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Starch-based gel electrolyte thin films derived from native sago (*Metroxylon sagu*) starch

Suh Cem Pang · Chen Lim Tay · Suk Fun Chin

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Abstract Starch-based gel electrolyte (SbGE) thin films were prepared by mixing native sago starch with different amounts of glycerol, and subsequently doped with various types of ionic salts. SbGE thin films showed substantially enhanced mechanical properties and ionic conductivity through incorporating optimal composition of native sago starch, glycerol, and ionic salts. A maximum room temperature ionic conductivity of the order of 10^{-3} S cm^{-1} was achieved for optimized SbGE thin film consisting of 80 wt% of native sago starch and 20 wt% of glycerol, and doped with 8 wt% of LiCl. SbGE thin films were characterized by Fourier transformed infrared spectrometry, scanning electron microscopy, and electrochemical impedance spectroscopy. Due to their favorable mechanical properties, high ionic conductivity at room temperature, ease of preparation, environmentally benign, and cheap, SbGE thin films show high potential utility as gel electrolyte materials for the fabrication of solid-state electrochemical devices.

Keywords Native sago starch · Gel electrolyte · Ionic conductivity · Plasticizer · Ionic salts

Introduction

Solid polymer electrolyte (SPE) is a type of electrolyte material that has been developed to replace conventional liquid electrolyte in various electrochemical devices such as

rechargeable batteries, supercapacitor, and electrochromic window [1, 2]. SPE behaves as an ionic conductor that allows ions to move between two electrodes during electrochemical reactions and serves as a separator for both electrodes at the same time. Among the advantages of SPE as compared to conventional liquid electrolytes include prevention of internal short-circuiting due to formation of dendrites, leakage of electrolyte, and volume expansion due to electrochemical reactions on the electrolyte/electrode interface, and reactive explosion [3]. The development of SPE has led to improved overall safety, portability, and durability of various electrochemical devices.

Various synthetic polymers such as poly(ethylene oxide) (PEO), poly(acrylonitrile) (PAN), poly(methyl methacrylate) (PMMA), poly(vinylidene fluoride) (PVdF), and poly(vinylidene fluoride-hexafluoro propylene) (PVdF-HFP) have been used as the polymeric matrices for polymer electrolyte [4–7]. Besides synthetic polymers, natural biopolymers such as starch and cellulose which are abundant, renewable, and cheap constitute attractive alternatives for the development of SPE [8–10]. However, the current utilization of biopolymers in the development of SPE was not widely studied. Lopes et al. [11] reported the preparation of gel electrolyte from high amylose starch with an ionic conductivity of 5×10^{-5} S cm^{-1} at room temperature. Such level of ionic conductivity has failed to meet the requirement of various electrochemical device applications which required an ionic conductivity of 10^{-3} S cm^{-1} and above.

In this study, starch-based gel electrolyte (SbGE) in the form of flexible, conformal, and ionically conductive thin films was prepared from native sago starch powder. Native sago (*Metroxylon sagu*) starch shows similar physicochemical properties as those of cassava and sweet potato starches such as granular size, moisture content, swelling power, solubility, and gelatinization temperature [12, 13]. Being environmentally benign and cheap, optimized SbGE thin films of enhanced

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