Small-angle X-ray scattering studies on Composite Nafion membranes

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INTRODUCTION

High temperature (130-140°C) operation of polymer electrolyte membrane fuel cells is desired to enhance the level of CO tolerance to above 100 ppm in reformed fuels. In the state-of- the-art PEMFCs, operating at 80ºC, the CO tolerance level with a Pt electrocatalyst is only around 10 ppm. Composite membranes with zirconium hydrogen phosphate, silicon oxide, or metal oxides incorporated into Nafion perform better than the pure Nafion membranes at these elevated temperatures. The composite membranes at 130°C yield current-potential profiles that are superior to that observed using a fuel cell with pure Nafion at 80°C (1). The objective of this study is to investigate how the presence of these inorganic materials affects the morphology of the membrane.

Small angle x-ray scattering (SAXS) was used to examine the structure of Nafion membranes with different loadings of zirconium hydrogen phosphate, silicon oxide, and titanium oxide. Nafion undergoes a reorganization in structure upon hydration resulting in fewer, larger ionic clusters (2). During the SAXS experiment, the pure Nafion and composite samples were hydrated to determine how the structures of the composite membranes changed with increasing water content.

EXPERIMENTAL

Composite membrane samples were prepared as described in previous publications (1,3). The X-ray are generated by a Cu K-α source (Philips XRG-3000), slit collimated and the scattering was detected by a Kratky multichannel detector. The intensity is measured as a function of scattering angle/distance. The Bragg spacing is the distance at which the maximum intensity occurs.

RESULTS

In all cases, it was found that the Bragg spacing increased with increasing water content (Fig. 1). For a given water content, the Bragg spacing was lower for the composite membranes than for the control membrane. This indicates that the presence of the inorganic compound may inhibit the agglomeration of the ionic clusters to the extent that occurs in pure Nafion. However, for the same weight percentage loadings of titanium and silicon oxide, the silicon oxide membrane has a larger Bragg spacing for a given water content. Further experiments are in progress examining the effects of inorganic particle size and surface properties effect the behavior of the composite membranes during water uptake.

This SAXS study provides information on the structural changes of the membrane during the uptake of water in the presence of certain inorganic materials. It is very possible that a decreased Bragg spacing can enhance the conductivity of the membrane and enhance fuel cell performance.

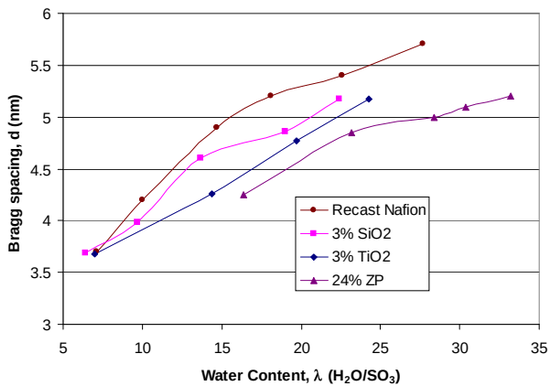

Figure 1. Comparison of Bragg spacing of composite membranes with pure Nafion at different

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