

Modification of cathode catalyst to improve PEFC cell performance under low relative humidity

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The lack of water in the polymer electrolyte fuel cell (PEFC) causes to the loss of cell performance; not only in the polymer electrolyte membrane but also in the cathode catalyst layer because of the decrease of the proton conductivity of binder ionomer [1, 2], catalyst utilization [3], and so on.

To improve the cell performance under the dry condition, several studies of the improvement of the catalyst layer were tried, for example, microporous layers [4]. In this study, cathode Pt catalyst itself was modified. Recently heat treatment of catalyst was performed to improve stability. It caused to the decrease of cell performance under the dry condition even it was used at the cathode side [5]. To recover the cell voltage, here we report several trials to modify cathode Pt catalysts.

First approach was to introduce hydrophilic group such as organic sulfonic group to Pt catalyst. Pt / HSAC (Pt content = c.a. 50 wt%, Surface Area of carbon= c.a. 800 m² g⁻¹, Not heat treated) was used as base Pt catalyst. The introduction method was referred to ref. [6]. MEAs were prepared using these modified Pt catalysts as cathode and the cell voltages were measured at 0.8 A cm⁻² and RH=31%. Cell temperature was 80°C. Anode gas and cathode gas were H₂ and Air, respectively. The ratio of ionomer to carbon (in catalyst) in MEA was 0.6. This I / C ratio was lower than the best ratio in view of cell performance to reduce the effect of the water in ionomer.

Figure 1 showed the effect of the content of sulfur in cathode catalyst on the cell voltages at RH=31%. The content of sulfur in modified catalysts was determined by combustion ion chromatography method. The content of organic sulfonic group was assumed to be related to the content of sulfur. Several samples of modified catalysts exhibited better cell voltages than the base catalyst. Nevertheless, the modified catalysts containing excess amount of organic sulfonic group exhibited lower cell voltage at dry condition. The cell voltages were different among the catalysts whose contents of sulfur were almost the same. It indicated that the condition other than the content of organic sulfonic group also affected the cell performance under the lower humidity.

Figure 2 showed the correlation of ECSA and cell voltage at RH=31%. The cell voltage was not correlated to ECSA. The effect of the state near the platinum particle to the cell voltage at low RH was low.

Figure 3 showed the examples of the optimization of modifying condition. Cell voltages at RH=31% of modified catalysts were around 70-80 mV higher than that of unmodified Pt/HSAC catalyst. Cell voltages at RH=100% were almost the same. These family of modified catalysts were effective both low RH and high RH.

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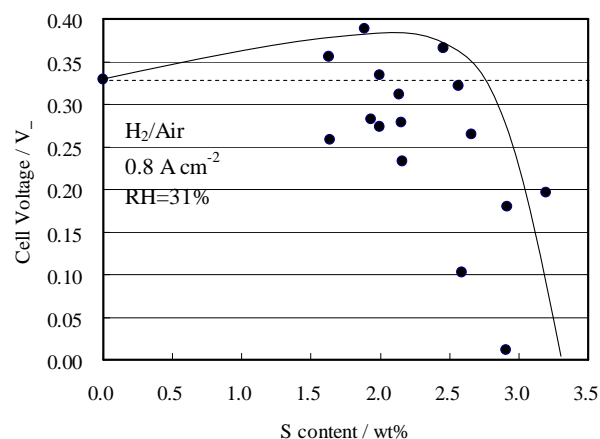


Fig. 1. Effect of the content of sulfur in cathode catalyst on the cell voltages at RH=31%. Ambient pressure, flow rates of H₂ / Air = 220 / 950 mL min⁻¹. Cell temperature = 80°C. Ionomer / Carbon = 0.6.

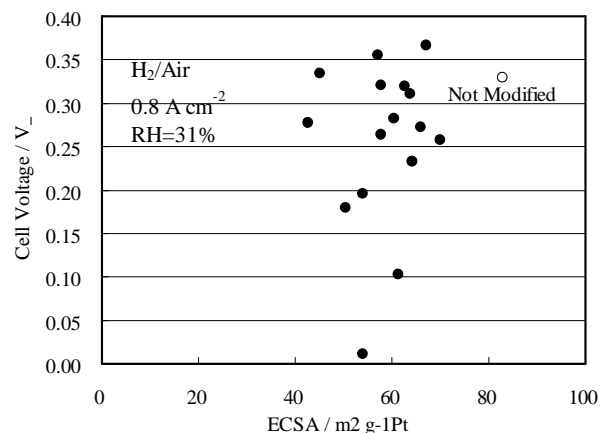


Fig. 2. Effect of the electrochemical surface area in cathode catalyst on the cell voltages at RH=31%. Ambient pressure, flow rates of H₂ / Air = 220 / 950 mL min⁻¹. Cell temperature = 80°C. Ionomer / Carbon = 0.6.

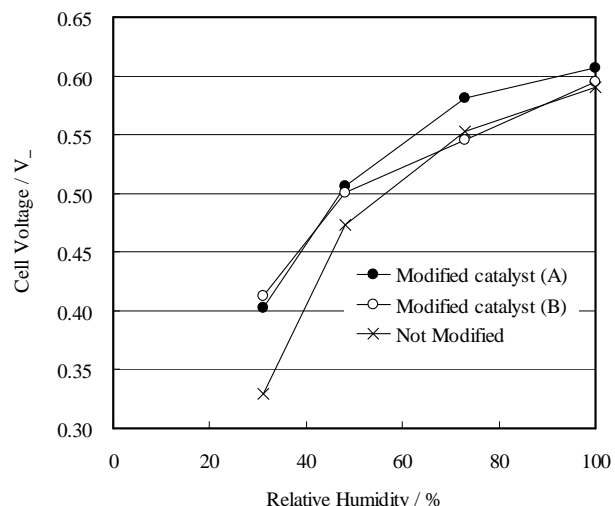


Fig. 3. Examples of the optimization of modifying Pt/HSAC catalysts. Ambient pressure, flow rates of H₂ / Air = 220 / 950 mL min⁻¹. Cell temperature = 80°C. Ionomer / Carbon = 0.6.

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