Development of quarternized-chitosan membrane for Direct Alcohol Alkaline FuelCell (DAAFC)

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Abstract

Quarternized chitosan polymer has been developed as one of membrane material for direct alcohol alkaline fuel cell (DAAFC). In this study, the quarternized-chitosan membrane was synthesized through grafting method of chitosan with glycidyl trimethyl ammonium chloride (GTMAC) and crosslinked with succinic acid (SA). Several characterization methods namely FTIR, degree of swelling in water and methanol and ion exchange capacity have been investigated. Chitosan was synthesized with GTMAC to produce HTCC (N-[2 hydroxy-3-trimethylammonium) propyl] chitosan chloride) with a ratio of 2:1 (w/w). FTIR has been used to ensure that the grafting process was successful. In addition, degree of quarternization (DQ) of 2,76 had also confirmed the result of grafting process. Crosslinking reaction of HTCC and succinic acid was performed to strengthen the molecular structure of the chitosan membrane. The membrane was then soaked in alkali solution to exchange the Cl\textsuperscript{-} ion to OH\textsuperscript{-} ion. This anion exchange membrane of chitosan has ion exchange capacity in the range of 0.943 – 0.997 meq/g depended on the ratio of succinic acid per HTCC. The quarternized chitosan membrane has a 28.26% degree of swelling at 40\textdegree{}C in water and 1.31% in methanol 80% (v/v). Therefore, it can be summarized that the quarternized chitosan membrane shows a potential candidate as solid polymer electrolyte for direct alcohol alkaline fuel cell.

Keywords: Anion exchange membrane, Alkaline fuel cell, Chitosan, GTMAC, HTCC.

Introduction

Fuel cell technologies are at the forefront of the effort towards green and sustainable energy generation. For mobile and portable applications, the emphasis has been focused on lower temperature types (< 80 °C) including direct alcohol proton exchange membrane fuel cells (DAPEMFCs) and direct alcohol alkaline fuel cells (DAAFCs). This type of devices, for example methanol feed DMFCs, is of primary interest in the field of portable devices due to ease and speed of refuelling and large volumetric energy density of liquid methanol fuel.

Most proton exchange membrane fuel cells (PEMFCs) are currently based on perfluorosulphonic acid polymers such as Nafion and Flemion, which have been extensively studied in fuel cell applications (Mauritz, 2004; Devanathan, 2008). Despite their advantages of high conductivity and good mechanical and chemical properties, certain disadvantages exist that restrict their successful use in fuel cells. These drawbacks include high cost, high methanol permeability and relative low activity when used in direct alcohol fuel cells (DAFCs) at temperatures above 80°C (Hickner, 2004).

The main drawback of current AFCs containing a liquid electrolyte (aqueous KOH solution) is their sensitivity to carbon dioxide pollution, which drastically reduces performance (Varcoe, 2005). A solution to this obstacle could be the replacement of the KOH solution by an anion conducting polymer electrolyte. On the other hand, in DAAFCs, OH\textsuperscript{-} anions are produced at the cathode and transported through the membrane to the anode where they are consumed. Due to the opposite movement of the OH\textsuperscript{-} anions through the anion exchange membrane (AEM), as compared to the transport of proton in PEM and the direction of methanol flux, an intrinsic reduction in methanol crossover is expected (Fang, 2006). All these facts imply that there is an urgent need for the development of novel AEMs that can be applied in fuel cells. Novel methods of synthesis (Summers, 2001) have also allowed the production of membrane materials and ionomers that could facilitate the development of AEMs equivalent to proton exchange membranes (PEMs). These polymeric membranes are expected to have lower cost and comparable electrochemical properties than PEMs. Ion-exchange membranes have been prepared using polysulfone, a high-performance engineering thermo-plastic material as base polymer due to its excellent workability and high mechanical strength (Hwang, 1998).

Alkaline fuel cells using alkaline anion exchange membranes (AAEMs) have several important advantages over conventional AFCs: (i) since there is no mobile cation, there is no precipitated carbonate, (ii) no electrolyte weeping, (iii) reduced...