

Preparation of Pt/NiO-C Catalyst for the Methanol Electro-oxidation

Dong Baek Kim, Dong-Ha Lim, Hee-Joon Chun and Ho-In Lee*

Department of Chemical and Biological Engineering and Research Center for Energy Conversion and Storage, Seoul National University, Seoul 151-744, Korea

*hilee@snu.ac.kr

Introduction

Platinum has universally used as catalyst for the methanol electro-oxidation. However, platinum is easily poisoned by carbon monoxide (CO) which is the byproduct of methanol oxidation. Therefore, to increase the resistance to the CO poisoning, platinum is alloyed with the oxophilic metals which could oxidize adsorbed CO with OH adsorbed on them [1, 2]. Metal oxide has also an oxophilic nature to remove the adsorbed reaction intermediates, and it leads to an improvement of the catalytic activity toward methanol oxidation [3]. In this work, we prepared NiO-added Pt/C catalyst and studied the effect of NiO on the methanol oxidation.

Materials and Methods

Nickel oxide was loaded on the Vulcan XC-72R (Cabot) by precipitation method. The aqueous solution of nickel nitrate hexahydrate (99.9%, Aldrich) was injected into a suspension of the carbon in deionized water. The pH was controlled to be 10 by injection of ammonia solution. After washing with water, precipitation precursor was dried under vacuum overnight. The precursor was calcined for 3 hours at 400 °C. Using nickel-loaded carbon (NiO-C) as support, Pt catalyst (Pt/NiO-C) was synthesized by a polyol process [4]. xNiO-C means that x weight percent of NiO to NiO-C was loaded on the carbon. The electrochemical activity of the catalyst was measured by the methanol electro-oxidation. The particle size of Pt was calculated by Scherrer Formula from X-ray diffraction (XRD) pattern, and confirmed by transmission electron microscopy (TEM). The Ni state was analyzed by X-ray photoelectron spectroscopy (XPS).

Results and Discussion

NiO on the carbon was confirmed by XRD pattern. Pt particle size of Pt/NiO-C was smaller than that of Pt/C which was prepared by same method as Pt/NiO-C. Pt particle of Pt/NiO-C was well-dispersed on the support via TEM image. The presence of NiO on the carbon support suppressed the aggregation between Pt particles and made Pt particle dispersed well. However, Pt particle sizes of catalysts were similar with each other as 2.0 nm in spite of the increase of NiO amount. The electrochemical activities of the catalysts shown in Figure 1 suggest the optimum amount of NiO. The addition of NiO to Pt/C increased electrochemical activity, and the current densities of the home-made catalysts were higher than that of commercial one. However, higher amount of NiO on the carbon surface induced lower current density because high resistance of metal oxide decreases the conductivity of electrons which is produced on the Pt surface. The CO stripping test of Pt/NiO-C showed lower onset voltage by 0.1 V for CO oxidation than that of Pt/C regardless of the amount of NiO added. Adsorbed CO on the Pt surface was oxidized more easily with the addition of NiO to the catalyst. Figure 2 shows that the Ni state consists of NiO, Ni(OH)₂, and NiOOH. Among them, NiOOH was the

most major component. OH species on the NiO contributed to oxidize CO adsorbed on the surface easily.

Significance

We prepared NiO-containing electrocatalyst which has nano-sized and well-dispersed Pt particles. It showed better performance and higher resistance against CO poisoning than the commercial Pt catalyst due to the presence of nickel oxide.

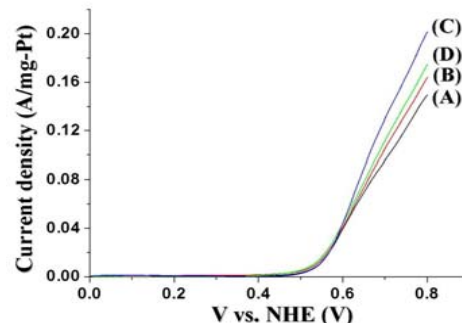


Figure 1. Cyclic voltammograms of the Pt catalysts for the methanol oxidation: (A) Pt/C (commercial), (B) Pt/1NiO-C, (C) Pt/5NiO-C, and (D) Pt/10NiO-C.

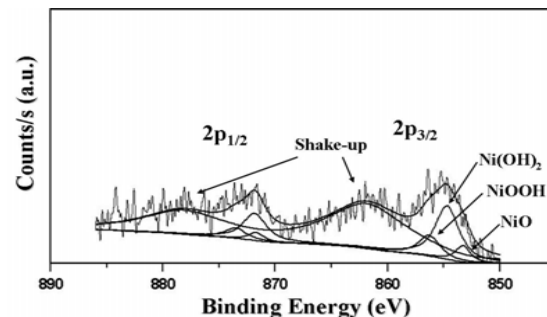


Figure 2. X-ray photoelectron spectra of Ni2p in Pt/10NiO-C.

References

1. Choi, J.-S., Chung, W.S., Ha, H.Y., Lim, T.-H., Oh, I.-H., Hong, S.-A., and Lee, H.-I., *J. Power Sources*, 156, 466 (2006).
2. Deivaraj, T.C., Chen, W., and Lee, J.Y., *J. Mater. Chem.* 13, 2555 (2003).
3. Rajesh, B., Thampi, K.R., Bonard, J.-M., Mathieu, H.J., Xanthopoulos, N., and Viswanathan, B., *J. Power Sources*, 141, 35 (2005).
4. Wang, Y., Ren, J., Deng, K., Gui, L., and Tang, Y., *Chem. Mater.*, 12, 1622 (2000).