Article

Development of Polymer Blend Electrolyte Membranes Based on Chitosan: Dextran with High Ion Transport Properties for EDLC Application

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Abstract: Solid polymer blend electrolyte membranes (SPBEM) composed of chitosan and dextran with the incorporation of various amounts of lithium perchlorate (LiClO4) were synthesized. The complexation of the polymer blend electrolytes with the salt was examined using FTIR spectroscopy and X-ray diffraction (XRD). The morphology of the SPBEs was also investigated using field emission scanning electron microscopy (FESEM). The ion transport behavior of the membrane films was measured using impedance spectroscopy. The membrane with highest LiClO4 content was found to exhibit the highest conductivity of 5.16 $\times$ 10$^{-3}$ S/cm. Ionic ($t_i$) and electronic ($t_e$) transference numbers for the highest conducting electrolyte were found to be 0.98 and 0.02, respectively. Electrochemical stability was estimated from linear sweep voltammetry and found to be up to ~2.3V for the Li$^+$ ion conducting electrolyte. The only existence of electrical double charging at the surface of electrodes was evidenced from the absence of peaks in cyclic voltammetry (CV) plot. The discharge slope was observed to be almost linear, confirming the capacitive behavior of the EDLC. The performance of synthesized EDLC was studied using CV and charge−discharge techniques. The highest specific capacitance was achieved to be 8.7 F·g$^{-1}$ at 20th cycle. The efficiency ($\eta$) was observed to be at 92.8% and remained constant at 92.0% up to 100 cycles. The EDLC was considered to have a reasonable electrode-electrolyte contact, in which $\eta$ exceeds 90.0%. It was determined that equivalent series resistance ($R_{eq}$) is quite low and varies from 150 to 180 $\Omega$ over the 100 cycles. Energy density ($E_d$) was found to be 1.21 Wh·kg$^{-1}$ at the 1st cycle and then remained stable at 0.86 Wh·kg$^{-1}$ up to 100 cycles. The interesting observation is that the value of $P_d$ increases back to 685 W·kg$^{-1}$ up to 80 cycles.

Keywords: biopolymer electrolyte membranes; XRD analysis; FTIR study; Morphology; Impedance study; EDLC fabrication

1. Introduction

Electrochemical capacitors are classified into three types: Pseudocapacitor, electrical double-layer capacitor (EDLC), and hybrid capacitor [1]. In pseudocapacitor, Faradaic process is involved as the energy storage mechanism with metal oxide and conducting polymer electrodes [2]. However, in EDLC, which is usually composed of two identical carbon-based electrodes, non-Faradaic process is involved