Development and Characterization of $Mg(NO_3)_2$-Doped Cellulose/Graphene Composite Biopolymer Solid Electrolytes

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Abstract:
Cellulose/graphene composite biopolymer solid electrolytes were successfully prepared using the solution casting technique. The composition of the undoped cellulose/graphene composite matrix was fixed at an 80:20 ratio. Magnesium nitrate was incorporated into the biopolymer matrix at concentrations ranging from 5 to 20 wt.% to enhance the ionic conductivity of the composite biopolymer electrolyte. The results showed that the addition of 10 wt.% $Mg(NO_3)_2$ provided the optimum performance, achieving an ionic conductivity of 1.0214×10^{-4} S cm^{-1} with improved dielectric properties. X-ray diffraction analysis revealed a reduction in the diffraction peak intensities of graphene and $Mg(NO_3)_2$ at 26° and 15°, respectively, indicating a decrease in crystallinity and enhanced amorphous phase formation within the composite electrolyte. Differential scanning calorimetry demonstrated that the melting temperature increased from 85.9 °C for the undoped composite to 106.7 °C after salt incorporation, suggesting significant structural modification of the host matrix. Fourier transform infrared spectroscopy confirmed interactions between $Mg(NO_3)_2$ and the cellulose/graphene composite biopolymer network. Transference number measurements indicated that ionic conduction dominated the charge transport mechanism in both doped and undoped systems. Linear sweep voltammetry analysis further showed that the composite electrolytes were electrochemically stable up to 2.1–2.2 V. Unlike previous studies that focused on modified cellulose or graphene derivatives, this work highlights the potential of unmodified of cellulose/graphene composites as promising composite biopolymer solid electrolytes for electrochemical energy storage applications.

Keywords:
Cellulose/graphene composite, solid biopolymer electrolyte, magnesium nitrate, electrochemical stability, energy storage materials.