Influence of NiO and La_2O_3 nanoparticles on the optical, mechanical and electrical properties of PVAc–PMMA blend: a comparative study

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Abstract

Nano-sized metal oxides are fascinating materials as fillers used for improving the polymeric materials' performance and expanding their multifunctionality. Two metal oxides; NiO and La_2O_3 nanoparticles (NP) were prepared and introduced into poly(vinyl acetate)/poly(methyl methacrylate), PVAc/PMMA blend via solution casting route. XRD and HR-TEM analysis confirmed the preparation of a cubic NiO and a hexagonal La_2O_3 NP with an average crystallite size of 59.85 and 29.13 nm, respectively. Introducing NiO and La_2O_3 increases the films' amorphous structure. FTIR analysis confirmed the existence of all blend' functional groups and hydrogen bond formation. SEM investigation showed that NiO or La_2O_3 loading affects the blend surface morphology. A UV-vis-NIR study showed that NiO narrowed the direct bandgap of the blend from 4.1 to 3.3 eV, whereas La_2O_3 reduced it to 3.4 eV. 1.0 wt.% NiO significantly improved the various optical constants of the blend. DMA revealed that storage modulus G' increased with loading of 1 wt.% NiO or La_2O_3 by 79.3% and 51.0%, respectively while G' decreased with heating. The dielectric behavior of films is analyzed using several dielectric parameters. The maximum σ_{ac} reported for 1.0 wt.% NiO/blend film is 5.8×10^{-6} (S/cm). The AC conduction mechanism is discussed for all films in the temperature and frequency ranges (298−373 K) and (5 Hz−2 MHz). 1.0 wt.%/PVAc/PMMA nanocomposite showed enhanced optical and mechanical properties, making it suitable for architectural, flexible display screens, and photovoltaic cell devices. Moreover, loading NiO and La_2O_3 improved the dielectric properties of the blend to be used in the semiconductor industry, besides energy storage devices and supercapacitors.

Keywords: PVAc/PMMA; NiO and La_2O_3 doping; Optical constants; Dynamic mechanical analysis; Dielectric properties.