

A Direct Methanol Fuel Cell with Pt-alloys with Ru, Mo, W and Os as Anode Catalysts

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Introduction

There is presently much interest in the direct methanol fuel cell (DMFC) because of the possible applications in vehicles and in portable systems. One of the limiting factors in the performance of this cell is the poisoning of the anode with strongly adsorbed intermediates, mainly CO. An approach to deal with this problem is the use of Pt alloys with transition metals that form oxide species at low potentials facilitating the oxidation of CO to CO₂.

Among the investigated Pt alloys encouraging results have been obtained using as second metal Ru, Mo, W and Os[1-3]. In this laboratory, these alloys have been produced with a formic acid reduction method [4] and some of the alloys were tested for the oxidation of CO and methanol, using suitable rotating electrodes. In this work, the alloys were used to construct gas diffusion electrodes that were tested in a single cell operating with a methanol solution.

Experimental

The composition of the prepared alloys was determined by EDX using a LEO 440 equipment. Further information was obtained with x-ray diffraction in a URD-6 Carl Zeiss-Jena diffractometer.

The catalysts were characterized electrochemically by cyclic voltammetry and chronoamperometry, using a thin porous coating/rotating disk electrode [5]. The electrochemically active areas of the materials was determined using the charge of oxidation of adsorbed CO.

Gas diffusion electrodes consisted of a diffusion layer containing PTFE and carbon powder on a carbon cloth. With the catalysts, containing 20% metal, an ink was prepared using a mixture of alcohols and Nafion[®] solution, which was applied on top of the the diffusion layer. The catalytic layer contained always 1mgPtcm⁻² and 35% Nafion[®]. The anodes were prepared with Pt-alloys 20 % metal/C and the cathodes were prepared using 20% Pt/C E-TEK. Membrane and electrode assemblies were prepared by hot pressing the electrodes onto a Nafion[®] 117 membrane. A 2 mol L⁻¹ methanol solution was used in the anode and pure oxygen in the cathode. The cell was operated at 70 °C and the O₂ pressure was 1 atm.

Results and Discussion

The particle sizes of the alloys prepared here were about 2,5 - 4 nm consistent with the results of alloys prepared by other methods. Also, it was observed that for some of the alloys the diffractograms were very similar to those of the Pt/C material. The cell parameter a was in all cases smaller than for Pt/C suggesting the formation of solid solutions.

Different Pt-Ru compositions were tested with different concentrations of methanol (0.1 - 4 mol.L⁻¹) in a half cell containing 0.5 mol.L⁻¹ H₂SO₄ and the best performance was obtained with a Pt-Ru 75:25 catalyst. Actually, the performance was better than with a Pt-Ru 50:50 E-TEK. The other catalysts tested in the methanol fuel cell were Pt-Ru/C 84:16, Pt-Ru/C 92:08, Pt-Mo/C 60:40, Pt-Ru-Mo/C 70:20:10, Pt-W/C (90:10, 80:20 and 70:30) and Pt-Os/C 80:20, all prepared by reduction with formic acid. The experimental curves for some of the catalysts are presented in Fig. 1 showing that all the alloys gave better results than Pt/C but the best performance corresponds to Pt-Ru/C 75:25.

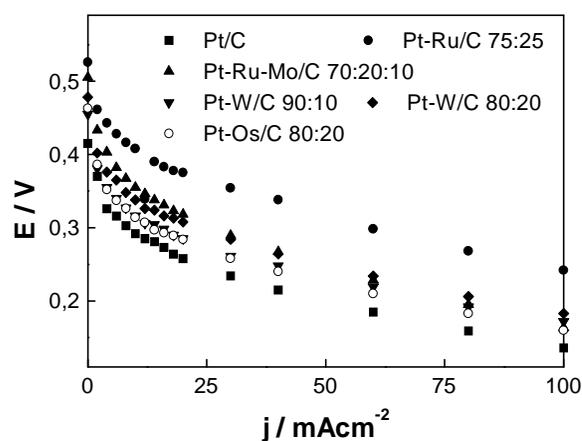


Figure 1. Potential-current density curves for a single DMFC using several electrocatalyst in the anode.

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