

Nafion/Polypyrrole Composite Polymer Electrolytes for Use in Direct Methanol Fuel Cells

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Introduction

Significant commercial advances of direct methanol fuel cells (DMFCs) continue to be hampered by several issues involving the use of proton exchange membranes (PEM). Reduced methanol efficiencies and catalyst poisoning occur as a result of the high methanol permeability of commercially available Nafion, a perfluorosulfonate polymer and the current mark for PEM performance in DMFC applications. The composite approach has recently been used to obtain reduced methanol permeability of the Nafion membrane while maintaining high power density.¹ Yang et al. have introduced zirconium phosphate into Nafion by the ion exchange of Zr^{4+} followed by precipitation of zirconium phosphate by treatment with phosphoric acid. The retention of high ionic conductivity is proposed to arise from the high water content of the Nafion/zirconium phosphate composite.

Previously, we have reported the preparation of a composite PEM utilizing Nafion and a conjugated polymer.² The Nafion/poly(1-methylpyrrole) composite was prepared by the *in situ* polymerization of 1-methylpyrrole in Nafion. Preliminary results demonstrate a reduction in methanol crossover by as much as 50% without significant increase in the resistance of the Nafion/poly(1-methylpyrrole) composite PEM. The mechanism by which the Nafion/poly(1-methylpyrrole) composite restricts methanol transport has not been fully determined. A simple clogging of the pores would reduce the volume available for solvent transport. This explanation necessitates a static, rigid structure of the Nafion framework, a distinct possibility with the availability of electrostatic crosslinking afforded by the oxidized conjugated polymer. Further characterization is necessary in order to provide a definitive explanation.

Results

We will present results describing an analogous Nafion/polypyrrole composite PEM. The switch to the polypyrrole composite system allows for the investigation of a larger range of loading levels of polypyrrole into the Nafion membrane due to the relative ease of polymerization of pyrrole compared to 1-methylpyrrole. The composite membrane systems were obtained by the *in situ* polymerization of pyrrole in the Nafion membrane with the addition of an oxidizing agent, either Fe^{3+} or H_2O_2 . A significant reduction in methanol crossover combined with minimal increase in resistance is obtained for Nafion/polypyrrole composites as measured by steady-state voltammetry. While complete characterization of the Nafion/polypyrrole composite in terms of the extent of loading and location of polypyrrole remains challenging, investigations in several areas can

shed light on the morphology of this system in order to elucidate structure/property relations to aid in the future design of PEMs. Details of these investigations will be presented.

Acknowledgments

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References

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