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Conducting carbon/polymer composites as a catalyst support for proton exchange membrane fuel cells

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SUMMARY

Carbon/poly(3,4-ethylene dioxythiophene) (C/PEDOT) composites are synthesized by *in situ* chemical oxidative polymerization of EDOT monomer on carbon black in order to decrease carbon corrosion that occurred in carbon-supported catalysts used in proton exchange membrane fuel cell. The effects of different dopants including polystyrene sulfonic acid, *p*-toluenesulfonic acid and camphorsulfonic acid with the addition of ethylene glycol or dimethyl sulfoxide on the properties of the composites are investigated. The synthesized composites are characterized by X-ray diffraction, Fourier transform infrared spectroscopy, thermogravimetric analysis, surface area analysis and scanning electron microscope. Electrical conductivity is determined by using the four-point probe technique. Electrochemical oxidation characteristics of the synthesized C/PEDOT composites are investigated by cyclic voltammetry by applying 1.2 V for 24 h. The composite prepared at 25 °C with *p*-toluenesulfonic acid and ethylene glycol shows the best carbon corrosion resistance. Platinum-supported catalyst by using this composite was prepared using microwave irradiation technique, and it was seen that the prepared catalyst did not significantly lose its hydrogen oxidation and oxygen reduction reaction activities after electrochemical oxidation. Copyright © 2013 John Wiley & Sons, Ltd.

KEY WORDS

PEM fuel cell; conducting carbon/polymer composite; carbon corrosion; durability; electrical conductivity

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1. INTRODUCTION

Carbon-supported platinum is a commonly used electrocatalyst for hydrogen oxidation and oxygen reduction reactions occuring at the anode and cathode electrodes of proton exchange membrane fuel cells (PEMFCs) [1–3]. The carbon supports are getting corroded during the long-term operations of PEMFCs, which resulted in performance loss, so it is needed to eliminate or decrease this corrosion and increase the oxidation resistance of the supports [4,5]. One of the ways in order to decrease the carbon corrosion is to use conducting polymers [6] or carbon/conducting polymer composites instead of plain carbon support [7].

In the late 1980s, a new polythiophene derivative, poly (3,4-ethylene dioxythiophene) (PEDOT) was developed. Since then, it has been considered as one of the most successfully conjugated polymer due to its remarkably high conductivity and excellent environmental stability, and this made PEDOT and its complexes excellent candidates for several applications [8,9]. The solubility and long-term stability of PEDOT can be enhanced by blending with poly(styrenesulfonate) (PSS) [10,11]. Furthermore, the network structure of PEDOT : PSS has the resemblance of Nafion. PEDOT : PSS provides 3D reaction zone and increases the active surface area of Pt particles in contact with the electrolyte. The presence of anionic dopants in PEDOT : PSS generates a pathway for protonic species and hence possesses suitable characteristics for direct methanol fuel cell applications [12,13].

Electrical conductivity of PEDOT can be increased with the addition of different dopants and also the secondary dopants including polyalcohols or high dielectric solvents such as glycerol or dimethyl sulfoxide (DMSO) [14,15]. The effect of secondary dopant was based primarily on a change in molecular conformation of the conducting polymers from compact coil to expanded coil. The secondary dopant is the additive being generally inert, having low molecular weight and high dielectric constant. Its function is to solve the counter anions of the polymers, increase the repulsion between positively charged polymer backbones,