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Effect of Nd^{3+} Substitution on Structural and Magnetic Properties of Mg-Cd Ferrites Synthesized by Microwave Sintering Technique

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Abstract:

Nd^{3+}substituted spinel ferrites with formula $Mg_xCd_{1-x}Nd_{0.03}Fe_{1.97}O_4$ (x = 0, 0.2, 0.4, 0.6, 0.8 and 1.0) were prepared by oxalate co-precipitation method using novel microwave sintering technique. AR grade sulphates were used as starting chemicals. The samples were sintered at optimized power of 70% watt for 10 min in a microwave oven (800 W). The structural analysis of these samples was done by using X-ray diffraction; scanning electron microscope and Fourier transform IR techniques. The XRD analysis of the synthesized ferrite confirms the formation of cubic spinel structure of ferrite. The influence of Nd^{3+} substitution on various structural parameters of Mg-Cd ferrites was reported. IR study indicates the spectra contain two intense absorption bands around 600 and 400 cm^{-1} in addition with four extra bands. The magnetic properties of all ferrites were studied by using a vibration sample magnetometer. The crystallite and grain size dependant magnetic properties are observed. The composition $Mg_{0.6}Cd_{0.4}Nd_{0.03}Fe_{1.97}O_4$ has better magnetic properties that can be used in recording media. The fast synthesis of spinel ferrites is yielded due to use of the microwave sintering technique.

Keywords: Mg-Nd-Cd ferrite, Rare earth, Microwave sintering, IR study, Coercive force.

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1. Introduction:

Nanocrystalline ferrites are technological important materials because of their wide applications in a number of fields like sensors, antennas, drug delivery, pigments, catalysts, electronic devices, etc. [1-6]. This is due to their properties like low dielectric loss, high saturation magnetization, high resistivity, etc.[7-9] These properties of ferrites depend on synthesis techniques, substitution of divalent and trivalent ions, sintering atmosphere and sintering techniques [10-12].

Generally ferrites are synthesized by ceramic method. In this method the required proportion of high purity oxide metals for final product are mixed together. They are mixed manually or wet milled with steel balls for few hours. After milling the mixture is dried and passed through the mesh screen. The mixture is sintered under conventional sintering technique. But this method has several disadvantages like inhomogeneity of product, requirement of higher sintering temperature and time. It also consumes costly chemicals. The chemical methods such as co-precipitation [13], combustion [14], hydrothermal [15], sol-gel [16], citrate precipitation [17], sol gel self-combustion hybrid route [18] to overcome these disadvantages. Among all chemical methods, co-precipitation method is effective, superior and requires low cost chemicals for the preparation of nanocrystalline ferrites. This method requires low sintering temperature, achieves excellent control of crystallite size [19], improves homogeneity and yields high purity and fine powder [20].

Many researchers have synthesized ferrites by co-precipitation method with conventional sintering technique [13, 16, 18-20]. The conventional sintering technique, due to non-uniform heating in the furnace, results in absence of few ferrite phases during the formation of material. The conventional method of heating also suffers from the drawbacks like energy and time consumption. Such drawbacks are overcome by microwave heating technique. In microwave heating, due to absorption of microwaves, uniform heat maintains individual phases of the material [21]. Ponzoni et al. [22] have concluded that reaction time in conventional hydrothermal synthesis is significantly longer than the microwave assisted hydrothermal synthesis. Microwave synthesis technique enhances the rate of chemical reactions and gives superior yields in some cases [23]. The conventional and microwave heating techniques were successfully used to prepare cobalt ferrite nano-particles by using polyol method [24].