

### Preparation of Fuel Cell Electrode Using Conducting Polymer and Its Application to Fuel Cell

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In order to improve Pt utilization in the polymer electrolyte fuel cells, we are developing a new method to prepare the catalyst layer, that is use of the conducting polymer as a conducting network in place of usual carbon material. Since the conducting polymer possesses semiconductor properties, it is expected to induce photo-deposition of Pt at limited places where Pt particles are really desired to be present as catalysts. After the Pt deposition, the conducting polymer is expected to work as the conducting network.

The conducting polymers we tested were polyaniline (PAn) and polypyrrole (PPy), which were prepared by chemical oxidation of the corresponding monomers with  $(\text{NH}_4)_2\text{S}_2\text{O}_8$  in 1 M HCl. The prepared polymer powder was mixed with 5 wt% Nafion-suspended alcohol and this solution was put onto a glassy carbon (GC) electrode. Evaporation of solvent gave a GC electrode coated with a composite film of the conducting polymer and Nafion (PAn-Nafion|GC, PPy-Nafion|GC). The composite film-coated electrode was immersed in 1 M HCl solution containing 5 mM of hexachloroplatinate and 500 mM of ascorbic acid, followed by being irradiated with a 500 W Xe lamp. The ascorbic acid was used as a hole scavenger for the photoreaction.

Amount of Pt deposited on the composite film was estimated by fluorescent X-ray analysis and the results are shown in Fig. 1. In both cases of PAn-Nafion and PPy-Nafion, Pt loading took place and its amount was increased with irradiation time, indicating that photo-induced reduction of Pt ions occurred on both films [1].

Cyclic voltammograms of PAn-Nafion|GC and Pt-deposited PAn-Nafion|GC taken in  $\text{O}_2$ -saturated 0.5 M  $\text{H}_2\text{SO}_4$  solution are shown in Fig. 2. The Pt-deposited electrode exhibits cathodic currents due to  $\text{O}_2$  reduction. It is noted that an increase in the cathodic currents was accompanied with reduction in height of the anodic wave representing oxidation of the reduced PAn. This behavior suggested that electrons transferred from PAn to Pt particles where  $\text{O}_2$  reduction took place. Accordingly, it can be concluded that PAn works as a conducting matrix between the deposited Pt and the electrode substrate [1].

The RDE measurements were adopted to compare catalytic activities of the electrodes toward  $\text{O}_2$  reduction. Fig. 3 shows voltammograms of Pt-PPy-Nafion|GC and Pt-PAn-Nafion|GC electrodes taken at 4,000 rpm in  $\text{O}_2$ -saturated 0.5 M  $\text{H}_2\text{SO}_4$  solution. The photodeposition of Pt was made with different irradiation time. It is clearly shown that current values increased with irradiation time, and catalytic activity of the PAn composite was much larger than that of the PPy composite [1]. It might be concluded that the amount of deposited Pt is mainly related to activities of  $\text{O}_2$  reduction and that the PAn-Nafion composite is much desirable for preparation of the electrodes possessing high catalytic activities.

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#### Reference

[1] H. Nakano, Y. Tachibana and, S. Kuwabata, *Electrochimica Acta*, in press.

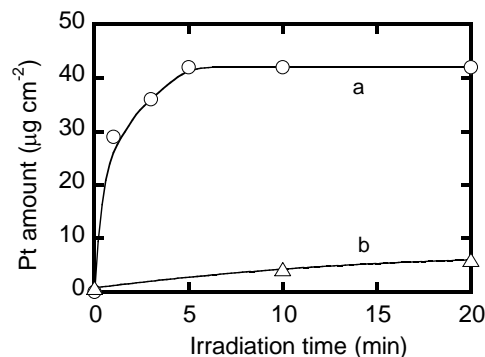


Fig. 1 Plots of Pt amount loaded on PAn-Nafion (a) and PPy-Nafion (b) composite as a function of light irradiation time

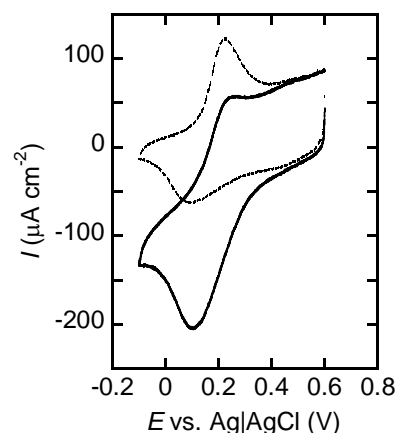


Fig. 2 Cyclic voltammograms of PAn-Nafion|GC (dotted line) and Pt-deposited PAn-Nafion|GC (solid line) electrodes taken at  $10 \text{ mV s}^{-1}$  in  $\text{O}_2$  saturated 0.5 M  $\text{H}_2\text{SO}_4$  solution.

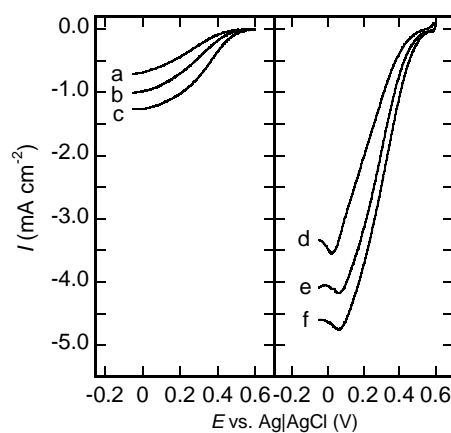


Fig. 3. Rotating disk electrode voltammograms taken in  $\text{O}_2$ -saturated 0.5 M  $\text{H}_2\text{SO}_4$  at 4,000 r.p.m. for PPy-Nafion|GC (a - c) and PAn-Nafion|GC (d - f) electrodes. Irradiation time for Pt deposition was 20, 40, 60, 1, 3, and 5 min for the cases of (a), (b), (c), (d), (e), and (f), respectively.