International Journal of Research in Advent Technology, Vol.5, No.6, June 2017
E-ISSN: 2321-9637
Available online at www.ijrat.org

Preparation And Study of Nanocrystalline Ferrite $MgNiCoFe_2O_4$ Prepared by Sol-Gel Auto-Combustion Technique

S.V. Gaikwad
Research Centre & P.G. Department of Physics, MES Abasaheb Garware College, Karve Road, PUNE-411004[MS], INDIA
svg10.agc@gmail.com

Abstract- The combustion and chemical gelation processes are combined in a new way with sol-gel auto combustion. The sol-gel combustion process was used to manufacture nanosize (d) powders with MgNiCoFe2O4 compositions. For four hours at a temperature of 4000C, the puffy, porous brown powder was calcined in its combusted state. IR spectroscopy was used to confirm the presence of ferrite bonds. In order to determine the nanocrystalline's particle size and morphology, X-ray diffraction (XRD) and SEM were used. Calculated powders had an average particle size of roughly 25 nm.

Keywords: Sol-gel auto-combustion, Nanocrystalline, $MgNiCoFe_2O_4$, IR- Spectroscopy, X-ray diffraction, Scanning electron microscopy.

1. INTRODUCTION

In order to make the synthesis of complicated materials go more quickly, we use the sol-gel auto-ignition approach. It's a straightforward procedure that saves both time and energy as compared to the old ways. Spinel ferrites' structural, electrical, and magnetic properties are all affected by this method's ability to produce ferrites with improved power characteristics, greater uniformity, and smaller particle sizes [1]. Nanoparticles of ferrite, a metal that can be used to make permanent magnets and other types of memory devices in the future. Recently, ferrite nanoparticles have emerged as a scientific focus.

Electronic, magnetic, and catalytic capabilities can be achieved with spinel ferrites due to their high resistivity and negligible eddy current losses. Magnetite ceramics play a significant role in electronic component manufacturing. Small permanent magnets can be used to perform simple functions, but more complex devices for the electro-electronic industry can also benefit from their use. Computer peripherals, telecommunication equipment, permanent magnets, electrical and magnetic media used in computers and recording devices, and magnetic cards are all examples of fascinating applications of these materials. Ferrites' electrical and magnetic properties are highly dependent on the production parameters, sintering temperature, sintering time, chemical composition, and the amount and kind of additives [2]. There are a number of advantages to using sol-gel chemical processes in terms of their characteristics and ease of use. Sol-gel studies on nickel- and zinc-containing nano-crystalline ferrite particles have gotten a lot of attention. The ferrites' primary requirements, on the other hand, have received far less attention. Because it is a new method that relies on organic compounds to create ferrite cores, the sol-gel strategy is now prohibitively expensive in terms of the resources it need to get started[3, 4].

Unlike their bulk counterparts, nanosized ferrites have unique magnetic properties, such as super-paramagnetic behaviour and its associated qualities. A range of applications, including targeted drug delivery, ferrofluids, medical imaging and other biomedical applications, magnetic data storage, etc.[5-8] require nanosized ferrites with uniform particle size and narrow particle size distribution.

2. EXPERIMENTAL PROCEDURE

To prepare MgNiCo ferrite, the analytical grade of Magnesium, Nickel, Cobalt and Iron nitrates are utilised, as well as citric acid. Materials are weighed in accordance with the specified stoichiometry. The nitrates and citrates were dissolved in deionized water and then homogenised using a magnetic stirrer at 750C. The pH of the solution was adjusted by adding liquid ammonia to it. A magnetic stirrer was used throughout this technique to keep the fluid moving. Heating at 1000C with continual stirring resulted in a xerogel being formed. The dried gel burned in a self-propagating combustion way until it was totally burned out to form a loose powder when lit at any spot.

FIGURE 1: Experimental Setup

FIGURE 2: Burnt ash

This loose powder was crushed well in a crucible and sintered in a heating furnace at 400^0C for 4 hours. The heating rate of the furnace was maintained constant at 5^0C per minute until the temperature reaches to 400^0C then the temperature of the furnace was kept constant for 4 hours and after that it was cooled slowly up to room temperature.

From 400 to 4000 cm-1, the IR spectra of the as-burnt powder sintering at 600 0C was acquired using the KBr pellet technique.

3. ANALYSIS

X-Ray Diffraction

In the case of MgxNi0.6-xCo0.2Fe2O4 (with x = 0.2, 0.4, 0.6), XRD was used to examine the phase formation behaviour. The charred powder lacked a metal oxide phase for analysis. The Scherrer formula was used to compute the crystallite size for all the peaks:

$$t = \frac{0.9\lambda}{\beta \cos\theta}$$

β=full width at half maximum, θ=bragg angle for the actual peak.

The lattice parameter was calculated by using the following formula:

$$\sin^2\theta = \frac{\lambda^2}{4a^2}(h^2 + k^2 + l^2)$$

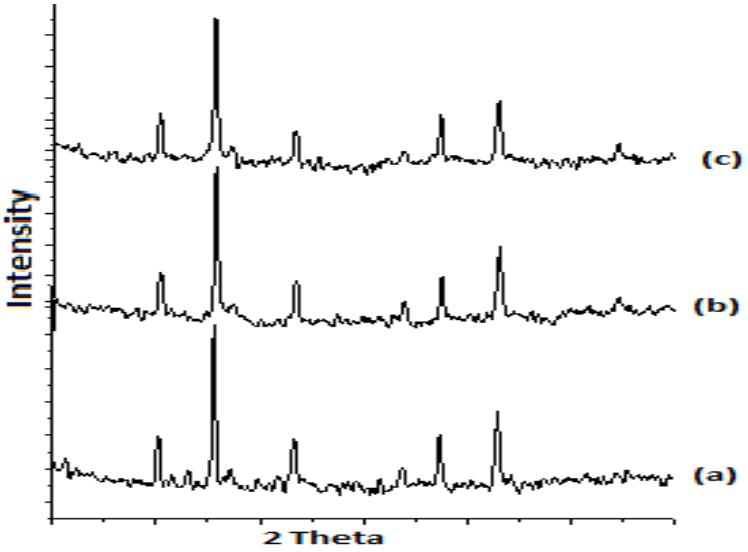


FIGURE: XRD graph of MgNiCo ferrite
(a)$Mg_{0.2}Ni_{0.6}Co_{0.2}Fe_2O_4$
(b)$Mg_{0.4}Ni_{0.4}Co_{0.2}Fe_2O_4$
(c)$Mg_{0.6}Ni_{0.2}Co_{0.2}Fe_2O_4$

Infrared Characterization:

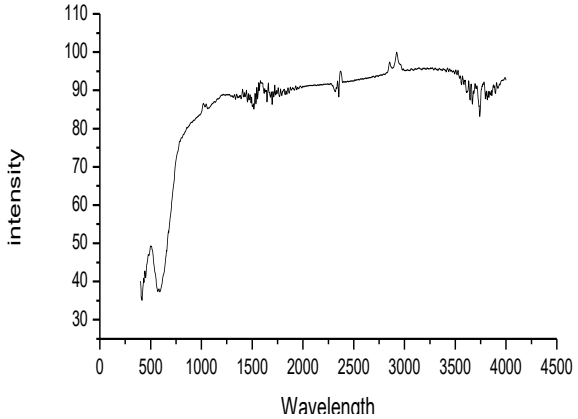


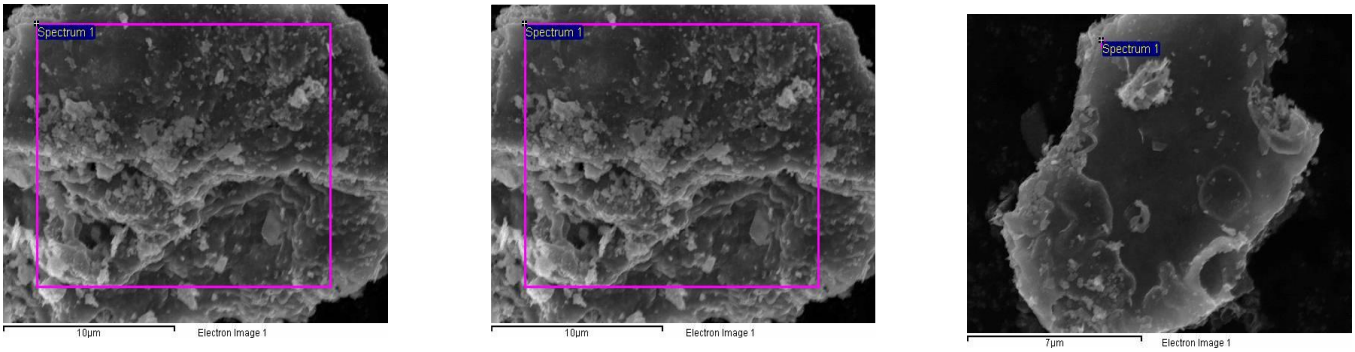
FIGURE: IR graph of $MgNiCoFe_2O_4$

There is only one prominent spectroscopic band at about 560 cm-1 in the IR curves of the as-burned powder. AlNiZn ferrite has a distinctive band like this. IR spectroscopy demonstrated that the carboxyl group and the (NO)3 ion are involved in the combustion reaction by the elimination of the distinctive bands in the IR spectra curve after burning. That's why it's possible to think of the combustion process as the result of an anionic redox reaction of the gel, in which an acidic acid (citrate) is reduced by acidic acid (nitrate). In order to speed up the degradation of the organic component, nitrate ions offer an in situ oxidising environment.

Scanning Electron Microscopy

Scanning electron microscopy is used to examine the structural morphology of MgxNi0.6-xCo0.2Fe2O4 in various proportions (where x = 0.2, 0.4, and 0.6).

The MgNiCo ferrite SEM images revealed that there isn't much of a morphology to this material.



(a)$Mg_{0.2}Ni_{0.6}Co_{0.2}Fe_2O_4$ (b)$Mg_{0.4}Ni_{0.4}Co_{0.2}Fe_2O_4$ (c)$Mg_{0.6}Ni_{0.2}Co_{0.2}Fe_2O_4$

FIGURE 1 SEM image of $Mg_xNi_{0.6-x}Co_{0.2}Fe_2O_4$

4. RESULTS AND DISCUSSION

This work used the low temperature Sol-Gel Auto-Combustion method to manufacture MgxNi0.6-xCo0.2Fe2O4 (where x = 0, 2, 4, 6). The two different compositions of MgNiCo ferrite by varying composition of Mg as x=0.2, 0.3 in $Mg_xNi_{0.6-x}Co_{0.2}Fe_2O_4$. The average grain size for two different compositions of $Mg_xNi_{0.6-x}Co_{0.2}Fe_2O_4$ found to be 21 nm and 27 nm as change in Al composition for x=0.2 and 0.3 respectively.

The morphology seen from the SEM images for $Mg_xNi_{0.6-x}Co_{0.2}Fe_2O_4$ where x = 0.2, 0.4, 0.6) for change in Aluminium composition x= 0.2 and 0.3 respectively revealed that the MgNiCo ferrite does not have any specific morphology.

Acknowledgments

We are grateful to Abasaheb Garware College's Department of Chemistry for allowing us to conduct our research there. For their generous cooperation and provision of their tools for characterisation, we further thank the Department of C-MET Pune, IIT Powai, and the Department of Physics, University of Pune.

REFERENCES

[1] M. A. Gabal, Y. M. Al Angari and M. W. Kadi, *Polyhedron*, 30 (2011) 1185-1190.
[2] A. T. Raghavender and K. M. Jadhav, Bull Mater. Sci., Vol. 32, No. 6, *Indian Academy of Sciences* December 2009, 575-578. 3. S. Zahi, *J. Electromagnetic Analysis and Applications, 2010, 2:56-62.*
[3] S. Zahi, *J. Electromagnetic Analysis and Applications, 2010, 2:56-62.*
[4] Dyal A, Loos K, Noto M et al (2003) *J Am Chem Soc* 125:1684
[5] Tiefenauer LX, Tschirky A, Kuhne G et al (1996) *Magn Reson Imaging* 14:391
[6] Skmoski R (2003) *J Phys Condens Matter* 15:R841
[7] Gibbs MRJ, Opin C (2003) *Solid State Mater Sci* 7:83
[8] Zhenxing Yue, Ji Zhou, Longtu Li, Hongguo Zhang, Zhiluin Gui, J*ournal of Magnetism and Magnetic Materials* 208 (2000) 55-60.