Preparation and electrochemical characterizations of electrodes with different shapes for low Pt loading

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Proton exchange membrane fuel cells (PEMFCs) are of importance for alternative power sources due to their high efficiencies and ability to operate without greenhouse gas emissions. One of main issues to commercialize PEMFCs is to reduce cost and to increase durability. Among main components of PEMFCs, membrane-electrode assemblies (MEAs) are most costly due to the utilization of noble metals such as most often platinum or platinum based alloys. To reduce the cost of MEAs, there are two options: i) to use non-noble metals or ii) to reduce the amount of the noble metals.

A method of using inkjet printing (IJP) to deposit catalyst materials onto a sheet of gas diffusion layer (GDL) or proton exchange membrane (PEM) is used to make MEAs. Much attention has been devoted to reduce the amount of platinum in electrodes of MEAs with a minimum loss in MEA performance. The IJP with peculator precision provided good 3-D catalyst layers.

In this study, we investigated characterization of inks for preparation of MEAs using IJP. Catalyst solutions for printing were prepared by thoroughly mixing a carbon-supported catalyst (Vulcan XC-72R, 40wt%, Hi-spec 4000, Johnson Matthey) as an electrocatalyst with Nafion™ solution (EW1100, Dupont) as an ionomer binder and Milli-Q grade de-ionized water with a magnetic stir. The mixtures were sonicated and were shook with an orbital mixer (Thinky Mixer), and ball miller. Commercial desktop inkjet printers were used to deposit the active catalyst electrode layer directly from print cartridges onto Nafion® polymer membranes in the hydrogen form. For IJP, the ink cartridges were opened, cleaned of the original ink and filled with a catalyst ink using a syringe.

We fabricated two MEAs of different shapes (square shape, channel shape) by inkjet method. Their performance, impedance data and cyclic voltammetry were measured and compared with fabricated of the membrane-electrode assembly by spray method. When tested in our experimental apparatus, open circuit voltages up to 0.91V and power densities of up to 336mWcm−2 were obtained with a catalyst loading of 0.20 mg Pt cm−2.

The objective of this work was to demonstrate some of the processing advantages of drop-on-demand technology for fabrication of MEAs. It remains to be determined if inkjet fabrication offers performance advantages or leads to more efficient utilization of expensive catalyst materials.

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