Metal Oxide/Zeolite Nafion Composite Membranes for PEMFC Operation above 100^{o}C

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High temperature proton-exchange membrane fuel cells (PEMFCs) are being investigated to alleviate some of the problems encountered at the present temperature of 80^{o}C. These difficulties include CO poisoning of the platinum electrodes, and thermal and water management. The proton conductivity of Nafion relies on water, and at higher temperatures the conductivity dramatically decreases due its loss by evaporation. Therefore, in order to maintain desirable proton conductivity at elevated temperatures, one possible approach is to modify Nafion from its original form. This was previously accomplished by incorporating silicon oxide via sol-gel within the Nafion membrane.[1] The purpose of this study is to investigate composite Nafion membranes for operation in PEMFCs at temperatures above 100^{o}C. This was accomplished by incorporating various metal oxide and zeolite particles into the Nafion membrane using a recasting procedure that employs solubilized Nafion.[2] The particles varied in particle size, surface area, chemical makeup and surface chemistry.

Results and Discussion - Shown in figure 1 are the PEMFC polarization curves obtained when silica, alumina or titania are incorporated in the Nafion membrane at a cell temperature of 130^{o}C and a total pressure of 3 atm. All three metal oxides have the same particle size and surface area. Silica clearly provides the best response. This can be quantified by considering the liner portion of the polarization curve, which reflects the cell resistivity. (Reported as R values in figures 1 and 2)

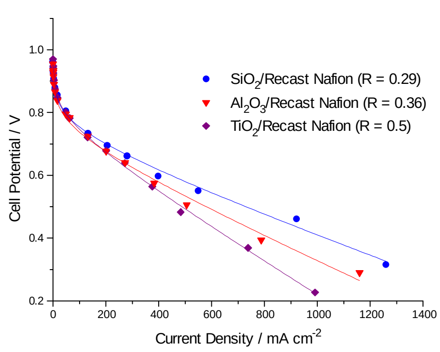

Figure 1: PEMFC performance of silica, alumina and titania Recast Nafion membranes at 130^{o}C and 3 atm.

This variation in PEMFC performance can be attributed to the differences of metal oxide composition and the nature of the Nafion –metal oxide interface.

Figure 2 shows the polarization curve for three different silicas all with the same particle size and surface chemistry, but with different surface areas.

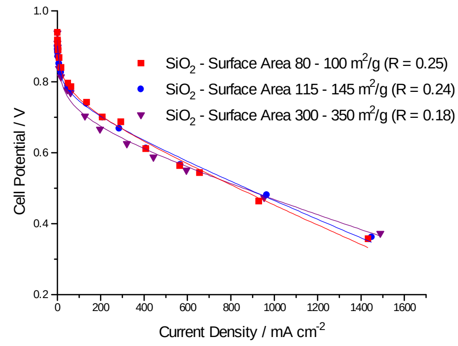

Figure 2: PEMFC performance of silica with different surface areas Recast Nafion membranes at 130^{o}C and 3 atm.

Here we see that with increasing surface area, the resistances of the cells decrease (see R values in figure 2). This can be attributed to the increased number of sites the water molecules can form hydrogen bonds with.

Conclusions – The characteristics of PEMFC can be improved by increasing it operating temperature above 100^{o}C. Composite membranes prepared by suspending metal oxide or zeolite particles in Nafion solution show improved PEMFC performance at elevated temperatures. The particles size, surface area, chemical makeup and surface chemistry all play vital roles in its ability to improve water retention, thereby improving high temperature PEMFC operation. In all four cases of the silicas shown here, current densities are high enough to manufacture a high temperature PEMFC with the added benefits of increased CO tolerance and improved water and heat management.

References:

1. K. T. Adjemian, S. J. Lee, S. Srinivasan, J. Benziger, and A. B. Bocarsly, *Journal of the Electrochemical Society* In press 2002.
2. P. L. Antonucci, A. S. Arico, P. Creti, E. Ramunni, and V. Antonucci, *Solid State Ionics* 125 431-437, 1999.

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