Electrical characterization of corn starch-LiOAc electrolytes and application in electrochemical double layer capacitor

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\textbf{A B S T R A C T}

Corn starch based solid biopolymer electrolytes doped with lithium acetate (LiOAc) and plasticized with glycerol are prepared by solution cast technique. In unplasticized system, the maximum room temperature conductivity of \((2.07 \pm 0.53) \times 10^{-8} \text{ S cm}^{-1}\) is obtained by the electrolyte consists of 75 wt.% starch and 25 wt.% LiOAc. In plasticized system, addition of 30 wt.% glycerol to the highest conducting unplasticized electrolyte has further increase the conductivity up to \((1.04 \pm 0.10) \times 10^{-7} \text{ S cm}^{-1}\). Results from X-ray diffraction (XRD) explain that the enhancement of conductivity is contributed by the degree of crystallinity of electrolytes. Linear sweep voltammetry (LSV) shows that the highest conducting plasticized electrolyte is stable up to 2.1 V. The highest conducting plasticized electrolyte is used in the fabrication of an electrochemical double layer capacitor (EDLC). The EDLC is characterized using cyclic voltammery (CV) and galvanostatic charge-discharge measurements. From CV, the specific capacitance \((C_s)\) of fresh EDLC is calculated to be 33.00 \(\text{F g}^{-1}\) at scan rate of 0.5 \(\text{mV s}^{-1}\). The value of \(C_s\) increases as the scan rate decreases. From the charge-discharge measurement, the value of \(C_s\) is almost constant at \(\sim 33.31 \text{ F g}^{-1}\) for 1000 cycles.

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1. Introduction

The potential application of solid polymer electrolytes (SPEs) in electrochemical devices is an interesting issue due to some advantages including the ease of fabrication, free of leakage and good electrode–electrolyte contact [1,2]. Recently, research on new materials from renewable sources as the possible electrolyte’s host has grown vigorously, since synthetic polymers are obtained from finite sources [3]. Natural polymers are well known for their biodegradation properties, richness in nature and low cost [4]. The use of natural polymers in electrolytes could overcome the main shortcoming of synthetic ones, which are mostly insoluble in the solvents [5]. Many natural polymers have been used as polymer host in electrolytes, such as chitosan [6], cellulose derivatives [7], pectin [8] and natural rubber [9,10]. Among the natural polymers, great attention has been paid to corn starch. Starch is a mixture of amyllose (poly-\(α-1,4\)-glucopyranoside) and branched amylopectin (poly-\(α-1,4,1,6\)-glucopyranoside) where it is regenerated from carbon dioxide and water by photosynthesis in plants [11]. Starch is completely biodegradable and it has good solubility and superior steel adhesion properties [12–15]. Starch is able to form mechanically stable films while starch based SPEs exhibit good opto-electrochemical characteristics [14,15].

It has been reported that ions are favorably mobile in the amorphous phase since their motion is assisted by polymer segmental motion [16–18]. The addition of salts to the polymer matrix can increase the percentage of amorphous nature of the polymer [19]. Ibrahim et al. [20] suggested that the incorporation of lithium hexafluorophosphate (LiPF\textsubscript{6}) to polyethylene oxide (PEO) based SPE transforms some of the portion of PEO to amorphous phase. However, the commercial LiPF\textsubscript{6} salt is very sensitive to moisture and thermally unstable [21]. Lithium salts such as lithium tetrafluoroborate (LiBF\textsubscript{4}) [22–24], lithium arsenate (LiAsF\textsubscript{6}) [25] and lithium triflate (LiCF\textsubscript{3}SO\textsubscript{3}) [26,27] have been studied as dopant in polymer electrolytes to improve the performance of electrochemical devices. Yahya and Aref [28] reported that lithium acetate (LiOAc) doped chitosan electrolyte exhibits a conductivity of \(\sim 10^{-6.5} \text{ S cm}^{-1}\) at room temperature. In the application of electrochemical devices, an electrolyte with a high conductivity value is required so that the device can deliver a good performance. SPEs based on only polymer and salt are normally insufficient for the application in electrochemical devices. Hence, researchers have tried to increase the conductivity by introducing other additives to

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