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Dual-Layer Microporous Layer of Gas Diffusion Layer for Proton Exchange Membrane Fuel Cells under Various RH Conditions

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Abstract : Energy usage has been increased throughout the years, leading to severe environmental impacts. Since the majority of the energy is currently produced from fossil fuels, there is a global need for clean energy solutions. Proton Exchange Membrane Fuel Cells (PEMFCs) offer a very promising solution for transportation applications because of their solid configuration and low temperature operations, which allows them to start quickly. One of the main components of PEMFCs is the Gas Diffusion Layer (GDL), which manages water and gas transport and shows direct influence on the fuel cell performance. In this work, a novel dual-layer GDL with gradient porosity was prepared, using polyethylene glycol (PEG) as pore former, to improve the gas diffusion and water management in the system. The microporous layer (MPL) of the fabricated GDL consists of carbon powder PUREBLACK, sodium dodecyl sulfate as a surfactant, 34% wt. PTFE and the gradient porosity was created by applying one layer using 30% wt. PEG on the carbon substrate, followed by a second layer without using any pore former. The total carbon loading of the microporous layer is ~ 3 mg.cm-2. For the assembly of the catalyst layer, Nafion membrane (Ion Power, Nafion Membrane NR211) and Pt/C electrocatalyst (46.1% wt.) were used. The catalyst ink was deposited on the membrane via microspraying technique. The Pt loading is ~ 0.4 mg.cm-2, and the active area is 5 cm2. The sample was ex-situ characterized via wetting angle measurement, Scanning Electron Microscopy (SEM), and Pore Size Distribution (PSD) to evaluate its characteristics. Furthermore, for the performance evaluation in-situ characterization via Fuel Cell Testing using H2/O2 and H2/air as reactants, under 50, 60, 80, and 100% relative humidity (RH), took place. The results were compared to a single layer GDL, fabricated with the same carbon powder and loading as the dual layer GDL, and a commercially available GDL with MPL (AvCarb2120). The findings reveal high hydrophobic properties of the microporous layer of the GDL for both PUREBLACK based samples, while the commercial GDL demonstrates hydrophilic behavior. The dual layer GDL shows high and stable fuel cell performance under all the RH conditions, whereas the single layer manifests a drop in performance at high RH in both oxygen and air, caused by catalyst flooding. The commercial GDL shows very low and unstable performance, possibly because of its hydrophilic character and thinner microporous layer. In conclusion, the dual layer GDL with PEG appears to have improved gas diffusion and water management in the fuel cell system. Due to its increasing porosity from the catalyst layer to the carbon substrate, it allows easier access of the reactant gases from the flow channels to the catalyst layer, and more efficient water removal from the catalyst layer, leading to higher performance and stability.

Keywords : gas diffusion layer, microporous layer, proton exchange membrane fuel cells, relative humidity
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