Direct Methanol Fuel Cell Experimental and Model Validation Study

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Although direct methanol fuel cells (DMFCs) show promise for future power generation applications due to simplicity of design and other factors, much more detailed data are required for a more complete understanding of the effects of various parameters such as pressure, flow rate, and temperature on two-phase mass transport, and current density distribution.

In this investigation, a transparent, highly instrumented, 50cm^2 direct methanol fuel cell was utilized. A close-up picture of the windowed stainless steel fuel cell with adjustable (parallel or serpentine) flow channel configuration is shown in Fig. 1. The fuel cell assembly includes discrete locations for measurement of chemical species and current density as a function of location on both anode and cathode sides of the fuel cell.

A two phase full-cell model has been developed by the Penn State Electrochemical Engine Center (ECEC) to simulate DMFC behavior, and detailed experimental data including species distributions in both the anode and cathode have been taken to provide more complete model validation and provide insight and direction into water management and methanol crossover phenomena. Fourier transform infrared (FTIR) spectroscopy is used to determine the species distributions of water vapor, methanol, carbon dioxide, and other minor species in the anode and cathode flows as a function of location along the flow path within the fuel cell. Comparison of numerically predicted results with experimental data is discussed. Fig. 2 shows results from FTIR spectroscopy, showing increasing water vapor distribution with distance along the flow path, taken from a cathode during operation at 0.12 A/cm^2 and 70°C. Direct experimental evidence of the location of the onset of flooding within the cathode is obtained using this method. The detailed data taken, coupled with advanced model development and validation from this investigation should benefit modeling and scale-up efforts in this area, especially in terms of water management.

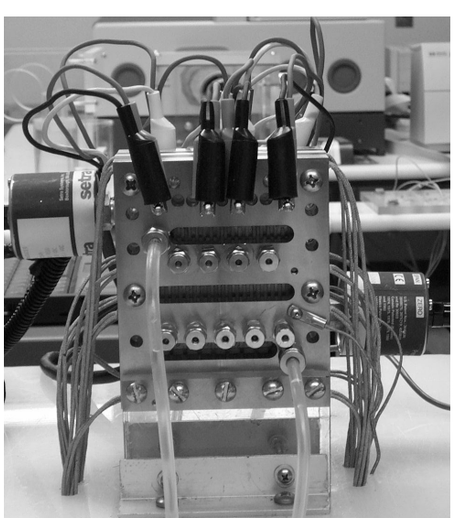

Figure 1. Close-up view of the anode side of the stainless steel, windowed 50cm^2 DMFC.

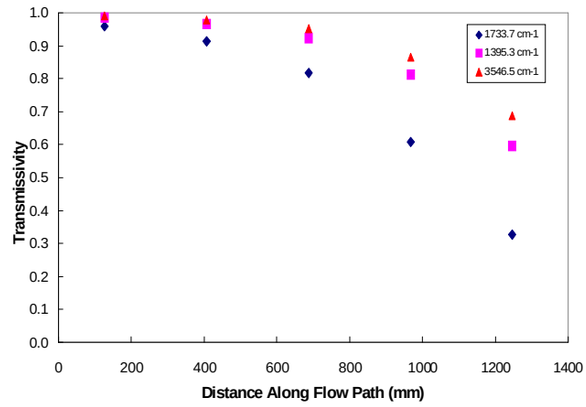

Fig. 2 Results of FTIR spectroscopy showing increasing water vapor distribution with distance along the cathode flow path. Taken from discrete locations within the DMFC during operation at 0.12 A/cm^2 and 70°C