Mechanical Engineering Thesis Defense

Development of gas diffusion layers to improve the lower and higher relative humidity performance of the proton exchange membrane fuel cells

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Abstract

Gas Diffusion layers based on PUREBLACK® carbon and Vulcan(XC72R) carbon along with catalyst coated membranes were used to fabricate the membrane electrode assemblies for use in proton exchange membrane fuel cells (PEMFCs). Polyethylene glycol was used as the pore-forming agent on the microporous layer to improve the lower and higher relative humidity performance of the fuel cells. Accelerated stress tests based on the dissolution effect of GDLs were conducted and the long-term performance of the GDLs was evaluated. A single-cell fuel cell was used to evaluate the effect of porosity of the micro-porous layer and the effect of different types of carbon powder on the performance of the fuel cell at different operating relative humidity conditions and compared with commercial GDLs.Both PUREBLACK® and Vulcan(XC72R) based GDLs show crack-free surface morphology in the Scanning electron microscopy and hydrophobic characteristics in the contact angle measurements. The fuel cell performance is evaluated under relative humidity conditions of 60 and 100 % using H2/O2 and H2/Air at 70 °C and the durability is also evaluated for the sample with and without 30% PEG for both carbons. The pristine PUREBLACK® based GDL sample with 30% pore-forming agent (total pore volume of 1.72 cc.g-1) demonstrated the highest performance (peak power densities of 432 and 444 mW.cm-2 at 100 and 60 % RH respectively, using H2/Air). There was a significant increase in the macropores when GDLs are aged in H2O2 and the contact angle dropped to about 14 and 95° for Pureblack and Vulcan carbon, respectively. Overall Pureblack based GDLs performed the best after ageing both in H2O2 and H2O (average performance degradation of 8% in H2O2 and 8.25% in H2O).

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