Polymer Materials for Polymer Electrolyte Fuel Cells: Sulfonated Poly(ether sulfone)s for Fuel Cell Membranes

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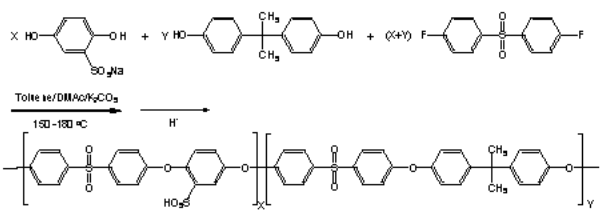
Introduction

Membrane electrode assembly (MEA) is one of the most important parts in PEFCs. Among several components for the MEA, membrane is a key element and determines the performance of the fuel cell. At the moment, Nafion type perfluorosulfonated polymers have been used because of their high proton conductivity and excellent chemical inertness. However, they have some problems such as high liquid fuel permeability, low proton conductivity at high temperature under low humidity and high manufacturing cost [1,2]. These are the drawback for commercialization of fuel cell membranes.

Recently, numerous researchers have synthesized several different kinds of hydrocarbon-based sulfonated polymers for a fuel cell membrane to overcome the problems of the perfluorosulfonated polymers. Hydrocarbon-based sulfonated polymers are very promising for fuel cell membranes because they can be synthesized relatively easily and inexpensively. Sulfonated poly(ether sulfone)s [3,4,5], sulfonated PEEKs [6,7], sulfonated polyimides [8,9,10], sulfoalkylated polysulfones [11], sulfonated polyphthalazines [12,13] and sulfonated polybenzimidazoles [14,15] were prepared for fuel cell membranes. Also, several sulfonated polymers were tested for PEMFC [16-19] and DMFC [20-23] operations.

In the report, we present the possibility of the hydrocarbon-based sulfonated polymers for versatile PEFC applications. A lot of sulfonated polymers have been synthesized and characterized for a fuel cell membrane. However, none of them have been successfully demonstrated for different kinds of polymer electrolyte fuel cell systems. We report PEMFC, DMFC and DFAFC performances of the sulfonated poly(ether sulfone) membrane. Even though the cell performances of the sulfonated polymer are lower than those of commercially available Nafion, the polymer was a good candidate for universal PEFC operations.

Experimental



Scheme 1. Synthesis of sulfonated poly(ether sulfone) copolymer

Results and discussion

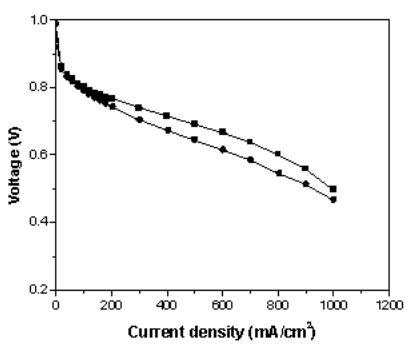


Fig. 1. Polarization curves for MEAs using PES 60 (●) and Nafion 112 (■) with the H_2/air (65-70% relative humidity) at 70 °C under ambient pressure. Flow rate: 400 mL/min (anode), 1000 mL/min (cathode).

Conclusions

Sulfonated poly(ether sulfone) membrane was used for three different kinds of polymer electrolyte fuel cells (PEMFC, DMFC and DFAFC). It generated 730 mA/cm^2 at 0.60 V for PEMFC operation with H_2 and air. Also, the sulfonated membrane was used for DMFC and DFAFC operation under different operation temperature, feed concentration and humidification conditions. The cell performance improved as temperature increased and feed concentration lowered. We believe that the sulfonated poly(ether sulfone) is one of the best candidate for a fuel cell membrane.

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