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Magnetic Properties of Co_3O_4 Nanoparticles

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Abstract: Spinel–type cobalt oxide nanoparticles have been prepared by Microwave Irradiation Technique using cobalt nitrate hexahydrate as precursor. Apart from being a simple technique it produces monosized particles without the need of expensive organic solvents and complicated equipment. The as–prepared sample was characterized by X-ray diffraction (XRD), Scanning Electron Microscope (SEM) and Vibrating sample Magnetometer (VSM). The XRD results indicate the formation of Co_3O_4 phase with FCC structure. The lattice constants being a = b = c = 8.085 Å. Using the Sherrer formula, the size of particles was found to be about 24 nm. SEM confirms the spherical morphology of the particles. Bulk Co_3O_4 is known to be antiferromagnetic. The VSM data taken at room temperature shows a weak ferromagnetic behavior with saturation magnetic moment of 0.2 emu/g at the maximum field of 9 kOe.
Keywords: Co_3O_4 nanoparticles; microwave irradiation technique; magnetic properties.

1. Introduction and Experimental Details:

In recent years nanometer-scale materials have attracted considerable interest because of the departure of properties from bulk materials due to quantum confinement effects[1]. Spinel type cobalt oxide (Co_3O_4) is a technologically important material with numerous applications in microbatteries, nanowires and in various catalytic applications[2,3]. In recent years, many efforts have been made to synthesize Co_3O_4 nanostructures with different morphologies such as nanoparticles, nanorods, and nanoporous structures[4]. These have been prepared by various techniques such as sol-gel method, chemical spray pyrolysis and hydrothermal method. In the present work, we have used Microwave Irradiation Technique to synthesize Co_3O_4 nanoparticles. The main advantage of this method is that it yields monosized nanoparticles due to simultaneous heating of the precursor solution.

Co_3O_4 is described by a formula unit AB_2O_4 [A $\rightarrow$ Co^{2+} , B $\rightarrow$ Co^{3+}] and exhibits a normal spinel structure with occupation of tetrahedral A sites by Co^{2+} and octahedral B sites by Co^{3+}. Its magnetic moment arises due to Co^{2+} ions largely because of spins. On the other hand Co^{3+} ions have no permanent magnetic moment. Thus, Co_3O_4 behaves like an antiferromagnetic material with the Neel temperature T_N = 40 K with each Co^{2+} ion in the A- site having four neighbouring Co^{2+} ions of opposite spins [5].

Aqueous solution of Cobalt nitrate hexahydrate (Co $(NO_3)_2.6H_2O$) was used as a precursor and ammonium hydroxide was added to it with stirring to get a pH = 10. Microwave irradiation was carried out at 80ºC for 15 minutes at 140 Watt power. The solution was cooled to room temperature and centrifuged at 2000 rpm. After washing with water and ethanol, the precipitate was dried over night in air. The sample was then calcined at 400ºC for 2 hours. It was then characterized by XRD, SEM and VSM.

2 Results and Discussion:

2.1 Phase evaluation and morphology:

Fig.1 shows X –ray diffraction pattern of Co_3O_4 nanoparticles. All diffraction peaks match very well with those reported in JCPDS card no 781970. These correspond to the FCC structure of Co_3O_4 with lattice constants a = b = c = 8.085 Å. The average crystalline size was calculated to be 24 nm by Sherrer formula. The value of strain determined from the Williamson-Hall plot (β Cosθ versus Sinθ) is $\eta = 4.87\times10^{-3}$.

The SEM data of fig. 2 shows particles of spherical morphology with average size of about 25 nm.

2.2 Magnetic properties:

The magnetic measurements were carried out using Vibrating Sample Magnetometer (VSM) at room temperature. The VSM data of as prepared Co_3O_4 nanoparticles is shown in fig.3. This is compared with the VSM data of bulk Co_3O_4 shown in fig. 4 [6]. The VSM data of nanoparticles exhibits a weak ferromagnetic behavior with saturation magnetization of about 0.2 emu/g at the maximum applied magnetic field of 10 kOe. Whereas bulk particles show antiferromagnetic behavior. It is known that the magnetic properties of nanomaterials are shape and size dependent. Thus we conclude that the ferromagnetic behavior originates from the nanosized particles.

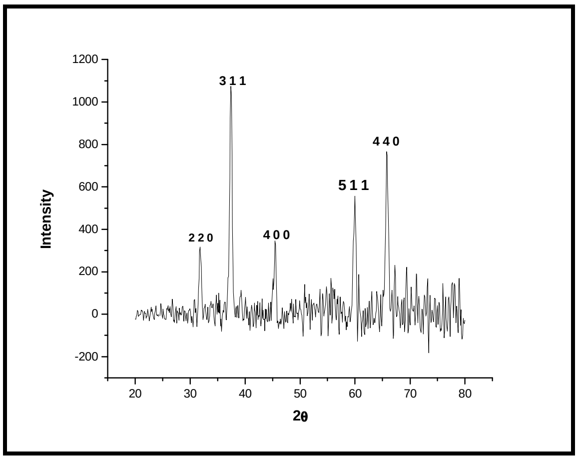

Fig.1 XRD of Cobalt oxide nanoparticles

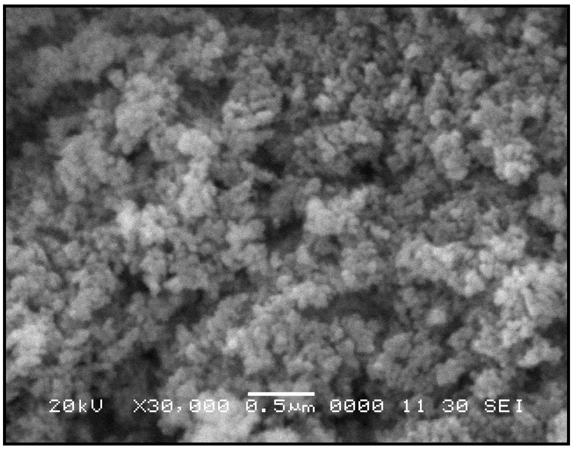

Fig.2 SEM data of Cobalt oxide nanoparticles

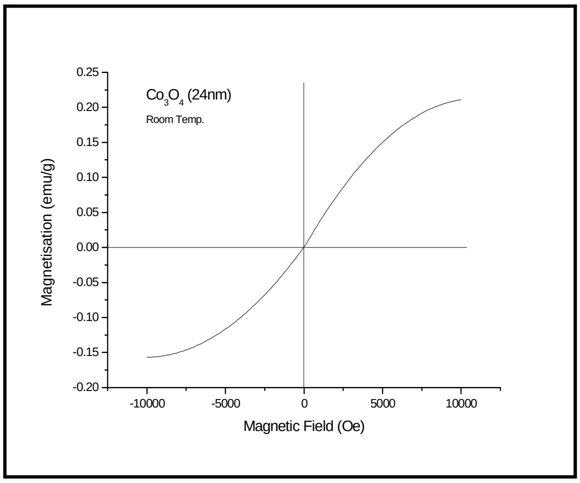

Fig.3: VSM data of Co_3O_4 nanoparticles at room temperature

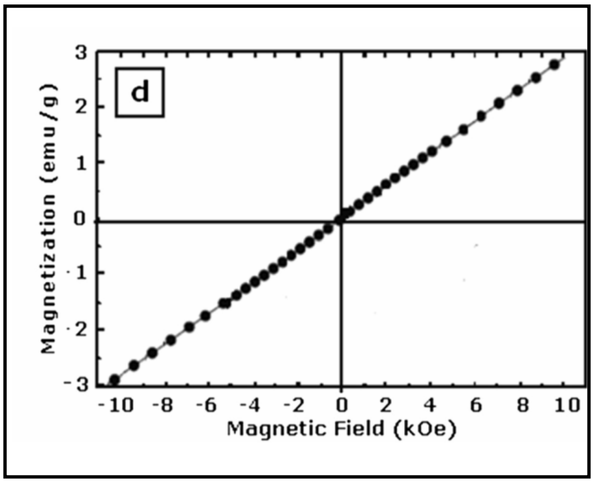

Fig.4: VSM data of bulk Co_3O_4 at room temperature (6)

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References:

1. Klabunde K.J., Richards R.M.: Nanoscale Materials in Chemistry, John Wiley, New York, 2012.
2. Mate V.R., Shirai M, Rode C.V.: Heterogeneous Co3O4 catalyst for selective oxidation of aqueous veratryl alcohol using molecular oxygen. Catal Commun 2013, 33, 66–69.
3. Warang T., Patel N., Santini A., Bazzanella N., Kale A., Miotello A.: Pulsed laser deposition of Co3O4 nanoparticles assembled coating: role of substrate temperature to tailor disordered to crystalline phase and related photocatalytic activity in degradation of methylene blue. Appl. Catal. A: Gen.2012, 423–424, 21–27.
4. Casas-Cabanas, Binotto M., Larcher .G, Lecup D., Giordani A., Tarascon J.M.: Defect chemistry and catalytic activity of nanosized Co3O4. Chem Mater 2009, 21, 1939–1947 .
5. Makhlouf S.A.: Magnetic properties of Co3O4 nanoparticles. J Magn Magn Mater 2002, 246, 184–190.
6. Farhadi S.; Safabakhsh J.; Zaringhadam P.: Synthesis, characterization, and investigation of optical and magnetic properties of cobalt oxide (Co3O4) nanoparticles. Journal Of Nanostructure in Chemistry ,2012,3,69.

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