Structural, Optical Analysis, and Poole–Frenkel Emission in NiO/CMC–PVP: Bio-Nanocomposites for Optoelectronic Applications

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Abstract

The properties and related applications of biopolymer-based nanocomposites are dependent on the composition of the polymeric blend and the type and morphology of the nanofillers used. In this work, high purity NiO nanoparticles (NP) were prepared by a facile sol-gel route and introduced into carboxymethyl cellulose–polyvinyl pyrrolidone (CMC–PVP) blend. The crystallinity, surface morphology, and chemical composition of the resulting films were studied using FE-SEM, XRD, EDX and FTIR spectroscopy to evaluate the NiO NP's dispersion level inside the blend and their influence on the film structure and complexation with the functional groups in the blend. UV-Vis-NIR spectroscopy showed that the NiO NP reduce the transparency of the resulting films from 90 to 43.1% and interestingly modified their reflectivity. The optical bandgap was determined using two different approaches and found to decrease (from 5.1 to 4.5 eV) upon increasing the NP content. The current–voltage (*I*–*V*) characteristics were found to be of a non-ohmic type. The DC conductivity (σ_{dc}) was significantly increased and the activation energy (E_a) decreased after loading 1.2 wt.% NiO. The possible conduction mechanisms have been discussed. The results indicate that novel NiO/CMC–PVP nanocomposites can be prepared with improved conductivity, reduced band gap, and highly improved refractive index. Therefore, these materials are suitable for coatings and lenses as well as for engineering, electrochemical and optoelectronic applications.

Keywords: NiO; CMC biopolymer; refractive index; dielectric loss; Poole-Frenkel conduction.

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