The Effect of Internal Air Bleed in a Proton Exchange Membrane Fuel Cell

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Introduction

A Pt-alloy catalyst is used as the anode catalyst in a PEMFC when the fuel gas is a reformed mixture that contains CO. In order to combat CO poisoning, Gottesfeld and Pafford[1] first proposed to inject pure oxygen into the anode fuel gas stream. Schmidt *et al.* [2] described another method using an oxygen-evolving compound, H_2O_2, in the humidification bottle. For the oxidation of CO by O_2, O_2 must first adsorb on Pt, so it can react with CO[3]. It is known that the dissociation energy of O_2 is very large and thus only 1 of 400 oxygen molecules can oxidize CO to CO_2 in an air or oxygen bleeding technique[4]. For relatively thin MEAs, the rates of hydrogen and oxygen crossover may influence the fuel cell reactions occurring on anode and cathode sides and subsequently the cell performance of the whole fuel cell. The diffused oxygen (also known as internal air bleed) was quantified with a model that includes O_2 solubility and heterogeneous oxidation constants.

Experimental

The fuel cell used in the experiment was 25-cm^2 single cell with a triple serpentine flow field. Multiple MEAs were used in the experiments. They were reproducible to within ±5 mV at a given current and they consisted of a 0.45 mg/cm^2 Pt-Ru (1:1) on the carbon anode and a 0.4 mg/cm^2 Pt on the carbon cathode deposited onto either a 5 or 25 μm Gore Select® membrane. The thickness of the anode or the cathode coating was about 12.5 μm. CARBEL™ CL Gas Diffusion Media (GDM) was used and compressible gaskets (0.25 mm) were inserted between flow field plates and the MEA to prevent fuel gases from leaking.

The gas flow rates, humidification bottle temperature were controlled with a test station. The cell temperature was 70°C. The gases of anode and cathode were humidified by passing the gas through deionized water and the correlation of dew points and humidification temperatures were measured as described in Ref. 5. For the 25 μm MEA, the humidification temperatures were 85°C and 75°C, respectively. The humidification temperatures for the 5 μm MEA were 75°C and 65°C for anode and cathode respectively, corresponding to dew points of 70°C and 60°C. The stoichiometry for the normal fuel cell operation was 1.2 for anode (dry H_2 base) and 2.0 for cathode. In this work, each new MEA was subjected to a constant-voltage three-step 70-hour break-in before the MEA was used in the experiments.

Results and Discussion

A model with internal air bleed term is proposed which can explain the observed effects of cathode backpressure and membrane thickness. The model results agree with the experimental data and show that only a fraction of the O_2 from the internal air bleed contributes to oxidizing the CO adsorbed on the anode. The internal air bleed needs to be included in the modeling of overall fuel cell performance when CO/H_2 system is used as the anode fuel gas, especially when the CO concentration is very low and the membrane is thin.

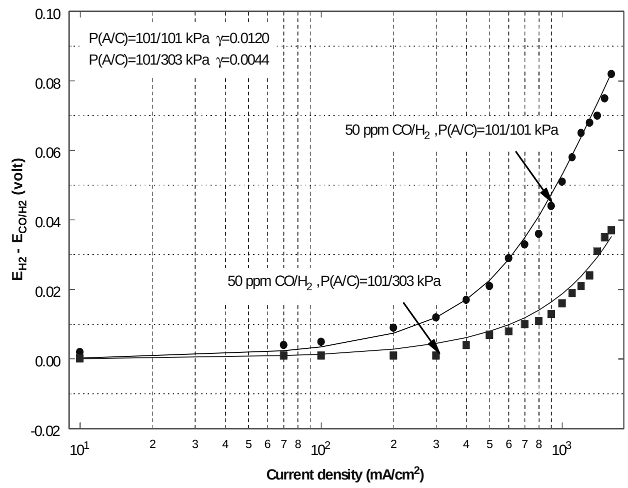

Figure 1. Comparison of anode overpotential between the model prediction and experimental data for 5 μm MEA with 50 ppm CO/H_2 (T_{cell}=70°C, T_H(A/C)=75/65°C, Stoic.(A/C)=1.2/2.0) Line: model, Symbols: experimental

References

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