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Reducing crystallinity on thin film based CMC/PVA hybrid polymer for application as a host in polymer electrolytes

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ABSTRACT

The carboxymethyl cellulose and polyvinyl alcohol (CMC/PVA) based hybrid polymer (HPe) system with different ratio of composition have been prepared via solution casting. The features of interaction between CMC and PVA were investigated using X-ray diffraction (XRD), and infrared (IR) spectroscopy to disclose the reduction of crystallinity of the HPe system. Morphological properties observed by Scanning electron microscopy (SEM) confirmed the homogeneity of the HPe system. Differential scanning calorimetry (DSC) result explains the miscibility of the HPe system which was confirmed by means of variations in the glass transition temperature (T_g). Two degradation mechanisms were revealed by thermogravimetric analysis (TGA) in the HPe system attributed to the decarboxylation in CMC and degradation of bond scission in PVA backbone. The blend of 80:20 compositions of CMC/PVA HPe system was found to be the optimum ratio with an increase in conductivity of CMC/PVA by one magnitude order from 10^{-7} to 10^{-6} S/cm with the lowest in crystallinity.

1. Introduction

Advancement of more efficient energy storage devices employing the polymer electrolyte (PE) has emerged as powerful platforms. PE based solid form is a key material for all-solid-state energy devices which are known as the key of many electrochemical devices [1–3]. For these reasons, numerous efforts have been considered during the development of solid polymer electrolyte including the application of petroleum-based polymer or renewable bio-polymer based. Extensive study has been focusing on the application of petroleum-based polymers which give disadvantages such as high cost, depletion of petroleum resources and trigger environmental problems.

Recently, the use of biopolymer material has raised special attention as they are abundant in nature and eco-friendlier. The growing interest in biodegradable materials has aggravated the researchers to study extensively as polymer electrolyte system. Several renewable resource of polymer are suitable to act as host polymer including chitosan [4,5], carrageenan [6–8], polylactides [9], agarose [10,11] and carboxymethyl cellulose [12] which are favorable in the preparation of polymer electrolytes. Carboxymethyl cellulose (CMC) is regarded as the most important classification of polysaccharide. CMC is a biodegradable material, low-cost material to be produced, non-toxic to environment, semi-crystalline material and exhibit excellent film forming ability but lack of strength and low in conductivity [12]. Large number of works has been reported on the application of CMC as a single polymer electrolyte system, however, due to exceptionally stiff behavior, small elongation at break (less than 8%) and trigger the problem in the electrochemical stability which is not well-suited especially in the application of electrochemical devices [13]. On top of that, the properties of single polymer may not offer outstanding physical and mechanical or chemical properties to accommodate wide range especially in energy storage device applications.

Thus, blending method, which is incorporation with other polymer, becomes an alternative method which can alter the structural and electrical properties and therefore widen their fields of application [14,15]. According to Rudzhiah et al. [6] the incorporation of CMC into carrageenan has proved that blending can manipulate the structure of the polymer and increase the conductivity via the formation of H-bonding. Blending method study has been focusing on intermolecular complexation in governing the enhancement of amorphousness and conductivity [16]. Tremendous study on hybrid polymer system has been carried out including starch/chitosan [14,17], carboxymethyl cellulose (CMC)/chitosan [18], starch/chitosan and polyvinyl alcohol (PVA)/ polyethylene oxide (PEO) [19]. Incorporation of bio-polymer

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