Pt/C-Electrocatalyst Painting at Segmented Area of Nafion Surface Driven by Electrostatic Spray Deposition

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Introduction

For a downsizing of polymer electrolyte membrane fuel cell (PEMFC) to a miniature scale, non-bipolar stackings are preferably utilized incorporating planar cells,[1)] in which several membrane electrode assemblies (MEAs) are constructed at a Nafion film. To prepare the flat cells, an electrode-arrangement technique at segmented area of the Nafion film will be required. One idea to diminish a loss of the electrocatalyst is not to use any mask at the coating process. In the present study, we will employ an electrostatic spray deposition (ESD)[2)] as a conventional and effective painting procedure to arrange the planar cells.

Experimental

Pt/C electrocatalyst (20 wt.% Pt) and Nafion solution (5 wt.%) were mixed so that Pt/C:Nafion would be 1:1 in a weight ratio, and then diluted to 3 wt.% solid content using a solution of methanol:2-propanol:water=1:1:1 in a weight ratio. The obtained dispersion was sprayed to the Nafion film by ESD technique. The spraying conditions were as follows: air-gap distance and applied electric field between a nozzle and a target were 40 mm and 12 kV, respectively, and an ejection rate of the dispersion was 0.56 or 0.33 $\mu l \cdot s^{-1}$. All the experiments were carried out at room temperature under atmosphere.

Results and discussion

Nafion pretreated in 0.5 M H_2SO_4

Nafion film was pretreated by boiling in 0.5 M H_2SO_4 for 1 h, then boiled in Milli-Q water for 1 h and rinsed thoroughly using Milli-Q water. Two Nafion pieces were separately settled on Au electrode and PET/Au electrode. Figure 1 shows the experimental result of ESD at a rate of 0.56 $\mu l \cdot s^{-1}$ for 120 s. In the photograph, it is obvious that the Nafion film and Au electrode are painted black, indicating the Pt/C deposited onto electro-conductive materials. However, the Nafion on the PET as well as the PET film remains clear, which means that the Pt/C deposition occurs keeping away from insulated materials.

Nafion without pretreatment

Next, Nafion film was used as received with no pretreatment. Water droplets were placed on the Nafion/Au electrode by using a syringe. ESD was performed at a rate of 0.33 $\mu l \cdot s^{-1}$ for 30 s. Figure 2 shows the photograph after the deposition. Two black dots seen on the Nafion film are the points where the water droplets existed; while, a slight amount of Pt/C is deposited excluding the two spots. For a comparison, ESD was conducted to another target of water droplet/PET/Au electrode, resulting in no Pt/C deposition at the water or the PET. This explains the mechanism of the result seen in Fig. 2 that the water immediately penetrates into the Nafion and makes the spot electro-conductive.

In conclusion, the ESD technique enabled to paint the Pt/C electrocatalyst at the segmented area of the Nafion film.

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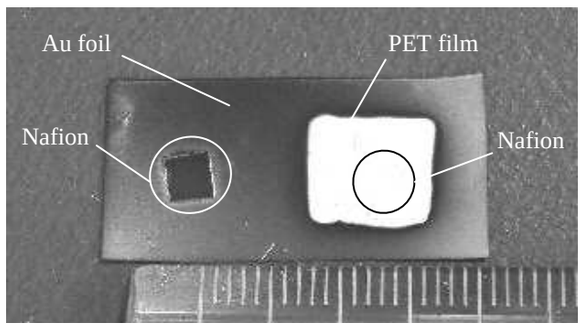

Fig. 1 Electrostatic spray deposited Pt/C + Nafion on Nafion/Au electrode(left) and Nafion/PET/Au electrode(right). Scale is 1 mm per division.

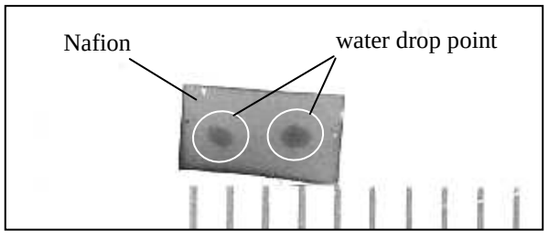

Fig. 2 Electrostatic spray deposited Pt/C + Nafion on water/Nafion/Au electrode. Scale is 1 mm per division.