Development of durable electrocatalysts for PEFC by controlling nanostructure of carbon supports

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Polymer electrolyte fuel cells (PEFCs) are attractive power devices for both stationary and automobile application. Nevertheless, there are still important issues to overcome for further commercialization of PEFCs. One of major problems is low durability of electrocatalysts. Electrocatalysts are generally composed of Pt nanoparticles dispersed on carbon supports. Two factors, unnecessary mobility of Pt nanoparticles and oxidation of carbon supports, result in degradation of PEFCs for the long time use. We are approaching these problems from nanostructural designing of electrocatalysts. Particularly, controlling carbon nanostructure has been focused on in order to improve the durability. For evaluation of our new catalysts, protocols recommended by Fuel Cell Commercialization of Japan (FCCJ)[1] are in use.

In our study, two separate methods are applied to overcome degradation problems. The first method is derived from encapsulation of Pt nanoparticles inside the carbon nano-space (Fig. 1)[2]. Mesoporous carbon, composed by the nano-channel structure, was developed in our lab. Nano-space, whose diameter was about 10 nm, was treated as a reaction site for electrochemical reactions. Since mobility of Pt nanoparticles dispersed on carbon was suppressed by encapsulation, the durability of electrocatalysts was improved. We also developed MEAs with this catalyst. Even though the condition to make MEAs should be further optimized, reasonably good current-voltage characteristics were so far obtained.

The second approach is graphitization of carbon surface through the heat treatment (Fig. 2)[3]. Since oxidation of carbon is suppressed when crystalline characteristics is high especially on the carbon surface, conditions of heat treatment leading to high durability have been evaluated within the range up to 2000 °C, by using commercially available carbon materials. Although higher temperature resulted in higher graphitization degree, the resulting smooth surface of graphitized carbon rather increased mobility of Pt nanoparticles. Therefore, an optimum heat treatment condition should be selected. In our 3-hour heating condition, graphitization at 1600 °C brought out the highest durability of electrocatalysts. Furthermore, structural change of electrocatalysts upon the potential cycling was evaluated by TEM in detail. Also, MEAs with these improved electrocatalysts was developed.

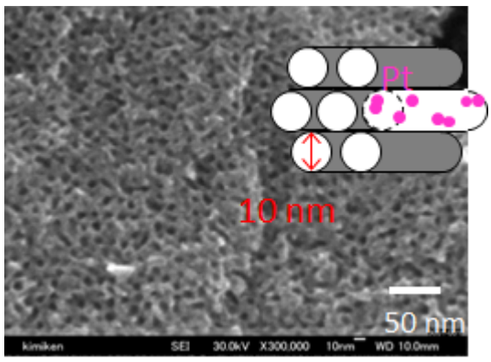

Figure 1. A SEM image of electrocatalysts with encapsulation of Pt inside the nano-space.

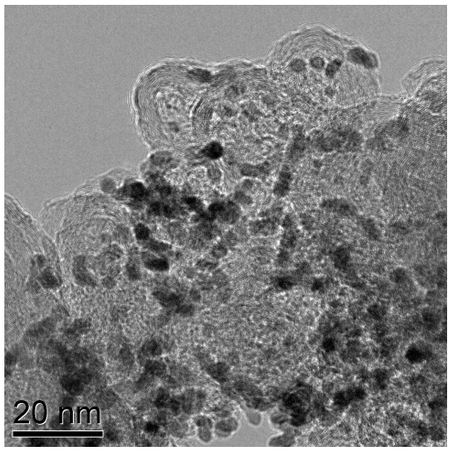

Figure 2. A TEM image of electrocatalysts made by Pt deposition on the graphitized carbon surface.

References

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