Synthesis, Optical, and Electrical Properties of Starch/Chitosan/$NaTiO_3$ Bio-Nanocomposites Modified with $ErCl_3$

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Abstract

Solid polymer electrolytes (SPEs) based on nanocomposites are attracting increasing attention due to their technological and industrial applications. In the present work, a facile aqueous casting method was utilized for the preparation of a starch-chitosan blend loaded with nanosized $NaTiO_3$ (NTO) and co-mixed with $ErCl_3$ (EC) salt. The interactions between OH group of starch and N–H group of chitosan with NTO and EC, and the the films' crystallinity and surface morphology were studied by FTIR, XRD, and SEM. UV-Vis-NIR measurements showed the indirect (direct) optical band gaps decreased from 3.4 to 2.0 eV (4.5 to ~ 2.5 eV), i.e., ~ 41–44 % shrinking. At the time that the films maintained a reasonable transmittance. The optical constants of the films; extinction coefficient, refractive index, and the carrier's concentration to the electron effective mass (N/m^*) are reported. N/m^* of the pure blend was 4.85 x 10^{39} (kg^{-1} m^{-3}) increased to 1.64 times and 2.8 times after loading with 1.0% NTO and 20% EC, respectively. Various dielectric parameters (dielectric constant ε', dielectric loss ε'', ac conductivity σ_{ac}, and dielectric moduli M' & M'') were evaluated in the frequency range 5 Hz - 1 MHz and temperatures of 298 - 353 K. The conductivity (σ_{ac}) of the blend increased from 1.10×10^{-3} S/cm to 8.17×10^{-3} S/cm after modifying with 20% EC, i.e., became 8 times greater. Moreover, the influence of NTO and EC on the conduction mechanism, and Cole-Cole plots are discussed. The improvements in the optical and electrical properties of EC/NTO/blend illustrate the possibility extending the applications of these smart materials to include the optoelectronic devices, batteries and supercapacitors.

Keywords: Nanocomposites; Biopolymers; Solid polymer electrolyte; $NaTiO_3$; Optical constants; Dielectric relaxation.