CONDUCTIVITY OF PBI MEMBRANES FOR HIGH TEMPERATURE POLYMER ELECTROLYTE FUEL CELLS

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Introduction

The current generation of proton exchange membrane fuel cell (PEMFC) technology uses Nafion®, a polymer electrolyte that is limited to a design operating temperature of 80°C and requires water management to keep the membrane moist for suitable electrochemical conductivity. The relatively low operating temperature poses limitations on energy efficiency, the usefulness of rejected heat, and, more important, tolerance for catalyst poisoning where carbon monoxide is present in the fuel.

The phosphoric acid doped polybenzimidazole (PBI) membrane has been proposed for high temperature PEMFC. The advantages of PBI and PBI-like polymers include: (1) Good protonic conductivity at elevated temperature; (2) Near zero electro-osmotic drag, which means that the proton transports through these membranes do not involve water transport, (3) Low gas permeability, and (4) Low methanol crossover [1]. In addition, acid doped PBI membrane exhibits excellent oxidative and thermal stability and mechanical flexibility at elevated temperature (200°C).

The object of the present study has been to study in detail the factors related to the conductivity of the acid doped PBI membrane at elevated temperature.

Experimental

The polymer films were cast from a solution of PBI in trifluoroacetic acid (TFA), doped with phosphoric acid with different doping levels.

Conductivity measurements were made using the four-probe technique [2,3]. The four-electrode apparatus consisted of a longitudinal geometry in which two grafoil electrodes were used to apply current to the ends of a long, narrow (3cm by 0.6cm) sample. Two platinum probe wires spaced 1 cm apart were used to measure the voltage drop along the film near the center of the sample. AC impedance measurements between 1Hz and 100kHz were made using an either Solartron 1287/1260 or 1280 potentiostat/frequency response analyzer with Zplot software.

The conductivity of acid doped PBI were measured for different doping levels, under conditions of low relative humidity (5-30%) and elevated temperature (100-200°C).

Results and Discussion

The conductivity of acid doped PBI film is known to vary with relative humidity (R.H.), temperature, and acid doping level [3].

In Fig. 1 and 3, the variation in conductivity with R.H. at constant temperature and doping level (420% and 558%) is shown. The conductivity increases with increasing R.H., and increases more steeply at higher temperatures.

Fig.2 shows that the conductivity increases with temperature at constant R.H. and doping level (420%).

Comparing fig.2 and fig.3, it can be seen that the conductivity of PBI films increases with increasing phosphoric acid doping level for a given temperature and relative humidity.

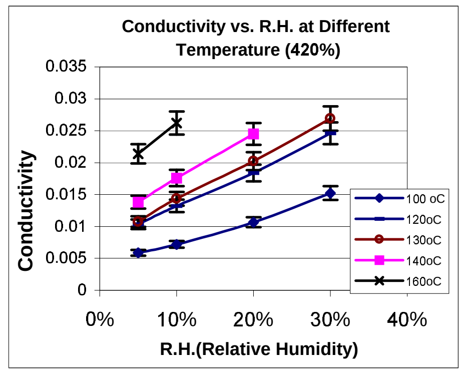

Fig.1 conductivity vs. R.H. at different temperature of 420% acid doping level PBI

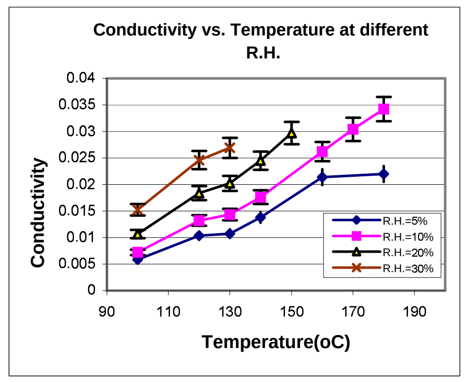

Fig.2 conductivity vs. temperature at different R.H. of 420% acid doping level PBI

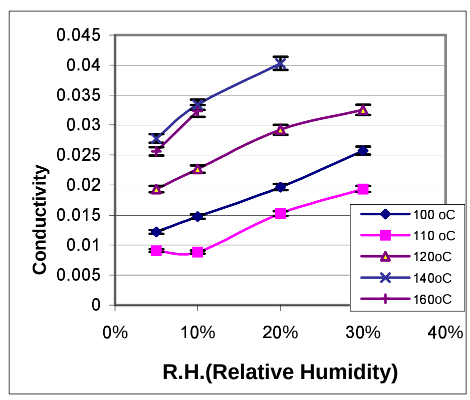

Fig.3 conductivity vs. R.H. at different temperature of 558% acid doping level PBI

Conclusions

The conductivity of phosphoric acid doped PBI films increases with increasing temperature, relative humidity, and doping level. This poster will present a discussion and interpretation of these and other conductivity measurements Additional analysis will be presented to elucidate the mechanism and activation energies for proton conduction.

Acknowledgement

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References:

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