$M^{3+}/NaTiO_3$/PVA–Chitosan Nanocomposites (M = Ga, Ce, Nd or Er): Novel Solid Polymer Electrolytes for Supercapacitors

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Abstract

Designing flexible and thermally stable solid polymer-electrolyte (SPE) -based green materials for energy storage devices is an interesting approach from environmental and technological points of view. In this paper, $NaTiO_3$ (ST) nanofibers of diameters in the range of 4.88–9.48 nm were hydrothermally prepared and loaded into the poly(vinyl alcohol)–chitosan (PVA–Ch) bio-blend via solution casting. Additionally, the obtained nanocomposite solution was mixed with Ga^{3+} and rare earths (Ce^{3+}, Nd^{3+}, or Er^{3+}) for preparing novel solid polymer electrolyte films. XRD results indicated the semicrystalline nature of all samples, and the degree of crystallinity decreased after loading these additives. FE-SEM and EDS were used to investigate the surface morphology, fracture cross-section and the elemental chemical composition. FTIR analysis confirmed the complexation and complete dissociation of the salts inside the blend. UV-vis spectroscopy showed that the optical band gap of the films was reduced from 4.4 eV to 3.5 eV, and the refractive index is in the range of 2.376–2.648. The thermo-gravimetric analysis (TGA) revealed that the samples are thermally stable until 200 ℃, and the maximum decomposition occurs in the temperature range 255–300 ℃. In addition, four endothermic peaks were detected in the differential scanning calorimetry thermograms. Dielectric properties were measured in the frequency range of 100 Hz–8.0 MHz and at temperatures in the range of 30–120 ℃. The dielectric constant and ac conductivity were greatly improved due to doping with ST and mixing the salts. The small dielectric loss associated with the improvements in the dielectric constant and ac conductivity suggest the use of the ST/blend and salts/ST/blend films for energy storage devices and related applications.

Keywords: Green solid polymer electrolytes; Energy storage devices; $NaTiO_3$ nanofibers; Rare earth ions; AC conductivity; Biopolymers.

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