

Pt-free cathode catalyst prepared from polyimide fine particles

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One major problem for polymer electrolyte membrane fuel cells (PEMFCs) in commercial applications is the cost and scarcity of platinum, which is used as the cathode catalyst. It is extremely important to develop precious-metal-free cathode catalysts.

Our research group has developed precious-metal-free cathode catalysts based on pyrolysis of polymer precursors such as novolac type phenolic resin.¹ Our carbon catalyst materials are prepared by pyrolyzing mixtures of polymers and metal complexes, rather than metal complexes loaded onto a carbon support surface. This approach could result in high density of active sites and high durability of the resulting catalysts, since the chemical structure of the active sites can be produced both in the bulk and on the surface of the carbon; however, the particle size of the catalyst tends to be large especially if it derives from thermoplastic resin such as novolac¹.

In this study, we have explored the synthesis of precious-metal-free catalyst from polyimide fine particles. Polyimide is a thermo resistive polymer and the morphology of precursor can be retained even after the carbonization; therefore, finer morphology can be expected compared to the case from phenolic resin.^{2,3}

Polyimide fine particle was prepared by a synthetic route shown in Fig. 1. By carefully selecting the polymerization condition, fine nano-particles around 100-150 nm were successfully prepared as shown in Fig. 2 (a). Thus obtained precursor was converted into a carbon catalyst by pyrolyzing it at 600°C under a N₂ flow. As shown in Fig 2 (b), the morphology of the fine particles was successfully retained even after the carbonization at 600 °C. The BET surface area of the resulting carbon was 570 m² g⁻¹.

The catalytic activity of the samples was tested by linear sweep voltammetry (5 mV sec⁻¹) at room temperature with a rotating disk electrode (RDE) in O₂ saturated H₂SO₄. The catalyst was applied onto a glassy carbon electrode using a Nafion solution. Fig 3 shows the RDE voltammograms of the polyimide fine particles before and after the carbonization. It is clearly suggested that the polyimide fine particles becomes catalytically active after the carbonization and such catalyst is a promising materials for the cathode in PEMFCs.

Acknowledgements

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Reference

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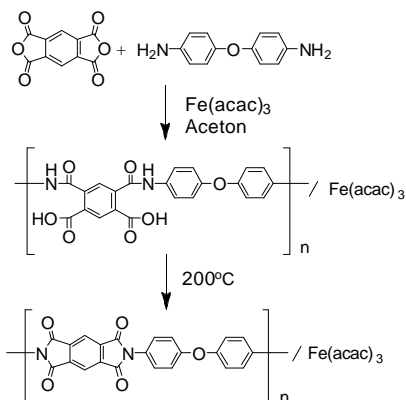


Fig. 1 Synthetic route of polyimide fine particles.

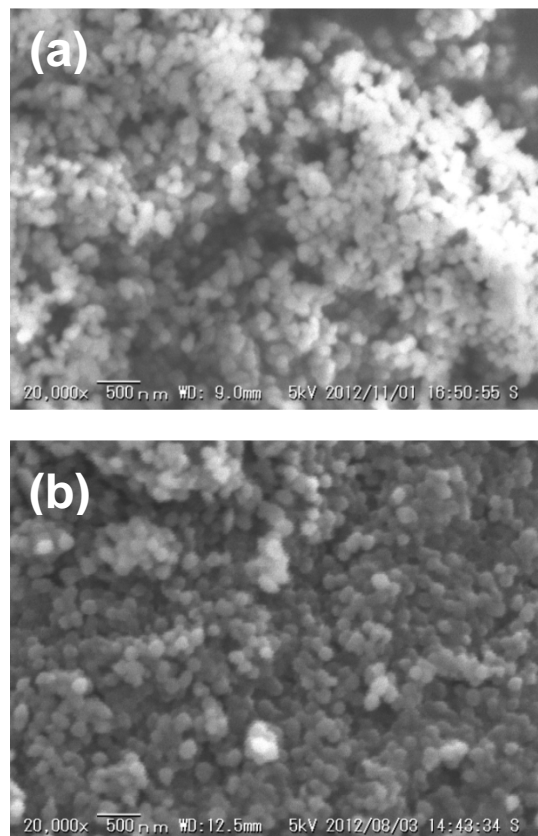


Fig. 2 SEM images of polyimide fine particles (a) before and (b) after the carbonization.

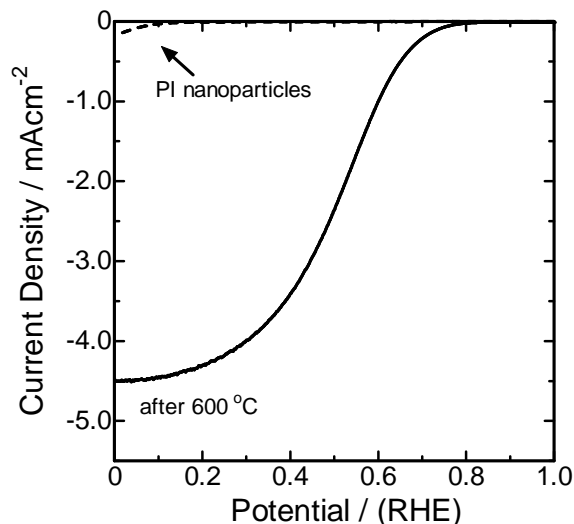


Fig. 3. RDE voltammogram of the polyimide fine particles before and after the carbonization. Catalyst loading: 0.2 mg cm⁻², rotation: 1500 rpm.