

PERFORMANCE OF CONDUCTIVE CARBON-CERAMIC COMPOSITES AS ELECTROCATALYST SUPPORT

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Introduction

Preparation of carbon-ceramic composites attracts the attention of researchers for different purposes. Some research groups are interested in these composites because the combination of both materials, that is, carbon and ceramic, can produce specific characteristics difficult to obtain by any of the original components separately.

Ceramic materials have a growing importance in electrochemical processes. Usually, they are used in the form of metal substrates coatings [1,2]. Less commonly, ceramic materials have conductivity high enough that they may be used as electrodes in the form of bulk materials [3]. Modified electrodes containing palladium, platinum and other metals are frequently used as fuel cell electrodes [4,5]. Many electrolytic processes employ precious metal electrodes and, for economic reasons, practical electrodes normally consist of a thin coating of the precious metal on an inert substrate.

In this work we describe the possible use of previously reported conductive carbon-ceramic composites [6] as platinumized electrode. The objective is to prepare stable Pt coated carbon-ceramic electrodes and evaluate their behaviour in the electrooxidation of methanol.

Experimental

A commercial coal tar pitch from Bilbaina de Alquitrans S.A. was used as carbon precursor. The ceramic component is produced by Domus S.L., already molded as monoliths with a honeycomb structure and fired [6].

The platinum coatings were deposited by two methods: i) impregnation from 1 cm³ of solution 2x10⁻³ M H₂PtCl₆ and 0.5 ml of ethanol as reducing agent, in atmosphere of nitrogen until total drying at 40°C and ii) electrodeposition from a 10⁻² M H₂PtCl₆ solution maintaining the carbon-ceramic electrode at constant potential of -0.58V/RHE for 2 minutes.

Cyclic voltammetry was carried out in a three electrodes cell using the standard experimental set-up. All potentials are referred to the reversible hydrogen electrode (RHE)

immersed in the same solution. The electrolyte was 0.5M H₂SO₄ solution prepared from a Millipore-Milli Q system. The geometric area of the carbon-ceramic electrodes was approximately of 10 mm² and the current densities are referred to this area.

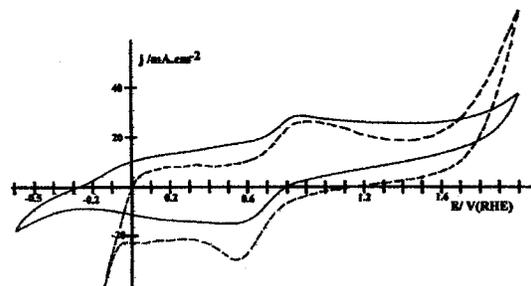


Fig. 1. Steady voltammograms for a carbon-ceramic (—) electrode and a platinumized carbon-ceramic (----) electrode. 0.5M H₂SO₄, $v = 100 \text{ mV s}^{-1}$.

Results and discussion

Figure 1 shows the voltammograms obtained for a carbon-ceramic electrode and for a platinumized carbon-ceramic electrode. They were cycled between the whole potential range until obtaining a steady voltammogram. The steady voltammogram does not change independently of the method used for deposition of platinum. It can be observed in the Pt/Carbon-ceramic (Pt/CC) electrode the features for platinum oxide formation-reduction and the zone corresponding to the hydrogen adsorption-desorption region. However, the peaks are not as sharp as those obtained with a polycrystalline platinum electrode. By comparison of both voltammetric profiles, it can be observed that the oxygen evolution reaction shifts to more negative potentials and the hydrogen evolution reaction shifts to more positive potentials as it is expected for a platinum electrode.

Table I contains the chemical composition of the Pt/CC materials obtained by EDX. It can be observed that the amount of electrodeposited platinum is lower than in the case of chemical method.

Table 1: Chemical analysis of the chemically (Pt/CCch) and electrochemically (Pt/CCel) deposited Pt/CC electrodes obtained by EDX.

	Wt%					
	Al	Si	Fe	K	Ca	Pt
Pt/CCch	15	19	4	4	4	54
Pt/CCel	23	35	8	7	6	21

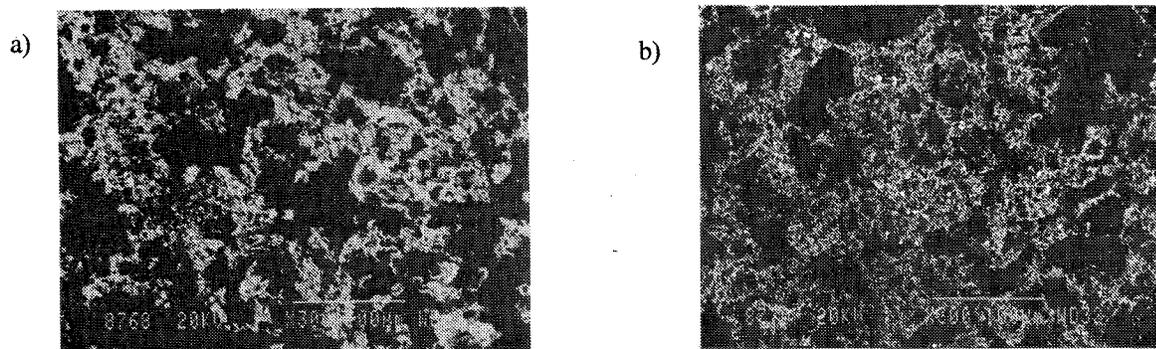


Fig. 2. SEM photomicrographs of chemically (a) (Pt/CCch) and electrochemically (b) (Pt/CCel) deposited Pt/CC electrodes.

Fig. 2 shows the scanning electron micrographs for the Pt/CC electrodes in which the platinum has been chemically and electrochemically deposited. It can be seen that the distribution of Pt is more uniform and the size of the particles are lower in the electrochemical deposit.

In order to investigate the electrocatalytic behaviour of these Pt/CC electrodes, they have been tested in the oxidation of methanol, and their performance has been compared with a polycrystalline platinum electrode. The carbon-ceramic substrate does not oxidise methanol; however, when the platinum is deposited an oxidation current is observed. Table 2 shows the peak potentials corresponding to methanol oxidation and the current densities obtained for both electrodes studied in this work. The same values for a polycrystalline electrode are also presented. The current density of Pt/CCel sample, referred to the amount of Pt, is larger than that of Pt/CCch sample. This is in agreement with the better distribution and smaller particle size of Pt in the former composite.

Conclusions

The use of a cheap conducting carbon-ceramic composite as substrates for metal deposition has been confirmed. Platinum has been deposited by two methods obtaining good voltammetric behaviour. The electrochemically prepared Pt/CC electrode shows a better electrocatalytic behaviour for the oxidation of methanol.

Table 2. Peak potentials and current density for the oxidation of methanol. 0.1M CH₃OH + 0.5M H₂SO₄.

	E(V)	j(mA cm ⁻²)	j(mAcm ⁻²)/%Pt
Pt	0.78	50	-
Pt/CCch	1.00	39	0.72
Pt/CCel	0.90	23	1.10

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