

Investigation of a cathodic bimetallic catalyst based on Platinum and cobalt for application in direct methanol fuel cells

To cite this article: Claudia D'urso *et al* 2013 *Meet. Abstr.* **MA2013-02** 1598

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Investigation of PtCo catalysts in direct methanol fuel cells

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Abstract

PtCo catalysts with different structure and surface characteristics were synthesized and investigated at the cathode of a direct methanol fuel cell (DMFC). A comparison with a commercial Pt catalyst was carried out. A higher performance in DMFC was obtained by using the bimetallic PtCo catalyst.

Keywords: direct methanol fuel cell, oxygen reduction reaction, PtCo catalyst.

1 Introduction

The direct methanol fuel cell (DMFC) is a promising alternative power source that combines the merits of direct hydrogen/air fuel cells with the advantages of a liquid fuel, such as convenient handling and high energy density. Despite these advantages, technical barriers still need to be overcome for their large scale commercialization of DMFCs. It is well known that one of the problems affecting DMFCs is the poisoning of the cathode surface in the presence of methanol cross-over. Although a Pt/C electrocatalyst is the most widely used cathode material, there is a great interest in the development of more active and more methanol tolerant electrocatalysts for the ORR. Promising results have been achieved by alloying Pt with non noble metals.

2 Experimental

A 50 wt.% Pt-Co/C catalyst with nominal alloy composition Pt₃Co₁ (at.) was prepared by incipient wetness of cobalt nitrate on an amorphous PtOx/C catalyst. The concentration of Co(NO₃)₂ was adjusted to achieve a Pt/Co atomic ratio of about 3:1 in the final catalysts. The PtOx/C was prepared by the sulphite complex route [1]. After the cobalt impregnation step, a high temperature carbothermal reduction in inert (Ar) atmosphere was carried out to form the carbon-supported PtCo alloy. Two specific temperatures were selected for the thermal reduction (600°C and 800°C). A pre-leaching procedure at 80°C in 0.5 M HClO₄ was carried out for the PtCo catalysts after the thermal reduction. This specific preparation procedure was selected to achieve a good dispersion of metal particles for the catalysts treated at different temperatures and to promote Pt enrichment in the outermost layers. The catalysts treated at different temperatures (600° and 800°C) were physico-chemically characterized by XRD, TEM, XRF and XPS analyses to investigate structure, morphology, bulk and surface composition, respectively.

3 Results and discussion

The catalysts showed a disordered cubic structure (fcc) for the alloy treated at 600°C and single ordered

primitive cubic (L12) phase for the alloy treated at 800°C. Line broadening analysis of the (220) reflection showed a crystallite size of 2.9 nm for the PtCo treated at 600°C and 3.3 nm for the PtCo catalyst that experienced 800°C. For both the PtCo catalysts, a large lattice (*A*₂₂₀) contraction compared to a Pt/C catalyst corresponding to a high degree of alloying was observed. The Co atomic content in the alloy, as determined by XRD, was about 24% and 29% in the PtCo samples with disordered and ordered structure, respectively. This was close to the nominal content (25%). TEM analysis showed a good dispersion for both catalysts. Electrocatalytic activity and performance characteristics for these catalysts were investigated in relation to the oxygen reduction reaction in half-cell. The ECSA of these catalysts was investigated by using conventional cyclic voltammetry (CV); it was in the range 47-49 m² g⁻¹ for both catalysts. Also the ORR polarization curves showed similar performance for the two PtCo catalysts. PtCo catalysts were used at the cathode of a direct methanol fuel cell and compared to a commercial Pt catalyst. A higher performance was obtained by using the bimetallic catalyst at the cathode.

4 Acknowledgements

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2011-2014) for the Fuel Cells and Hydrogen Joint Technology Initiative under grant agreement DURAMET n°278054.

5 References

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