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Magnetic properties of Cr doped CoV2O6: A binary phase study

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The one-dimensional spin chain system CoV2O6 is known to show unique magnetic properties such as metamagnetism characterized by a 1/3 magnetic plateau [1–3], and magnetocaloric properties [3]. CoV2O6 crystallizes in two structurally distinct but chemically identically phases, α–CoV2O6 and ɣ–CoV2O6. Several studies have explored the magnetic properties of these two phases in bulk single crystalline [1,4] and polycrystalline [2,3] as well as nanocrystalline samples [5,6]. Recently, the effects of Cr doping on the magnetic properties of α–CoV2O6 were explored [7] and the study revealed the presence of spin-glass-like behaviour in addition to metamagnetism. This study takes an innovative approach of investigating the magnetic properties of a binary phase Co(V0.90Cr0.10)2O6 sample. The sample was synthesized using a wet chemical synthesis method [7]. The structural, elemental, morphological and magnetic properties of Co(V0.90Cr0.10)2O6 were investigated using X-ray diffraction (XRD), energy dispersive X-ray spectroscopy (EDS), Scanning electron microscopy (SEM), and vibrating sample magnetometry (VSM), respectively. XRD data revealed that Co(V0.90Cr0.10)2O6 sample is a binary phase of α–CoV2O6 and ɣ–CoV2O6. Rietveld refinement was performed on the XRD data and revealed that the composition consists of 84.90 % α–CoV2O6 and 15.10 % ɣ–CoV2O6. The calculated lattice parameters for both phases are in good agreement with those reported by Nandi and Mandal [3]. EDS elemental spectra showed the presence of Co, V, Cr and O, indicating the elemental purity of the samples and demonstrating the successful doping of Cr in the CoV2O6 matrix. SEM analysis revealed that the prepared powder sample is made of particles of different morphologies. The magnetic properties of Co(V0.90Cr0.10)2O6 were probed by measuring the magnetization as a function of temperature, M(T), under zero-field-cooled (ZFC) and field-cooled (FC) protocols at 0.1 T, 2.5 T and 5 T. M(T) data at 0.1 T reveals an antiferromagnetic (AFM) ordering with ordering temperature, TN = 15.2 ± 0.3 K. Increasing field to 2.5 T results in a ferrimagnetic (FI)-like ordering with TN = 13.3 ± 0.2 K. Increasing the field strength to 5 T results in a ferromagnetic ordering with TN = 15.2 ± 0.2 K. Spin-glass-like freezing was observed at 2.5 T. Isothermal field dependence of magnetization, M(μ0H), measurements at 2 K, 5 K, and 7 K, show a stepwise dependence of magnetization on the applied field, known as metamagnetism, with the first, second and third step corresponding to AFM, FI, and FM ordering, respectively. Metamagnetic transitions occurs at critical fields Hc1 and Hc2, with Hc2 ≈ 2Hc1. Finally, magnetic saturation occurs at the FM state, with the values of saturation magnetization, Ms, smaller than those of α–CoV2O6 and larger than those of ɣ–CoV2O6 [2], demonstrating the binary nature of Co(V0.90Cr0.10)2O6. The results from this study will contribute significantly to the existing knowledge of the magnetic properties of CoV2O6 and potential application in technology.

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MSc

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