric acid were added in the metal nitrate solution. In beaker citrate solutions of Manganese nitrate, magnesium nitrate and cobalt nitrate were mixed in required stoichiometric ratio. The ammonia solution (1:1) was added drop by drop until the pH of the solution reached a value of 9.5. The resulting solution was stirred for 3h to maintain the homogeneity. The gel is formed when solution were heated on hot plate at 100°C after words the gel is further heated at 150°C to convert into fluphy mass. This fluphy mass was annealed at the temperature of 600°C for 6 h in a Box furnace [9].

In order to investigate the grain size and phase X-ray diffraction (XRD) analysis was performed (Philips PW-1710 X-ray diffractometer with CuKα radiation). The morphology of the material was studied by SEM (SEM Model JEOL-JSM 6360) [10].

III. RESULTS AND DISCUSSION

The XRD data of these ferrite samples agreed very closely with the standard values given in the JCPDS Data Cards, ($MgFe_2O_4$-73-2410 and $MnFe_2O_4$-22-1088) thus confirming the spinel phase Fig.1. The phase identification of the final products of the various compositions of $Mg_{1-x}Mn_xFe_2O_4$ oxides were made on Philips PW 1710 with Cu Kα radiation (λ=1.5405A°) [11].

The X-ray diffraction patterns of the investigated mixed Mg-Co ferrite revealed that all the samples had a single phase cubic structure. Lattice parameters varied between 8.33 and 8.36°A with increasing Co content. This increase may be related to the replacement of Mg^{2+} ion (0.065nm) with larger Mn^{2+} ion with ionic radius (0.0745 nm). Average particle size was determined from the broadening of X-ray diffraction peaks using the Scherrer equation and found to be in the range 24 to 48nm.(Table no.1)[12].