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Investigation on the effect of NH4Br at transport properties in k–carrageenan based biopolymer electrolytes via structural and electrical analysis

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ABSTRACT

The present work deals with the investigation on ionic conductivity and transports properties of biopolymer electrolytes (BEs) based on kappa-carrageenan (KC) by incorporating NH_4Br as polymer-salt system. The BEs was successfully prepared via solution-casting method and characterized by means of Fourier transform infrared (FTIR) spectroscopy, X-ray diffraction (XRD) and electrochemical impedance spectroscopy (EIS). It was established that the ionic conductivity for BEs system increased and achieved an optimum value of 3.89×10^{-4} S/cm for a sample containing 20 wt.% NH_4Br at ambient temperature (303 K). XRD analysis indicates that the highest ion conductivity complex exhibits optimum amorphous nature via the evaluation of the degree of crystallinity (X_c %). The conducting element in the BEs does favor the association of ion count from NH_4Br where the ionic mobility and diffusion coefficient of the transport properties were found increase parallel with the conductivity until it reaches optimum composition of BEs.

1. Introduction

The main goal in the development of energy conversion and storage such as fuel cell, solar cell, battery, sensors and super capacitors is to create good and excellent environmental friendly energy sources [1–4]. Nowadays, solid polymer electrolyte plays a vital role to replace the commonly used liquid electrolyte due to some drawbacks such as leakage and evaporation in real applications although it has advantages of higher energy density, improved safety hazards, and good processability [5,6]. Recently, most of researchers have shown an increased interest in solid polymer electrolyte study [7,8]. In particular, when considering the suitable electrolytes to be used in energy conversion and storage devices electrolytes, solid polymer electrolytes deserve to be an effective host polymer due to advantages of desirable shape mouldability, light-weight, free from leakage, mechanical strength, high physical and chemical stability and flexibility of design, thereby permitting miniaturization [9,10].

Polymer conducting electrolytes (PCEs) began with the development of solid electrolytes based on perfluorinated sulfonic acid (PFSA) in the early 1960's [11]. Subsequently, much work has been carried out on PCEs by employing different types of polymers and ionic dopants [12]. The ionic conductivity of PCEs has become the key object of academic and industrial interest as it offers significant potential in electrochemical devices.

Biopolymer based electrolytes address the shortcomings of synthetic polymers, i.e. not environmentally friendly and costly. In order to develop bio-based polymer electrolytes, the membrane or films should have good dimension, ionic conductivity, mechanical stability, as well as low cost [13]. Recently, researchers proposed many natural polymers such as cellulose and its derivative [14], starch [15], and chitosan [16], which are suitable to be used as the host in the electrolyte system.

Amongst biomaterials-based polymer, kappa-carrageenan (KC) is a class of carrageenan derivative which is a family of hydrophilic polysaccharides extracted from certain species of marine red algae [17]. Due to their desirable biocompatibility and biodegradable properties, KC is widely used in biomedical, food application and has shown its promising properties as hydrogels in the electrochemical field [18]. KC consists of one sulphate ester (OSO_3^-) group as shown in Fig. 1 which is the ideal repeating disaccharide unit. It is well known for its solid or gel form capabilities in the presence of counter-ions [19].

To date, various methods have been developed and introduced to investigate new types of polymer electrolytes with desirable ionic conductivity [20]. However, there are limited studies on proton conductors because of the difficulty in establishing the transportation of protons since it was discovered in the 1990s [21]. Commonly, the ionic conductivity of polymer electrolytes is mainly governed by two

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