



Characterization and single cell testing of Pt/C electrodes prepared by electrodeposition[☆]

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ABSTRACT

Electrodes for proton exchange membrane fuel cells (PEMFC) have been prepared by the electrodeposition method. For this task, the electrodeposition of platinum is carried out on a carbon black substrate impregnated with an ionomer, proton conducting, medium. Before electrodeposition, the substrate is submitted to an activation process to increase the hydrophilic character of the surface to a few microns depth.

Electrodeposition of platinum takes place inside the generated surface hydrophilic layer, resulting in a continuous phase covering totally or partially carbon substrate grains. Cross sectional images show a decay profile of platinum towards the interior of the substrate, reflecting a deposition process limited by diffusion of PtCl_6^{2-} through the porous substrate. Electrodes with different platinum loads have been prepared, and membrane electrode assemblies (MEA) have been mounted with the electrodeposited electrodes as cathode and other standard components (commercial anode and Nafion[®] 117 membrane). The electrochemically active surface area determined from hydrogen underpotential deposition charge, is lower on the electrodeposited electrodes than on standard electrodes. However, single cell testing shows higher mass specific activity on electrodeposited cathodes with low and intermediate Pt load (below $0.05 \text{ mg Pt cm}^{-2}$).

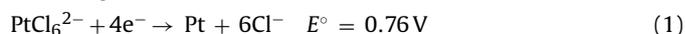
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1. Introduction

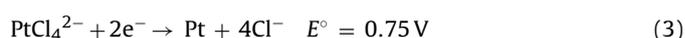
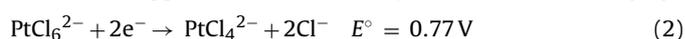
Most challenges related with proton exchange membrane fuel cells (PEMFC) reside in the electrodes, including the improvement of efficiency, life time, and cost. For this reason, the synthesis of the electrocatalyst and electrode fabrication, have become matters of basic and applied research for many groups. One technique of interest for PEMFC electrode fabrication is based on the electrodeposition of platinum [1–8]. The electrodeposition of platinum is a process used for different industrial applications, like fabrication of aviation components, electrodes, turbine blades, and in jewellery [1]. When applied for PEMFC gas diffusion electrodes, electrocatalyst synthesis and electrode fabrication take place at once, because platinum particles can be synthesised and deposited on the gas diffusion layer (carbon black substrate). Electrodeposition for PEMFC electrode fabrication has been carried out following different procedures. Platinum precursor impregnation with active layer components, carbon black and ionomer, before electroreduction, improves the interaction with carbon surface grains to

allow for high catalyst loads [2,3]. ‘Through-membrane’ deposition has also been used, using positively charged platinum precursors able to cross a thick cationic exchange membrane [4,5]. Direct deposition from aqueous solution on the carbon black substrate, previously submitted to a wetting procedure, has been carried out by means of current pulse electrodeposition, giving rise to Pt particles located in a thin layer, and demonstrating good performance as PEMFC electrode [6,7]. When compared with standard electrodes, electrodeposited electrodes show higher mass activities [8].

Different electrolyte compositions may be used, both in basic or acidic solutions, for platinum electrodeposition [9]. Hexachloroplatinic acid (H_2PtCl_6), a compound resulting from the refining of platinum concentrates by solvent extraction, is the most common precursor due to its availability, stability, and good solubility in acid media [10]. This compound reduces to metallic platinum according to:



Reaction (1) appears to be mediated by formation of PtCl_4^{2-} [11]:



If reaction (3) is slower than reaction (2), part of the intermediate PtCl_4^{2-} may remain in solution resulting in a decrease in

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