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Study of membrane electrode assemblies for PEMFC, with cathodes prepared by the electrospray method

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Abstract

The electrospray deposition of platinum supported on carbon (Pt/C) particles has been used for the preparation of electrodes for proton exchange membrane fuel cells (PEMFCs). The departing suspensions contain the Pt/C electrocatalyst together with an ionomer (Nafion®) and a solvent. Two types of solvent have been used, isopropanol and a mixture of butylacetate, ethanol and glycerol (BEG). The microscopic characterisation of electrosprayed films shows the electrospray deposited Pt/C films with a dendritic morphology. XPS analysis of the films reflects changes in the ionomer component after electrospray deposition. A decrease in the signal corresponding to backbone chain (CF_2) is observed on the films deposited with the low evaporation temperature solvent (isopropanol), indicating some disruption of ionomer chains during the electrospray process. With high evaporation temperature solvent (BEG), the disruption effect seems less acute. Membrane electrode assemblies were prepared with the electrosprayed electrodes as cathodes. Good general performance is encountered, comparable with standard commercial cathodes. Electrosprayed electrodes prepared from high evaporation temperature solvent (BEG) show a higher surface specific area. The internal resistance is something higher for MEAs with electrosprayed cathodes. The long term stability test shows a performance loss of about 10 $\mu V\,h^{-1}$ over 700 h continuous testing.

Keywords: Electrocatalyst; Electrospray deposition; Cathode; PEMFC

1. Introduction

One of the main objectives for future generations of polymer electrolyte fuel cells is cost reduction, which largely relies on a decrease of the platinum loading of the electrodes. This objective may be attained by different routes, like improved electrode preparation methods with higher control for platinum particle deposition, the search for high temperature tolerant membranes to promote electrocatalysis and hence reduce electrocatalyst requirements, or the search for new electrocatalyst materials other than platinum. Among novel electrode preparation methods, most interesting are those attaining thin films with high platinum dispersion and high surface area. In addition, the methods should be able to allocate platinum particles in a close proximity to the membrane surface to optimize the activity [1].

One interesting electrocatalyst deposition method is based on the electrospray effect. The electrospray effect consists of the transfer of a material (a liquid or suspension) to an aerosol phase (mist) under the action of an electric field [2]. From the aerosol phase, the material can be transferred to a substrate (electrospray deposition). Metal and compound nanoparticles have been deposited by electrospray and electrospray–pyrolysis with variable film morphology [3–6]. Localised deposition of organic and inorganic materials is possible with micrometric lateral resolution [7]. The electrospray effect is also applied for sample inlet in mass spectrometry [8] and for micro and nano-sized encapsulation [9].

Among the interesting properties of this technique, are the relatively simple experimental set up, which does not require special conditions in terms of temperature or vacuum, and the possibility to grow films with high uniformity and variable morphology. The electrostatic interaction between the charged particles and the surface substrate during electrospray deposition will prevent formation of agglomerates and favor the adhesion to the substrate. Surface morphology may be changed, depending on experimental parameters, such as substrate temperature,

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