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 PEMFC. Among several components for the MEA, membrane is a key element and determines the performance of the fuel cell. At the moment, Naion-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 drawbacks 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 PEIs [6,7], sulfonated polyimides [8,9,10], sulfonated polyarylates [11], sulfonated polyphenylenes [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[20-25] operation.

In the report, we present the possibility of the hydrocarbon-based sulfonated polymers for various PEMFC 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 PFPE performance of the sulfonated poly(ether sulfone) membrane. Even though the cell performance of the sulfonated polymer is lower than that of commercial available Naion, the polymer was a good candidate for universal PEMFC operation.

Experimental

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

Results and discussion

Fig. 1. Polarization curves for MEAs using FES 60 (●) and Naion 112 (▲) with the E/h of 0.71% relative humidity at 80 °C under ambient pressure. Flow rate: 400 mL/min (anode), 1000 mL/min (cathode).

Conclusions
Sulfonated poly(ether sulfone) membrane was used for three kinds of polymer electrolyte fuel cells (PEMFC, DMFC and DPAFC). It generated 730 mA/cm² at 0.6 V for PEMFC operation with 35% and 13% relative humidity. The sulfonated membrane was used for DMFC and DPAFC operation under different operating temperature, fuel concentration and humidification conditions. The cell performance improved as temperature increased and fuel concentration lowered.

We believe that the sulfonated poly(ether sulfone) membrane is one of the best candidates for a fuel cell membrane.

References