

Electrochemical properties of platinum-carbon aerogel catalysts for fuel cell applications using the CO stripping technique

Hyun-Joong Kim^{1,2}, Hyung-Sang Park², Tae-Hoon Lim³, and Dong Jin Suh^{1,*}

¹Clean Technology Research Center, Korea Institute of Science and Technology, P.O. Box 131 Cheongryang, Seoul 136-791 (Korea)

²Department of Chemical & Biological Engineering, Sogang University, C.P.O. Box 1142 Seoul 121-742, (Korea)

³Fuel Cell Research Center, Korea Institute of Science and Technology, P.O. Box 131 Cheongryang, Seoul 136-791 (Korea)

*Tel.: +82-2-958-5192, Fax.: +82-2-958-5205, E-mail: djsuh@kist.re.kr

Introduction

Carbon-supported platinum catalysts have been prepared by various techniques, such as impregnation, ion exchange, precipitation and colloidal method. Recently, particular attention has been paid to carbon aerogels as catalyst support for fuel cell applications. Carbon aerogels have unique properties such as high conductivity, pronounced mesoporosity, high surface area and relatively low degree of microporosity that can make them more suitable electrocatalyst support than other types of carbons. Marie et al. prepared platinum-loaded carbon aerogel catalysts for PEMFC electrodes by impregnation method (on the gel and on the carbon aerogel), which exhibited high oxygen reduction reaction activity compared with platinum-loaded carbon blacks [1]. However, there have been comparatively few reports on electrochemical properties of platinum-loaded carbon aerogels. Cyclic voltammetry is a simple tool for obtaining the electrochemical properties of fuel cell catalysts. In contrast to previous works on cyclic voltammetry studies of electrocatalysts [2-4], we here report the electrocatalytic activity and stability of platinum-carbon aerogels by using CO stripping voltammetry in comparison with other catalysts.

Materials and Methods

We synthesized platinum-organic composite aerogels from the alcoholic sol-gel reaction of organic precursors using propylene oxide as a primary particle formation agent from platinum salt and followed by supercritical drying with carbon dioxide. Subsequent carbonization of platinum-organic aerogels under inert gas or reducing gas flow produces platinum-carbon aerogels. Electrochemical properties of various platinum-carbon catalysts were measured by cyclic voltammetry with adsorption and desorption of CO on the platinum surface. The change of electrochemical active surface (EAS) area obtained from repeated CO adsorption/desorption cycles was indicative of the stability of the platinum-carbon catalysts. The surface and morphology of the platinum-carbon catalysts were characterized by XPS and TEM.

Results and Discussion

Fig. 1 shows the change of EAS area of the commercial and aerogel catalysts during repeated CO adsorption/desorption cycles. For the commercial catalyst, the EAS area obtained from the first CO stripping voltammogram was very high, but the EAS decreased gradually as the number of CO stripping experiment increased. On the other hand, the aerogel

catalyst exhibited relatively lower initial EAS area and increased consistently up to about 85m²/g during the first 6 runs, then decreased as the commercial catalyst did. Maillard et al. reported size effects of platinum nanoparticle in CO monolayer oxidation. According to their results, the peak of CO stripped was shifted toward lower or higher potential as the particle size of platinum [2]. In this work, the CO stripping peak was shifted toward lower potential as increasing the number of CO stripping. The shift of CO stripping peak toward lower potential means increasing the platinum particle size. Therefore, the decrease of EAS area of the commercial catalyst could be explained by the increase of the platinum particle size during the repeated electrocatalytic reactions. The increase of EAS area of the aerogel catalyst could be explained by the increase of the amount of exposed platinum surface by rearrangement of the catalyst nanostructure during the repeated electrocatalytic reactions. The explanation was confirmed by measuring the platinum particle size and the surface concentration of platinum using TEM and XPS (not shown).

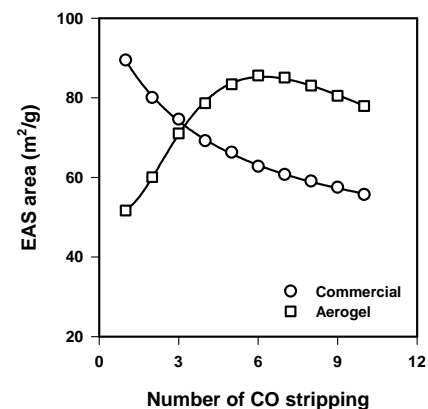


Figure 1. Change of electrochemical active surface areas of the commercial and aerogel catalyst as the increase of the number of CO stripping experiment.

References

1. Marie, J., Berthon-Fabry, S., Achard P., Chatenent, M., Pradourat, A., and Chainet, E., *J. Non-Cryst. Solids* 350, 88 (2004).
2. Maillard, F., Eikerling, M., Cherstiouk, O.V., Schreier, S., Savinova, E., and Stimming, U., *Faraday Discuss.* 125, 357 (2004).
3. Mayrhofer, K.J.J., Arenz, M., Blizanac, B.B., Stamenkovic, V., Ross, P.N., and Markovic, N.M., *Electrochim. Acta* 50, 1544 (2005).
4. Qi, Z., He, C., and Kaufman, A., *Electrochem. Solid-State Lett.* 4, A204 (2001).