

Improved performance of PtRu/C prepared by the selective deposition of Ru on Pt as an anode of PEM fuel cell

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Introduction

Polymer electrolyte membrane fuel cells (PEMFCs) have been investigated by numerous groups due to their advantages of zero emission, rapid cell start-up, and high power density at low temperatures, typically 60–100°C. However, there still remain some problems to be solved for the commercialization of PEMFCs. The carbon monoxide (CO) poisoning of anodic catalyst is one of them [1]. Ru-promoted Pt/C with an Ru/Pt ratio of 1.0 is considered as a solution to the problem due to its improved CO tolerance. Although an increase in the alloy content of PtRu/C catalyst was necessary for the improved CO tolerance of the catalyst, only part of the Ru (about 49%) formed an alloy with the Pt when Ru was added by impregnation (IMP) [2]. On the other hand, when promoters were added by chemical vapor deposition (CVD), they were selectively deposited on the Pt surface and consequently effectively modified the Pt after treatment at temperatures lower than in the case of promoter addition by IMP [3].

In this study, controlled amounts of Ru were selectively deposited on the Pt surface by a CVD method such that the Pt-Ru alloy was effectively formed in the catalyst. The CO tolerance of the prepared catalysts was compared with that of a catalyst prepared by IMP as well as the commercial PtRu(Ru/Pt=1)/C catalyst.

Experimental

PtRu/C catalysts of different Ru/Pt ratios were prepared by adding Ru to 20 wt.% Pt/C (E-TEK Co.) using either a CVD or an IMP method. For the CVD, ruthenocene ($\text{Ru}(\text{C}_5\text{H}_5)_2$, Aldrich), which was vaporized at 170°C in a nitrogen carrier gas, was introduced into a reactor containing Pt/C. The catalyst containing the adsorbed Ru precursor was heated up to 220°C in flowing hydrogen and kept at the final temperature for 0.5 h. The prepared catalysts were characterized by FT-IR, energy dispersive X-ray analysis (EDX) attached to the HR-TEM, X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), and CO-stripping test.

Results and Discussion

Pt-1.0Ru(IMP) and Pt-0.44Ru(CVD) catalysts, which had been thermally treated at 600°C, were tested for CO stripping to obtain the results of Figure 1. The CO oxidation potential (429mV) of Pt-0.44Ru(CVD) was lower than that of Pt-1.0Ru(IMP) (513mV), suggesting that the Pt surface was modified more effectively by the Ru when the latter was added by CVD instead of IMP.

Figure 2 shows that the XPS peaks of Pt are shifted to lower binding energies due to the Ru addition, indicating the transfer of electrons from added Ru to Pt [4]. The shift was larger, i.e., the Pt-Ru interaction was stronger, when Ru was added by CVD instead of IMP,

although the nominal amount of added Ru was smaller in the former case. Unit-cell tests of the prepared catalysts together with a commercial one also verified the highest CO tolerance of the catalyst prepared by CVD.

Conclusions

Pt/C catalyst promoted with Ru, which had been selectively deposited on the Pt surface by a CVD method, showed higher CO tolerance at a lower Ru content than in the case of catalyst containing Ru added by IMP.

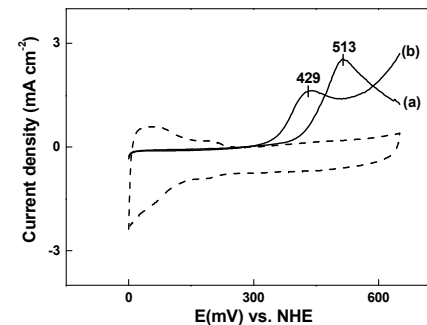


Figure 1. Results of CO stripping tests showing the CO oxidation potential of (a) Pt-1.0Ru(IMP) and (b) Pt-0.44Ru(CVD).

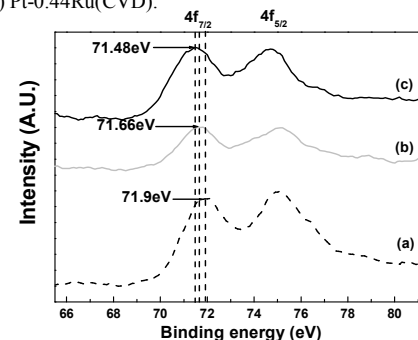


Figure 2. XPS of Pt 4f in (a) Pt alone, (b) Pt-1.0Ru(IMP), and (c) Pt-0.44Ru(CVD).

References

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