

Synthesis of Pt/Carbon Xerogel Electrocatalysts for Proton Exchange Membrane Fuel Cells (PEMFC): Effect of the Reduction Procedure



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Proton exchange membrane fuel cell (PEMFC) catalysts are generally made of carbon black-supported Pt-based nanoparticles. However, carbon blacks do not display optimal properties for electrocatalysis: they may contain high amount of chemical impurities, are essentially microporous, and the final structure of the electrodes is hardly tunable, which may cause diffusional limitation within the catalytic layer [1]. A possible solution to these drawbacks is the use of synthetic nanostructured materials with a controllable and reproducible texture and with a pure, known and constant chemical composition; carbon xerogels (CX) exhibit such properties [2]. In addition, high Pt weight percentages are necessary to achieve high electrical performance with thin electrodes.

Highly dispersed CX-supported Pt nanoparticles catalysts (Pt/CX) can be prepared by the strong electrostatic adsorption (SEA) method [3,4]. This method consists in impregnating the CX support by a solution of metal precursor at an optimum pH measured beforehand (2.4-2.5 for the impregnation of CX with H_2PtCl_6 [5]). If the conditions of synthesis are well controlled, the coulombic interactions between the support and the metal precursor are maximized. Metal nanoparticles can be obtained by SEA, followed either by filtration, drying and reduction under hydrogen, or by filtration and reduction with NaBH_4 solution. In both cases, the Pt weight percentage can be increased by repeating the procedure.

Using the H_2 reduction, the Pt loading of the catalyst can reach 25 wt.% in five “impregnation-reduction” cycles. Despite their different Pt weight fractions, all the catalysts obtained by H_2 reduction display Pt particles of 2-3 nm with an electroactive surface of ca. 95 m^2 and present the same specific activity for the ORR, i.e. ca. 0.05 mA at 0.8 V vs. NHE and 0.01 mA at 0.9 V vs. NHE. The catalysts obtained by NaBH_4 reduction are currently characterized by the same physicochemical and electrochemical measurements as the previous catalysts. Up to now, first results on NaBH_4 -reduced catalysts show that the Pt particles size distribution is wider (from 1 to 10 nm with some larger aggregates), the electroactive surface is higher (ca. $150 \text{ m}^2/\text{g}_{\text{Pt}}$) and the specific activity for the ORR is about half the specific activity for ORR of H_2 -reduced catalysts. The high surface area and the low specific activity for ORR show that the NaBH_4 -reduced catalysts contain a high amount of small Pt particles (ca. 1 nm).

After their physicochemical and electrochemical characterization, these catalysts will be studied as cathode materials for PEMFC Membrane Electrode Assemblies.

References

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