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Short communication

Synthesis of the ceramic-metal catalysts (PtRuNi-TiO_2) by the combustion method☆

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Abstract

Electrocatalysis on the anode side of PEM fuel cells (PEMFC) has been widely studied, however, little information has been published on cermet catalysts, probably due to the very low or negligible power density registered when a ceramic oxide is blended with Pt based powders. In spite of this, there exists an advantage in the use of oxides, such as TiO_2. This type of oxide can exhibit a bifunctional catalytical effect, as a Pt protecting matrix in the hydrogen oxidation reaction (H.O.R.) which increases CO oxidation and also promotes hydroxide formation, thus improving the oxidation of hydrogen. In this work, a trimetallic composition of 50 mol% (Pt-Ru-Ni, 60:30:10)–50 mol% TiO_2 is investigated as anode catalyst for a PEMFC. For the preparation of this catalyst, combustion synthesis was the route selected, which allows us to achieve a powder composite with trimetallic (PtRuNi) and ceramic (TiO_2) phases. X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS) and polarisation curves (after MEA construction) are used to evaluate the catalytic activity of this type of powder. The catalyst obtained shows a single trimetallic phase with an average particle size of 8 nm. The TiO_2 was found mainly as anatase phase with an average particle size of 2–3 nm. No reaction was detected between the two phases. The high power density exhibited (107 mW cm^{-2}) with this cermet may be attributable to by a bifunctional effect on the CO and hydrogen oxidation reactions which occur during the single cell operation.

Keywords: Catalyst; PEMFC; Cermet; Polarisation curves; Pt-Ru-Ni

1. Introduction

Development of the new anode material for PEMFC and direct methanol fuel cells (DMFC) can be regarded as one of the major goals in fuel cell research. In order to achieve new catalysts with lower Pt loadings and higher CO tolerance, bimetallic [1–4] and trimetallic [5,6] compositions based on Pt have been designed. These metallic alloys have shown improved CO tolerance with significant activity towards the hydrogen oxidation reaction (H.O.R.).

In the late 1980s, White and Sammels [7] reported on ceramic materials with a perovskite structure that exhibited intrinsic catalytical activity. Although their work appeared as an alternative to the problems associated with the use of platinum as an anode catalyst, few studies have been reported on this subject. This is probably due to the very low or negligible power density that was found when a ceramic oxide was blended with Pt-based powders. In spite of this, there is an advantage in the use of single and mixed oxides in anode catalysts, as they can exhibit a bifunctional catalytic effect which increases the oxidation of CO and promotes hydroxide formation on the catalyst surface thus improving the H.O.R. in the anode.

Therefore, the use of metal oxides for this specific application has not been rejected, but compositions have focused more on the development of composite materials: ceramic-metallic (cermets) in which the oxide behaves as a compatible protecting matrix that oxidises CO which is adsorbed on the catalyst surface. This process could also be linked to the formation of hydroxide on the metallic particle surfaces, which could contribute to the improvement of the H.O.R.

On the basis of this theory Chinarro et al. [8,9] have reported the preparation of cermets in the Al_2O_3-PtRu and $SrTiFeO_{3-\delta}$/PtRu systems, which could both exhibit an improved CO tolerance and a competitive catalytical activity. However, these catalysts showed low power density, less than

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