



Effect of the support properties on the preparation and performance of platinum catalysts supported on carbon nanofibers

L. Calvillo^a, M. Gangeri^b, S. Perathoner^b, G. Centi^b, R. Moliner^a, M.J. Lázaro^{a,*}

^a Instituto de Carboquímica (CSIC), Miguel Luesma Castán 4, 50018 Zaragoza, Spain

^b Dipartimento di Chimica Industriale ed Ingegneria dei Materiali, Università di Messina, Salita Sperone 31, 98166 Messina, Italy

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ABSTRACT

Platinum nanoparticles were supported on carbon nanofibers (CNFs) for their use as electrocatalyst for PEM fuel cells. Before platinum deposition, CNFs were oxidized using concentrated HNO₃ or a HNO₃–H₂SO₄ mixture as oxidizing agents. During these treatments, new surface oxygen groups were created. Moreover, the most severe treatments resulted in the shortening of CNFs. Both effects allow to study the influence of both the morphology and the surface chemistry of CNFs on the preparation and performance of Pt electrocatalysts. Catalysts were prepared by the incipient wetness impregnation method. CNFs and electrocatalysts were characterized by X-ray diffraction (XRD), transmission electron microscopy (TEM) and N₂-physisorption. Furthermore, the performance of Pt/CNF based electrodes was compared with that of a commercial Pt/carbon black electrode (E-TEK) in a 1-cm² PEM fuel cell.

The results showed that both the surface chemistry and the morphology of the support have an important effect on the dispersion, particle size and activity of Pt catalysts. An increase in the agglomeration degree of Pt particles as the severity of oxidation treatments increased was observed. However, the performance of Pt/CNF electrodes was better than that of the commercial one. This was attributed to the CNF porous structure and to the better Pt–support interaction through the surface oxygen groups of the support.

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1. Introduction

Among the different types of fuel cells, polymer electrolyte fuel cells, PEFCs (PEMFCs and DMFCs) are the most promising for both portable and stationary applications due to its advantageous features such as high power density at low temperatures (55–95 °C), low weight, compactness, and suitability for discontinuous operation [1,2]. However, the cost must be reduced and several technological challenges must be solved before PEFCs can start to be used extensively. The fuel cell catalyst is the major contributor to these difficulties. Therefore, the major task in moving toward fuel cell commercialization is the development of breakthrough catalysts, improvement of catalyst activity, stability and durability, and the reduction of catalyst cost [2–4].

At present, the most effective fuel cell catalysts are highly dispersed platinum-based nanoparticles. These Pt nanoparticles are normally supported on carbon materials in order to increase the active surface area of Pt and improve the catalyst utilization.

Nowadays, among all kinds of carbon supports, carbon blacks are the most commonly used due to their high mesoporous dis-

tribution and their graphite characteristics. Vulcan XC-72 is the most frequently used because of its good compromise between electrical conductivity and high specific surface area [5,6]. Recently, however, novel non-conventional carbon materials such as carbon nanofibers and nanotubes [7,8], carbon xerogels and aerogels [9,10], and ordered mesoporous carbons [11,12], have been proposed as platinum supports that can achieve uniform and highly dispersed Pt loadings.

Among these carbon materials, carbon nanofibers (CNFs) have attracted a great attention as electrocatalyst support due to their unique textural, mechanical and electrical properties. Due to their morphology, CNFs have been used as electrocatalyst support without any pre-treatment. This is due to the edges of graphite planes can serve as suitable sites for the stabilization of small platinum particles [13]. CNFs have been used as Pt and PtRu support. These carbon nanofibers-based catalysts showed a better performance than the conventional catalysts supported on Vulcan XC-72 [7,14,15]. However, the last studies about the use of CNFs as electrocatalyst support are aimed at optimizing their surface chemistry in order to improve the metal–support interaction. Due to their inert nature, CNFs contain only a small number of surface oxygen groups. However, their surface chemistry can be modified by oxidation treatments in a gas or liquid phase in order to create functional groups [16–18]. These functional groups can significantly affect

* Corresponding author. Tel.: +34 976 733977; fax: +34 973 733318.
E-mail address: mlazaro@icb.csic.es (M.J. Lázaro).