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Dispersion of Pt/Ru catalyst onto arc-soot and its performance evaluation as DMFC electrode

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ABSTRACT

The arc-soot (AS) nano-carbon was synthesized by using arc discharge apparatuses which were the conventional arc apparatus and the new twin-torch-arc apparatus. AS synthesized with the conventional arc apparatus contained cocoon-like carbon nano-horn (CNH), dahlia-like CNH, and graphite ball. On the other hand, AS which was synthesized using the new twin-torch-arc apparatus contained mainly cocoon-like CNH and dahlia-like CNH, and contained a little graphite ball. The quality of dispersion was characterized and evaluated by the index of dispersion which was based on a diameter and a number density of catalyst particles. The electrocatalytic activity of the Pt/Ru catalysts was evaluated by the methanol-impregnated paper burning method. If the index of dispersion of the AS was high, then the AS burned violently. In the dispersion process, the optimum dispersion temperature obtained was 150 °C. Some MEAs of DMFC cell consisted of each Pt/Ru–AS catalyst which had different characteristics. It was observed that the power density increased with the index of dispersion. It was suggested that the power density of DMFC increased by 500% with a 350% increase in the index of dispersion. Pt/Ru–AS catalyst used AS, which was synthesized using the new twin-torch-arc apparatus, was better than Pt/Ru–AS catalysts using AS which were synthesized with the conventional arc apparatus to apply for the catalyst of DMFC.

1. Introduction

Direct methanol fuel cells (DMFCs) are very promising power sources for portable applications and high efficiency due to simple handling and processing of fuel. Various DMFCs have been developed and improved [1–3]. However, their sufficient performance has not yet been obtained. Typically, DMFC electrocatalysts are based on precious metals, and their high cost still remains one of the drawbacks to the widespread use of these energy conversion systems. Carbon-supported Pt/Ru is the catalyst of choice for the DMFC anode, and much research is focused on the development of high catalytic activity electrodes for methanol oxidation by pursuing new synthetic routes as well as by developing new catalyst supports [4–10]. Electrocatalysts for fuel cell electrodes are mostly composed of Pt-based metal nano-particles, which are usually dispersed on porous carbon supports. For the fuel cell applications, carbon supports should have several characteristics, which include high surface area for finely dispersing catalytic metal particles, high electrical conductivity for providing electrical pathways, mesoporosity for facile diffusion of reactants and by-products, and water handling capability for removing water generated at the cathode. Various nano-carbons, including carbon nanofiber [11,12], carbon nanotube [13,14], macroporous carbon [15,16], graphitic carbon nanocoil [17,18], and ordered mesoporous carbon [19–23], have been utilized as catalyst supports for fuel cells. The electrocatalysts employing such nano-carbon supports exhibited promising catalytic activities for methanol oxidation and oxygen reduction reactions, which were attributed to the unique structural characteristics inherent in the nano-carbons, including high conductive framework structure by graphitization, periodic pore structure in mesoporous or macroporous regime, and high specific surface area.

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