

Integrity and Interfaces of Membrane and Electrodes Assembly: Influence on Polymer Electrolyte Fuel Cell performance

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Beyond the activity of the electrocatalyst, the overall performance of the polymer electrolyte fuel cell (PMFC) strongly depends on the integrity of the membrane-electrode assembly (MEA). The usual MEA has four interfaces between the gas diffusion and active catalytic layers of the two electrodes and the electrolyte. Depending on the method of fabrication, some interfaces are formed by simple mechanical contact between separated parts, which may be treated as typical touching interfaces. Others are formed by bonded contact, and may be treated as integrated interfaces. There are two generally-used MEA structures, which may be schematically considered as:

CGDL//CAL//M//AAL//AGDL,
and

CGDL/CAL//M//AAL/AGDL

where CGDL and AGDL are the cathode and anode gas diffusion layers, CAL and AAL are the cathode and anode active layers, M is proton exchange membrane. IF is a mechanical contact interface, and IIF is an integrated or bonded interface. From the overall integrity viewpoint, the Type I MEA is obviously preferable, while the Type II MEA is easier, faster and cheaper to produce. The aim of this work was to investigate both types of MEA and determine how PMFC performance may be influenced by the integrity of, and the type and placement of, interfaces into MEA.

Two-layer gas diffusion electrodes with active and backing (diffusion) layers were fabricated by the method described earlier [1]. Active layers were prepared from an ultrasonically-agitated dispersion (ink) containing a carbon black supported platinum electrocatalyst and 5 wt % Nafion™ solution [2]. The platinum loading used was 0.2 mg/cm² Pt (cathode) and 0.05 mg/cm² (anode). MEAs of Type I were prepared by depositing the ink for the active layer onto gas diffusion layers to form the integrated electrodes, which were then hot-pressed onto each side of a Nafion™ 112 membrane. Type II MEAs were prepared by depositing the active layer ink onto both sides of the membrane, which was then placed into mechanical contact with the gas diffusion layers in the 50 cm² active area test cells used in all experiments.

Steady-state potential-current density curves were obtained at 50°C at atmospheric pressure on hydrogen humidified to 60°C and air and oxygen humidified to 55°C. The results shown in Figure 1 demonstrate that the cell performance depends strongly on the type of interface between air or oxygen cathode and its gas diffusion layer. The lower performance of Type II MEAs may be explained by the formation of thin film of liquid water at the interface, which impedes oxygen diffusion to the electrochemical reaction zone of the active layer.

References:

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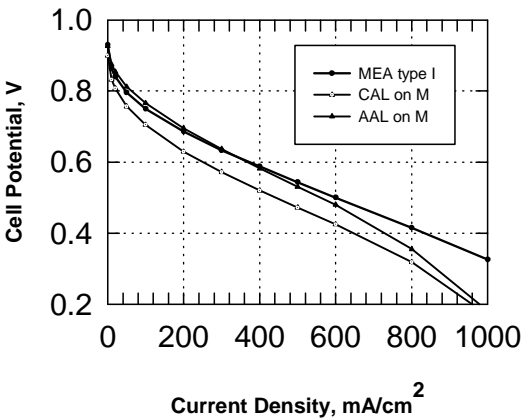


Figure 1. Potential vs. current density for hydrogen-air cell with different MEAs