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Structural, optical analysis, stress-strain, and dielectric properties of selenium oxide/$LaFeO_3$/blend nanocomposites with tunable properties for optoelectronics and micro-supercapacitors

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Abstract

This work focuses on developing flexible nanocomposites by introducing two types of ceramic nanofillers into a biopolymeric blend for optoelectronic and energy-storing applications. Selenium oxide (SeO_2) nanoparticles (NPs) and $LaFeO_3$ NPs were prepared by hydrothermal and solid-state reactions, respectively, and incorporated into the polyvinyl alcohol/polyvinyl pyrrolidone (PVA/PVP) through the solution casting process. Transmission electron microscope and X-ray diffraction tests revealed the creation of hexagonal SeO_2 and orthorhombic $LaFeO_3$ NPs, with average sizes of 17 and 93 nm. The blend's degree of crystallinity was dependent on SeO_2 NPs and $LaFeO_3$ contents. The infrared absorption spectra revealed the interactions/complexation of the fillers with the blend reactive groups. The scan *e*-microscope (field emission mode) investigated the films' surface morphology and detected the elements they contain. $LaFeO_3$/SeO_2 content impacted stress-strain behavior, raised the tensile strength from 64 to 70.9 MPa, and dramatically lowered the strain at break and toughness. UV-vis-NIR measurements exhibited that the transmittance, extinction coefficient, and refractive index can be tuned by SeO_2 and $LaFeO_3$/SeO_2 content. The direct ($E_{g.d}$)/indirect ($E_{g.id}$) band gaps were reduced from 5.25/4.9 eV to 4.95/4.7 eV. The dielectric parameters (constant, loss, energy density, and conductivity) were significantly increased after loading 5.0 wt% $LaFeO_3$/SeO_2. The dielectric moduli and Cole-Cole plots were also investigated. The structural modifications and enhancement of the optical features and dielectric parameters make the resulted samples the best candidates for optoelectronic devices and energy-storing applications such as sensors and supercapacitors.

***Keywords*:** SeO_2/$LaFeO_3$ NPs; PVA/PVP blend; optical parameters; AC conductivity; Energy density.