Methods for Manufacturing Diffusion Layers for PEMFCs

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Proton exchange membrane fuel cells (PEMFCs) require that the anode and cathode catalyst layers have electronic contact with current collectors that allow ready access of the fuel and oxidant, respectively, to the catalyst surfaces. These current collectors are called gas diffusion layers and are critical components in achieving high performance in PEMFCs. The requirements of an ideal gas diffusion layer are several, including diffusing the gaseous reactant effectively into the catalyst layer and assisting in water management by allowing passage of water into or out of the electrode without flooding with liquid water [1].

Resistance to flow is measured using a parameter called Gurley number, which is the volume flow rate of air at a fixed pressure difference through a fixed area of sample, and thus indicates the resistance to gas flow. Measured Gurley numbers here are reported in L/min/cm-water/cm^2. A Gurley device was built to measure this number, which can be correlated with diffusion layer performance in the PEMFC. A direct correlation would not be expected because the Gurley number involves viscous flow, while the diffusion layer performance is more dependent on diffusion [2]. An empirical correlation has been developed by University of Connecticut.

There are commercial gas diffusion layers available for fuel cell researches. However, the Gurley numbers of those commercial ones (Shown in Table1) are in the marginal values that put the performance of the PEMFC to its diffusion limit due to low reactant gas permeability. They also have a large variation in thickness, and homogeneity of the gas flow resistance within plane, which interfere with other variables studied in PEMFC research. Manufactured gas diffusion layers are necessary for PEMFC research to exclude the diffusion limit of the gas diffusion layers from the PEMFC performance. The criteria of a good method for manufacturing gas diffusion layers were selected to be a high resulting Gurley number, high concentration of macro-cracks for water management, high uniformity of thickness, and the ease of scaling-up with the process for a large-size fuel cell research in the future.

A blend of carbon powder (Vulcan XC-72) and polytetrafluoroethylene (PTFE-30, Dupont) are dispersed and coated on a carbon paper (Toray TGPH-120) to form a hydrophobic layer. Three methods are considered in applying this carbon-PTFE blend onto the carbon paper: spraying, vacuum-filtration, and silk-screening. Gurley numbers obtained from different methods are reported in Table 1, compared with those of some available commercial gas diffusion layers.

According to the data reported in Table 1, Gurley numbers are the highest for the spraying method, the second highest for the vacuum-filtration method, and the lowest for the silk-screening method at the same carbon loading (defined as carbon and PTFE weight per area of gas diffusion layers). However, the spraying method has some drawbacks including its low reproducibility, its difficulty in scaling-up, and the lack of macro-cracks shown on SEM pictures of the surface. The vacuum-filtration method is also difficult to scale-up and generates excessive roughness from observed mud-cracks on the surface. Considering all factors, the silk-screening method is superior to other methods due to its high reproducibility, its Gurley number of four times higher than that of commercial gas-diffusion layers, its desired macro-cracks, and its ease of scaling-up.

Optical microscopy pictures and SEM pictures of different gas diffusion layers will be discussed. Performance gain on PEMFC was also witnessed from using silk-screened gas diffusion layers with higher Gurley numbers, compared to commercial gas diffusion layers with low Gurley numbers.

Table1. Gurley number of different gas diffusion layers

Gas Diffusion Layers	Gurley Number L/min/cm-water/cm^2
Spraying, 1.5 mg/cm^2	0.50
Vacuum-filtration 1.5 mg/cm^2	0.25
Silk-screening 1.5 mg/cm^2	0.16
Commercial ETEK carbon cloth, V.2.20	0.04
Commercial ETEK Carbon cloth, V. 3.1	0.02

References

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