Structural and optical properties of CuO:PVC nanocomposite films

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Abstract

Metal oxides constitut the most diverse class of materials having properties covering almost all aspects of materials science and of physics. Among these materials, copper oxide CuO is very promising. It is a p-type semiconductor material with a band gap of about 1.8 eV. The growing interest granted to CuO is due to many potential applications that it offers in the conversion of solar energy, optoelectronics and photocatalytic degradation of organic pollutants. It is also used in consumer products such as pillowcases and socks because of its cosmetic and antimicrobial properties. In this work, we studied the structural and optical properties of hybrid nanocomposite consisting of Polyvinyl chloride (PVC) as a matrix and the crystallites of the semiconductor CuO as a filler. The samples in the form of thin films are deposited on glass substrates by the dip-coating technique using a colloidal solution prepared by dissolving the Polyvinyl chloride and dispersing the CuO nanocrystallites. The CuO nanoparticles have been previously synthesized by the hydrothermal method.

The characterization of the films of the CuO:PVC nanocomposite by the X-ray diffraction (XRD) has shown the incorporation of the CuO crystallites with monoclinic phase in the amorphous matrix or PVC. The resolution and intensity of the diffraction peaks show a good crystallinity and a random orientation of the crystallites of CuO.The CuO crystallite size was determined using the Scherrer relation ship and it was estimated to about 20 nm. Analysis of the CuO:PVC nanocomposite by the spectroscopy Raman and infrared confirmed the presence of the CuO cristallites in the PVC matrix by revealing vibration modes which are specific to the Cu-O bond. Surface morphology and topography of the CuO:PVC nanocomposite thin films were highlighted with the help of atomic force microscopy (AFM) and from which we deduce the homogenous dispersion of CuO crystallites. The characterization by the measurement of the optical absorption in the UV-Visible domain allows to observe a band at 372 nm which is attributed to the CuO nanocrystallites because the PVC is optically transparent in the UV- Visible domain. The optical gap of the CuO:PVC nanocomposite was estimated to 3.46 eV. Some discrepancies with respect to the gap of PVC and of bulk CuO are due to the nanometric size of the CuO crystallites and to the effect of the interaction between the CuO crtstallites and the PVC matrix. This variation of the gap is a result of the new optical behavior of PVC when it is doped with CuO nanocrystallites. Photoluminescence (PL) spectrum has showed two emissions bands in the visible domain at 500 nm (green emission) and 695 nm (red emission).

Keywords: Hydrothermal synthesis; CuO:PVC nanocomposite; XRD; AFM; Raman and infrared spectroscopies; optical absorption; Photoluminescence.