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Lithium ion conducting biopolymer membrane based on K-carrageenan with $LiNO_3$

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Abstract
Energy crisis and environmental pollution are the major problems faced by all the people at present time. It is time to switch over to biopolymer electrolyte-based batteries instead of synthetic due to its high cost and not being environmentally green. Biopolymer membranes have been prepared using 1 g K-carrageenan with different molar mass percentages of $LiNO_3$ by solution casting technique using double-distilled water as a solvent. Prepared biopolymer electrolyte membranes are characterized by XRD, FTIR, DSC, and AC impedance techniques. XRD confirms the amorphous nature of the biopolymer membranes. FTIR reveals the complexation formed between 1 g K-carrageenan and $LiNO_3$. It has been found from DSC analysis that glass transition temperature of the biopolymer membrane 1 g K-carrageenan with $LiNO_3$ decreases due to the addition of salt compared to the pure biopolymer 1 g K-carrageenan. Biopolymer membrane 1 g K-carrageenan with 0.65 wt% of $LiNO_3$ has got the highest ionic conductivity of 1.89×10^{-3} S cm^{-1}. Transference number analysis has been done by Wagner's polarization method and Bruce and Vincent method. Electrochemical stability has been studied by linear sweep voltammetry. The highest conducting biopolymer membrane (1 g K-carrageenan with 0.65 wt% of $LiNO_3$) is electrochemically stable up to 3.2 V. Lithium ion conducting battery has been constructed using the highest conducting biopolymer membrane and its performance has been analyzed.

Keywords K-Carrageenan · $LiNO_3$ · Activation energy · Lithium ion conducting battery

Introduction

Lithium ion conducting polymer electrolyte has its applications in high-energy batteries, super capacitors, gas sensors, electrochromic displays, etc. The polymer electrolyte can be used as separator and electrolyte in rechargeable lithium batteries [1–4]. Ionic conductivity, electrochemical stability, and compatibility are the requirements that must be fulfilled by the polymer electrolytes to function both as separator and electrolyte [5]. Environmental hazards are there while using synthetic polymers, so an effort has to be taken in order to develop environmentally friendly bio-based cost-effective material as alternate to synthetic polymer materials. Biopolymer has specific functional groups that allow modification to alter their properties [6] and are obtained naturally through living organisms and are eventually degraded and reabsorbed in nature [7]. One of the efforts includes an extensive research on natural polymers to produce biopolymer-based electrolyte membranes. Many research works have been undertaken using biopolymers such as starch [8], cellulose [9], chitosan [10], pectin [11, 12], agar-agar [13], and K-carrageenan [14–18] due to its abundant availability, biocompatibility, renewable, and cost effective.

Carrageenan is a linear polysaccharide extracted from red edible seaweed, and it is non-toxic and biodegradable.

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