Highly Loaded Carbon Black Supported Platinum Catalysts for Fuel Batteries

Kaluža, Luděk

2014

HIGHLY LOADED CARBON BLACK SUPPORTED PLATINUM CATALYSTS FOR FUEL BATTERIES

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Fulfilling of increasingly stringent environmental restrictions imposed on transportation drives the research on alternative energy resources such as hydrogen and fuel cells. Carbon supported Pt represents conventional catalyst in polymer electrolyte membrane fuel battery (PEM fuel cell). The aim of this work was to elucidate on the methods of Pt deposition on carbon black to achieve high loadings of Pt of about 60 wt.% in highly dispersed form. The carbon black supports were characterized by nitrogen physisorption. Platinum was deposited on the supports: (i) from true solutions of H_2PtCl_6, $Pt(C_5H_7O_2)_2$, $Pt(NH_3)_4(NO_3)_2$, or $Pt(NH_3)_2(NO_2)_2$, and (ii) from fine dispersions of $Pt(C_5H_7O_2)_2$, PtO_2, $Pt(NH_3)_4(OH)_2$. Atomic absorption spectroscopy, AAS, and scanning electron microscopy, SEM, were used for elemental analysis and determination of Pt content. The deposited Pt species were dried, calcined or reduced and were subjected to temperature programmed reduction, TPR. After degassing at increased temperature, the Pt dispersion was determined by hydrogen chemisorption at -60 °C. X-Ray diffraction and laser Raman spectroscopy was selected to characterize the reduced catalysts. It was acquired that the used carbon black supports exhibited features of N_2 adsorption-desorption isotherms of type IV. The samples XC72R, XC72 (Vulcan, Cabot Corp.), and ENSACO 290G (IMERYS Graphite & Carbon Ltd.) exhibited low surface area, S(BET), of about 226-236 $m^2g^{-1}$and low volume of micropores, V(Micro), of 55-65 mm^3g^{-1}. In contrast, the support ENSACO 350G (IMERYS Graphite & Carbon Ltd.) exhibited about 4-fold higher S(BET) and V(Micro). TPR revealed that PtO_2, H_2PtCl_6, $Pt(C_5H_7O_2)_2$, $Pt(NH_3)_4(NO_3)_2$, and $Pt(NH_3)_2(NO_2)_2$ deposited on carbon blacks and dried in rotary vacuum evaporator at 95 °C were reduced to metallic Pt at 0, 70, 120, 140, 150 °C, respectively. Hydrogen chemisorption experiments clearly showed that Pt dispersion in the catalysts mainly depended on the Pt precursor and activation conditions. Specific interaction of the Pt precursor with support surface was considered necessary for formation of the desired average 4 nm Pt particles. This interaction might be partly considered as support corrosion and might lead to desirable new edge defects on the support surface, which promotes high Pt dispersion (4-6 nm particles). On one hand, the corrosion caused by H_2PtCl_6 or $Pt(NH_3)_2(NO_2)_2$ was mild and desirable. On the other hand, the corrosion observed while treating the $Pt(NH_3)_4(NO_3)_2$ containing samples was strong and undesirable. Bearing in mind the undesirable corrosion effects, the deposition of colloidal form of PtO_2 or $Pt(C_5H_7O_2)_2$ seemed to be particularly promising because it represented relatively clean but delicate method of Pt deposition.

Acknowledgement. The research leading to these results has received funding from the European Union's 7th Framework Programme (FP7/2007-2013) through the Fuel Cells and Hydrogen Joint Undertaking Technology Initiative under Grant Agreement Number 303466 and project acronym IMMEDIATE. The authors also highly acknowledge the co-financing of the Ministry of Education, Youth and Sports of the Czech Republic (grant no. 7HX13003).