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Magnetic Phase Transitions in Ce^{3+} Substituted $CoCr_2O_4$ Nanoparticles

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Broken inversion symmetry is observed in compounds with a spiral ordering, leading to ferroelectricity has attracted recent attention [1]. $CoCr_2O_4$ is a compound with a complex conical-spiral spin ordering of ferrimagnetic nature that has a spontaneous magnetization [2]. This observed spiral ordering has induced ferroelectric polarization [3]. The crystal structure of $CoCr_2O_4$ is cubic spinel, where tetrahedral *A* sites are occupied by Co^{2+} and the octahedral *B* sites by Cr^{3+} [2, 3]. Isotropic antiferromagnetic *A*- *B* and *B*- *B* exchange interactions ($\mathcal{J}_{AB}$ and $\mathcal{J}_{BB}$) among the nearest neighbours with $\mathcal{J}_{BB}/\mathcal{J}_{AB} > 2/3$, give the solution for the ferrimagnetic spiral ground state having the spins located on the conical surfaces [4, 5]. The basic ordering of spins in the compound is AFM with unequal magnitudes that lead to a net FM order in the case of ferrimagnetic materials [6]. The present work investigates the role of Ce^{3+} substitution at the Cr^{3+} site on spiral ordering and other magnetic transitions in $Co(Cr_{0.95}Ce_{0.05})_2O_4$ nanoparticles. X-ray diffraction (XRD) studies of the sample calcined at 600 ℃ revealed phase purity and broadened diffraction peaks, which are signatures of the size effect. The crystallite size (D) estimated from the XRD was 6.3 ± 0.6 nm. The average particle size calculated from the transmission electron microscopy (TEM) data was found to be D_{TEM} = 8.4 ± 0.5 nm, corroborating the XRD results. Electron diffraction patterns confirm the crystalline nature of the nanoparticles having a bi-pyramidal shape. Magnetization as a function applied field shows an increase in coercivity as the temperature was decreased below the Curie temperature, T_C. Magnetization measured as a function of temperature indicated the ferrimagnetic behaviour, with T_C = 92.5 ± 0.5 K (using the "knee-point method"). However, the lock-in temperature observed for the $Co(Cr_{0.95}Ce_{0.05})_2O_4$ nanoparticles, T_L = 15 ± 2 K, is in agreement with that previously reported for pure $CoCr_2O_4$. Interestingly the spiral ordering was smeared by substituting Ce^{3+} at the Cr^{3+} site. The present work describes the impact of rare-earth Ce^{3+} ion substitution at the *B* site that can alter the exchange interaction in such a way that causes suppression of the spin spiral modulation.

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Apply to be considered for a student ; award (Yes / No)?

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