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EXTENDED ABSTRACT BOOK

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The Effect of Aluminium Oxide Nanofillers on Electrochemical Properties of Cornstarch/NaI Biopolymer Electrolytes

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ABSTRACT

Solid polymer electrolytes (SPEs) represent an alternative to conventional liquid electrolytes due to their improved safety, thermal stability, and electrochemical compatibility. Cornstarch-based SPEs are particularly attractive because of their abundance, low cost, and biodegradability, yet they are hindered by poor ionic conductivity and weak mechanical stability. This study investigates the effect of aluminium oxide (Al_2O_3) nanofillers on the structural and electrochemical performance of cornstarch–sodium iodide (NaI) based electrolytes fabricated via solution casting. Electrochemical impedance spectroscopy (EIS) was employed to measure ionic conductivity. Results revealed that NaI doping enhanced conductivity up to 9.43×10^{-9} S/cm at 15 wt% loading, beyond which conductivity decreased due to ion agglomeration. Incorporation of Al_2O_3 nanofillers further improved conductivity, with an optimum performance at 4 wt% filler (4.02×10^{-9} S/cm). These findings suggest that the synergistic effect of salt and nanofillers improves ion transport, thereby enhancing the applicability of cornstarch-based electrolytes in sustainable energy storage devices.
Keywords: Solid polymer electrolyte, cornstarch, sodium iodide, aluminium oxide, ionic conductivity

1. INTRODUCTION

The demand for safe, lightweight, and sustainable electrolytes for rechargeable batteries has motivated the exploration of solid polymer electrolytes (SPEs) as replacements for volatile liquid systems (Abdullah et al., 2023). SPEs eliminate risks of leakage, corrosion, and flammability while offering mechanical flexibility and wide electrochemical stability. Biopolymers such as starch, chitosan, and cellulose have gained attention for their environmental benignity (Huang et al., 2017). Among these, cornstarch is a promising host matrix due to its biodegradability, renewability, and favorable adhesion and recrystallization properties. However, cornstarch-based SPEs are limited by low ionic conductivity and poor thermal stability (Liew et al., 2015). Several strategies, including salt doping, polymer blending, and nanofiller addition, have been investigated to enhance conductivity. Sodium iodide (NaI) provides mobile Na^+ carriers, while aluminium oxide (Al_2O_3) nanofillers reduce crystallinity and promote Lewis acid–base interactions, thereby increasing charge carrier dissociation and mobility. This study focuses on evaluating how NaI and Al_2O_3 additions influence the conductivity and structural behavior of cornstarch SPEs.

2. METHODOLOGY

Cornstarch, NaI, and Al_2O_3 were used as host polymer, dopant salt, and nanofiller, respectively. Biopolymer films were prepared via the solution casting method. Samples with varying NaI contents (5–20 wt%) and Al_2O_3 fillers (2–10 wt%) were fabricated. The ionic conductivity was determined using Electrochemical Impedance Spectroscopy (EIS) over the frequency range of 50 Hz–5 MHz at room temperature. The bulk resistance (R_b) was extracted from Cole–Cole plots and conductivity calculated using $\sigma = t / (R_b \times A)$, where t = thickness, A = surface area, and R_b = bulk resistance. FTIR spectra were recorded in the range 650–4000 cm^{-1} to identify functional groups and confirm interactions between polymer, salt, and filler.

3. RESULTS AND DISCUSSION

Ionic conductivity increased with NaI loading up to 15 wt% (9.43×10^{-9} S/cm), beyond which conductivity decreased due to ion aggregation. The optimum Al_2O_3 nanofiller content was 4 wt%, yielding conductivity of 4.02×10^{-9} S/cm. Excess filler (>6 wt%) led to reduced conductivity, attributed to ion-blocking effects and particle agglomeration. (Teoh et al., 2014).

Table 1. Ionic conductivity values of cornstarch–NaI electrolytes

Sample	NaI (wt%)	σ (S/cm)
CN-5	5	2.73×10^{-9}
CN-10	10	7.19×10^{-9}
CN-15	15	9.43×10^{-9}
CN-20	20	4.23×10^{-9}

4. CONCLUSION

This study demonstrates that cornstarch, a renewable and biodegradable material, can be developed into SPEs with improved ionic conductivity through NaI doping and Al_2O_3 nanofiller addition. Optimal performance was achieved at 15 wt% NaI and 4 wt% Al_2O_3, showing improved ion transport and polymer–filler interactions. The findings suggest strong potential for cornstarch-based electrolytes in sodium-ion batteries and other eco-friendly electrochemical devices. Future work should optimize salt–filler ratios and explore alternative nanofillers for further enhancement.

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