Use of Carbon Nanocoil as a Catalyst Support in Direct Methanol Fuel Cell

Yoshiyuki Suda[a], Shota Kaida[a], Masahiro Ozaki[a], Yoshiaki Shimizu[a], Yuta Okabe[a], Hideto Tanoue[a], Hirofumi Takikawa[a], Hitoshi Ue[b], and Kazuki Shimizu[c]

[a]Department of Electrical and Electronic Information Engineering, Toyohashi University of Technology, 1-1 Hibarigaoka, Tempaku, Toyohashi, Aichi 441-8580, Japan
[b]Fuji Research Laboratory, Tokai Carbon Co., Ltd., 394-1 Subashiri, Oyama, Sunto, Shizuoka 410-1431, Japan
[c]Development Department, Shonan Plastic Mfg. Co., Ltd., 31-27 Daikan, Hiratsuka, Kanagawa 254-0807, Japan

Abstract. When carbon nanocoils (CNCs) are used in fuel cell electrodes, the diffusion of fuel and gas, and the removal of reaction products, becomes considerably smoother. In this paper, we used CNC as an anode or cathode catalyst support material in direct methanol fuel cells (DMFCs). Other carbon nanoparticles, Arc-Black (AcB) and Vulcan, were also used as catalyst supports to compare with the CNCs. Catalysts were loaded onto nanocarbon materials using the polyol method. We measured the methanol oxidation current of PtRu catalysts loaded on the carbon nanomaterials and the catalyst on CNC showed the highest current. Compared with the catalyst layers of AcB and Vulcan, the catalyst layer of CNCs was confirmed to have several voids. As for the cathode catalysts, the power density of Pt/CNC was 1.2 times higher than that of Pt/Vulcan and 1.6 times higher than that of Pt/AcB.

Keywords: Direct methanol fuel cell, Carbon nanocoil, Arc-black, Vulcan XC-72, Catalyst support
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1. INTRODUCTION

Direct methanol fuel cells (DMFCs) are widely applicable as portable electric power supplies for mobile devices, because the liquid fuel, used namely methanol, has a high energy density, and the corresponding DMFCs are operated at low temperature (room temperature-100°C). In order to apply DMFCs in commercial electronic devices, the problems of DMFCs, including low cost, miniaturization, and high efficiency, need to be resolved [1-7]. An effective diffusion of fuel/gas and effective exhaust of carbon dioxide/water generated during power generation are necessary. Gao, et al. reported the fabrication of a carbon nanotube-based gas diffusion layer (CNT-GDL), and compared its performance with a commercial-GDL in light of the differences between their minute structures [8]. The CNT-GDL, which has micrometer-scale pores, showed a higher performance than the commercial-GDL, which has nanometer-scale pores. Oedegaard, et al. reported the effect of the performance of GDL on the mass transport in DMFCs [9]. By adding Teflon to GDL, the pore size of GDL was enlarged. This enhanced the gas transport ability and the output of the corresponding DMFCs. An increase of fuel/gas diffusion ability in the DMFC electrodes as well as in GDL is reported to enhance the DMFC performance [10,11].

Recently, fibrous nanocarbon materials including carbon nanofibers (CNFs) [12,13] and CNTs [14,15] have been studied for the application of catalyst support materials in fuel cells. These fibrous nanocarbon materials are capable of having minute structures as well as a high electric conductivity in the fuel cell electrodes. In contrast, there are other types of fibrous CNFs which have a coiled shape. These are called carbon nanocoils (CNCs). We have studied their synthesis by chemical vapor deposition (CVD) and application [16-18]. By improvement of the catalyst preparation and CVD conditions, and by the development of an automatic CVD apparatus with a high production yield, CNCs with a purity of 80% can be grown [19,20]. Though some papers already reported the application of CNC to a catalyst support material in fuel cells [21-23], the CNCs used in these papers are not clearly helical, unlike the CNCs that we have synthesized herein. When CNCs are used in fuel cell electrodes, the diffusion of fuel and gas and the removal of the reaction products would become smoother owing to the formation of void structures in the electrode containing CNCs. So far, we have added carbon nanoballoons (CNBs) to the anode catalyst layer, which is composed of Arc-Black (AcB), a carbon nanoparticle produced by an arc discharge [24], in order to examine the effect of void formation on the fuel cell performance. As a result, 20 wt.% addition of CNBs showed the highest power density.

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