

Performance and Durability of Titanium Nitride-Supported Platinum Catalysts for Polymer Electrolyte Fuel Cells

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Platinum-based catalysts supported on carbon are widely applied as the cathode catalysts for polymer electrolyte fuel cells (PEFCs). However, carbon is not stable under high potential conditions that arise during startup and shutdown sequences, which leads to performance degradation of PEFCs. Therefore, alternative catalyst support materials are required to inhibit the degradation.

Titanium nitride (TiN) is known to be stable under acidic conditions and has higher electronic conductivity than carbon. Kakinuma et al. reported promising results of this material as a support for PEFC cathode catalysts with the rotating disk electrode RDE method in 0.1 M HClO₄.¹ In the present research, we investigated the performance and durability of MEAs with the use of titanium nitride-supported platinum (Pt/TiN) as the cathode catalyst.

Pt/TiN cathode catalyst layers with different acetylene black (AB) contents were fabricated by a spray method, in which AB was mixed as a conductive material to reduce the contact resistance between cubic TiN particles.¹ All of the Pt loading in the cathode catalyst layers were 0.05 mg/cm². As shown in Fig. 1, the ohmic resistance of the cell, R_{cell} , decreased with increasing AB content and saturated at around 30 wt%. Figure 2 shows the H₂/air polarization curves at 65 °C with 100% RH. A cell using around 30 wt% AB exhibited the highest performance. Such a behavior of the improvement was not simply explained by the decrease of R_{cell} in Fig. 1. For example, the cell voltage at 0.1 A cm⁻² with the cathode of 30 wt%-AB content was higher by 0.35 V than that of 10 wt% AB cell, whereas the reduction of the ohmic loss calculated from the decrease in R_{cell} in Fig. 1 was as small as 0.08 V. Hence, the improvement in the cathode performance was certainly brought about by constructing electronically conductive pathways among the Pt/TiN (increase in the Pt effectiveness) through contacts with the added AB particles.¹

A potential cycling test between 0.9 V and 1.3 V vs. H₂-anode at 65 °C with 100% RH was applied to the MEAs. Figure 3 shows the changes of electrochemically active surface area (ECA) with respect to the number of cycles. The loss of ECA increased with the AB content, except for 10 wt% AB, which showed extremely high R_{cell} . This is probably because the corrosion current increased with the electrical conductivity. However, all of the MEAs using Pt/TiN showed lower loss of ECA than the commercially available graphitized carbon-supported Pt

catalyst (Pt/GCB). These results indicate that Pt/TiN is more stable than the commercial Pt/GCB catalyst against such a high potential.

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References

1. K. Kakinuma, Y. Wakasugi, M. Uchida, T. Kamino, H. Uchida, S. Deki, and M. Watanabe, *Electrochim. Acta*, **77**, 279 (2012)

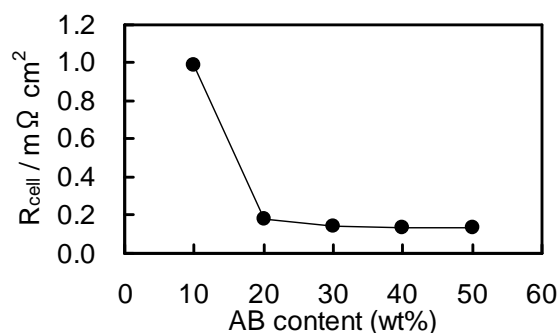


Fig. 1 Relationship between the resistance of Pt/TiN cathode cells and AB content at 65°C 100% RH.

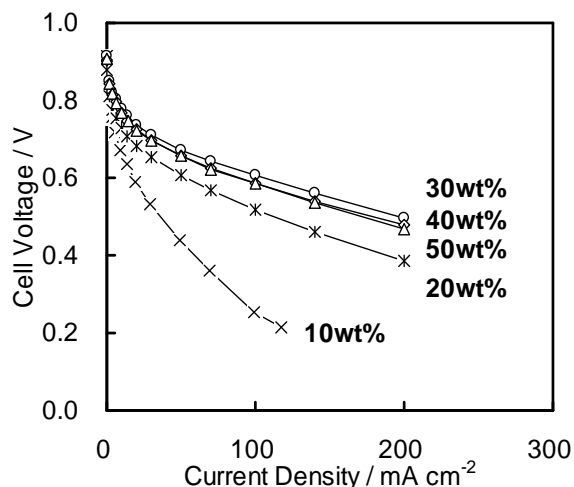


Fig. 2 H₂/air polarization curves of Pt/TiN cathodes with different AB content at 65°C 100%RH.

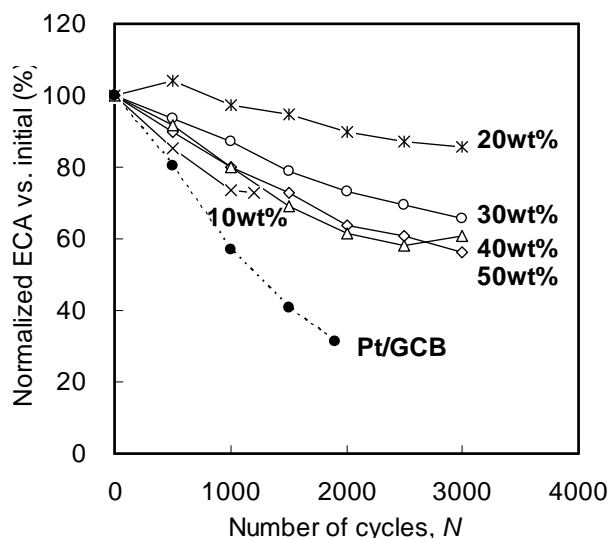


Fig. 3 Plots of the normalized ECA of Pt/TiN cathodes with different AB content and Pt/GCB cathode as a function of the number of potential cycles at 65 °C 100%RH.