Fabrication of Pt/Conductive Polymer Composite for Durability Improvement of Catalyst for Fuel Cells

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In the viewpoint of the electrode durability of polymer electrolyte fuel cells (PEFCs), some studies intended that the platinum catalyst diffuse into the ion-exchange membrane by oxidation during the oxygen reduction at the open circuit voltage. It is necessary to prevent the coagulation and diffusion of the platinum catalyst and its shortage of the durability. In this study, we carried out the quantitative analysis of Pt surface area using CO stripping method and the durability of Pt catalytic activity was discussed. According to cyclic voltammetry of Pt/PPy/C composite, we found the Pt oxidation and reduction peak from original stage to after 10000 cycles. At the original state, the specific surface area of platinum is 92 m^2/g, which corresponds to more than 85% of the surface area of Pt/C system (105 m^2/g). which is much more than our target (25%). After 10000 cycles of potential sweeps, the measured surface area was ca.18 m^2/g for Pt/PPy/C systems, which was 4 times of the value for the Pt/C systems (ca.4 m^2/g) after 10000 cycles. The mean diameter of platinum particles was ca 5.5 nm after 10000 cycles for Pt/PPy/C composites, whereas the pa Pt for Pt/C system aggregated in catalytic layer. These results indicated that Pt/PPy on carbon composite has higher durability than Pt/C. Coagulation condition for Pt/PPy/C during PEFC operation with the redox operation of Pt catalyst is shown in Fig.1. PPy acts a role as a blocking layer for dissolution and an inhibitor for agglomeration of platinum catalyst.

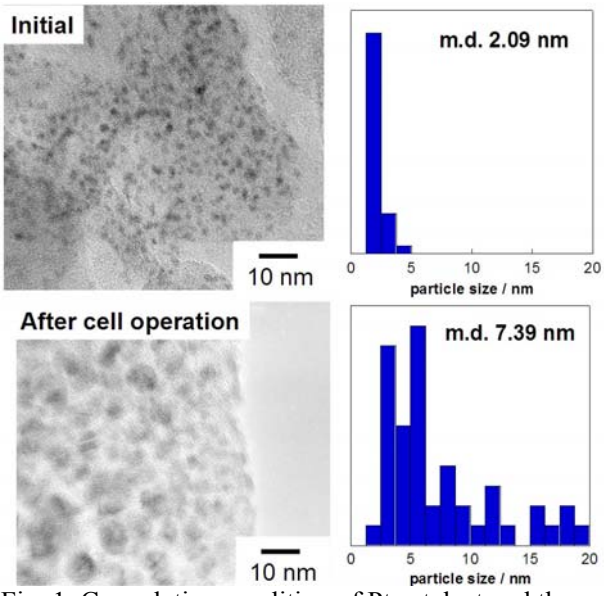

Fig. 1. Coagulation condition of Pt catalyst and the variation of the Pt catalyst for Pt/PPy/C during PEFC operation.

MEA with Pt/Polypyrrole (PPy) on C as gas diffusion electrode of cathode was prepared. The durability test of the MEA was performed with CV in PEFC operating temperature. It was observed that aggregation and dissolution of platinum in Pt/PPy on C is inhibited comparing with Pt/C. Besides, durability test of Pt/PANI on C with CV was performed in H_2SO_4 aqueous solution. The electrochemical surface area is maintained in Pt/PANI on C than Pt/C because their degradation of Pt is repressed in Pt/PANI on C. The gas diffusion electrode as the PEFC cathode with the conducting polymers has improved its durability.

We also attempt to prepare the Pt alloy catalytic composite with PPy. PtRu alloy particles were composed by ion-exchange reaction using $RuCl_3$ aqueous solution after platinum reduction with pyrrole polymerization. Ru content in PtRu alloy was controlled by the Ru/Pt content in the preparation reaction.

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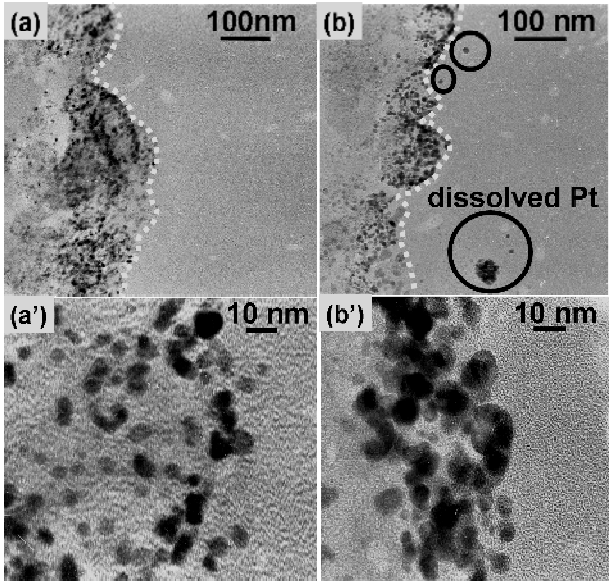

Fig. 2 Cross-sectional TEM images of MEA after CV measurement for (a)Pt/PPy on C, (b)Pt on C, and high resolution images are shown below (a') Pt/PPy on C, (b') Pt on C.

Reference

1) S. Deki, H. Nishikawa, M. Mizuhata, *Electrochemistry*, 72, 415 (2004).
2) M. Mizuhata, M. Oga, S. Deki, *ECS Transactions*, **2 (8)** 63-72 (2007).