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Synthesis, Structural, and Magnetic Properties of $CoCr_2O_4/Cu_2O$ nanocomposites.

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Nanocomposites have gained interest in current research because of the unique properties and scientific significance it has shown[1-2].It was found that composites that comprise of ferrimagnetic(FiM) and antiferromagnetic(AFM) materials exhibit fascinating magnetic phenomena including proximity effect and exchange bias[2,3].These phenomena manifest due to strong exchange coupling between FiM and AFM material[3].Cu_2O is an AFM material with a monoclinic crystal structure,that undergoes two magnetic transitions at T_{N1}=213K and T_{N2}=230K[3].The novel properties of Cu_2O such as weak FM and superparamagnetic(SPM) are attributed to size effects[4].$CoCr_2O_4$ is a FiM material with a cubic crystal structure, exhibiting three magnetic transitions at TC=93K,Ts=26K,and TL=15K[5].Ts is the temperature associated with the formation of a magnetic conical spin state anomaly due to the spiral ordering causes a multiferroic in a material[5].TL is the temperature associated with the transition from the commensurate to the incommensurate magnetic phase where spiral orderings are fully developed[5]. $CoCr_2O_4$ is a well-studied ternary multiferroic spinel with a conical structure and it manifests itself below Ts.$CoCr_2O_4$ exhibit an exchange bias without mixing with different magnetic material[5]. Rath et al.[7] investigated the magnetic properties of $CoCr_2O_4$ nanoparticles with average size 10-12 nm.SPM behaviour was observed,with a blocking temperature between 50-60K[7].The disordered spin at the surface and distribution of nanoparticle sizes play important roles in the observation of SPM behavior in a material[7].In order to expand on these observations, the present study considers a $CoCr_2O_4/Cu_2O$ composite that was synthesized using two-step methods.The initial step uses the sol-gel method[6] to synthesize the $CoCr_2O_4$ nanoparticles.The sample was calcined at 400 ^oC for 2 hours and characterized using different techniques. Single-phase $CoCr_2O_4$ formed,with the particle size of 12.47±0.50nm, and the particles undergo a FiM from a PM transition at T_C=98K.T_s and T_L were not observed due to the weak Cr-Cr interaction and size effect[8].The following step involves co-precipitation to synthesize the $CoCr_2O_4/Cu_2O$ composite, with cetyltrimethylammonium bromide (CTAB) used as a capping agent.The sample was again calcined at 400 ℃ to adjust the particle size [9].X-ray diffraction (XRD) results confirm the formation of multiphases associated with the Fd-3m and,C12/c1 space groups[4,6] related to the crystal structure of $CoCr_2O_4$ and,Cu_2O, respectively.The average crystallite size was estimated to be less than 43±1nm.Transmission electron microscopy(TEM) was employed to determine the average particle size and morphology.Both $CoCr_2O_4$ and $CoCr_2O_4/Cu_2O$ particles reflected non-uniform sizes and spherical shapes. Magnetic measurements were done using a vibrating sample magnetometer(VSM).The magnetic susceptibility as a function of temperature shows a PM to FiM transition at 94K for composite.The magnetic hysteresis loop shows SPM behaviour at 75K,while no exchange bias was observed at low temperatures for the composite.

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