Size Effect on Magnetic Properties of $MnCr_2O_4$ Nanoparticles

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Transition metal oxide spinels of the form AB_2O_4 have attracted a lot of interest because of the emerging interest in spin frustration, multiferroicity and critical point phenomena [1-2]. They have important applications in technology. This group of compounds has distinct tetrahedral (A) sites occupied by divalent cations and octahedral (B) sites populated by trivalent cations [3]. The physical properties of spinel oxides depend on the distribution of cations among the sites and the relative strength of the super-exchange interaction [4]. Among AB_2O_4 compounds, cubic spinel ACr_2O_4 oxides exhibit various significant physical effects, such as colossal magnetoresistance, multiferroicity, spin frustration and so on [5]. $CoCr_2O_4$ shows a magnetic transition from paramagnetic to ferrimagnetic and ferrimagnetic to spiral ordering as the temperature lowers and shows lock-in transition at low temperatures [2]. In this work, the size effect on the structural and magnetic properties of cubic spinel $MnCr_2O_4$ nanoparticles synthesized by the co-precipitation method is discussed [5]. The samples were calcined at different temperatures in the range 750°C - 1050°C. The average crystallite size of the synthesized nanoparticles was determined by powder X-ray diffraction (XRD), which showed an increase in particle size from 35.88 ± 0.01 to 55.53 ± 0.01 nm with an increase in calcination temperature. The lattice parameters of the nanoparticles decreased with an increase in calcination temperature. The average particle size was determined from the transmission electron microscopy (TEM) by fitting a Gaussian curve for the distribution of particles. Energy dispersive X-ray spectroscopy (EDS) confirmed Mn and Cr in the nanoparticles and selected area electron diffraction (SEAD) showed the crystalline nature.The optical spectra for $MnCr_2O_4$ nanoparticles was recorded using the UV-vis spectrometer. The Tauc model [6], was used to calculate the optical band gap that showed an increase in the value with increase in particle size. The magnetic properties as a function of temperature and magnetic field were measured using a vibrating sample magnetometer (VSM). Results showed $MnCr_2O_4$ nanoparticles have paramagnetic to ferrimagnetic transition at Curie temperature, T_C that ranges $42 \leqslant T_C \leqslant 46$ K followed by another transition at temperature T_S between 18 K and 21 K associated with the short-range spiral order. The observed anomaly will be discussed considering the change in lattice parameter

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Authors acknowledge financial support of SANRF and University of Johannesburg.