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Comparison of platinum deposit methods on carbon aerogels used in Proton Exchange Membrane Fuel Cells (PEMFC)

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With the rarefaction and price increase of fossil fuels along with the consequences of greenhouse effect, many challenges have to be taken up. Consequently, a strong research effort is devoted to cleaner energy converters like fuel cells. In the car industry, Proton Exchange Membrane Fuel Cells (PEMFC) are chosen by a majority. But, remaining problems must be solved before a development at a large scale, among which: reducing the costs and increasing the power density and durability. Costs reduction mostly implies both diminishing the platinum quantity required for the oxygen reduction reaction at the cathode and increasing its activity. For these reasons, researches are devoted to the impact study of various methods of platinum deposit on the performances of new electrocatalysts and to the understanding of phenomena occurring in fuel cells.

Nowadays, state-of-the-art PEMFC electrodes supports are made of carbon blacks. However, these carbons (and as a consequence the catalytic layers) do not have a controlled texture. As a result, it is hard to understand the diffusive phenomena limiting electrochemical performances. By contrast, carbon aerogels present a controllable texture and are thus suitable PEMFC electrodes catalysts supports [1]: they conduct electrons and are permeable to reactant gases. In this study, we compare four platinum deposit methods in order to improve the catalytic activity and the platinum active surface area in Membrane Electrode Assembly (MEA) by reducing the particle size and improving the particles dispersion.

The reference method consists in a platinum impregnation by H_2PtCl_6 followed by a chemical reduction in NaBH_4 and a thermal reduction in hydrogen. Such a method (referred as reference method) leads to large particles not-well dispersed (Fig. 1a). To limit the particle growth, we filtered the impregnated carbon solution and performed simply a chemical reduction in NaBH_4 (referred as controlled reduction method, Fig 1b). Then we tested the so-called "Strong Electrostatic Adsorption" method (referred as SEA method). The latter consists of maximizing electrostatic interactions between the platinum salts and the carbon support. The SEA method leads to small (2 nm) and well-dispersed platinum particles (Fig. 1c). Finally, we applied an UV reduction on platinum impregnated carbon (referred to as UV reduction method). This method leads to such small particles (Fig. 1d) and low Pt loading that we did not evaluate it in MEA.

The three remaining electrocatalysts were electrochemically characterized in rotating disk electrode and on a single fuel cell bench (Fig. 2). The characterizations showed that decreasing the particle size and improving their dispersion does not necessarily yield to good performance (SEA method in Fig. 2). This phenomenon was attributed to chloride pollution [3]: chloride ions adsorbed on platinum indeed block the active sites and modify the oxygen reduction reaction mechanism (2 electrons mechanism instead of a 4 electrons mechanism). Such chloride pollution is very sensitive with small platinum particles and less sensitive as the particle size increase (reference method and controlled reduction method in Fig. 2).

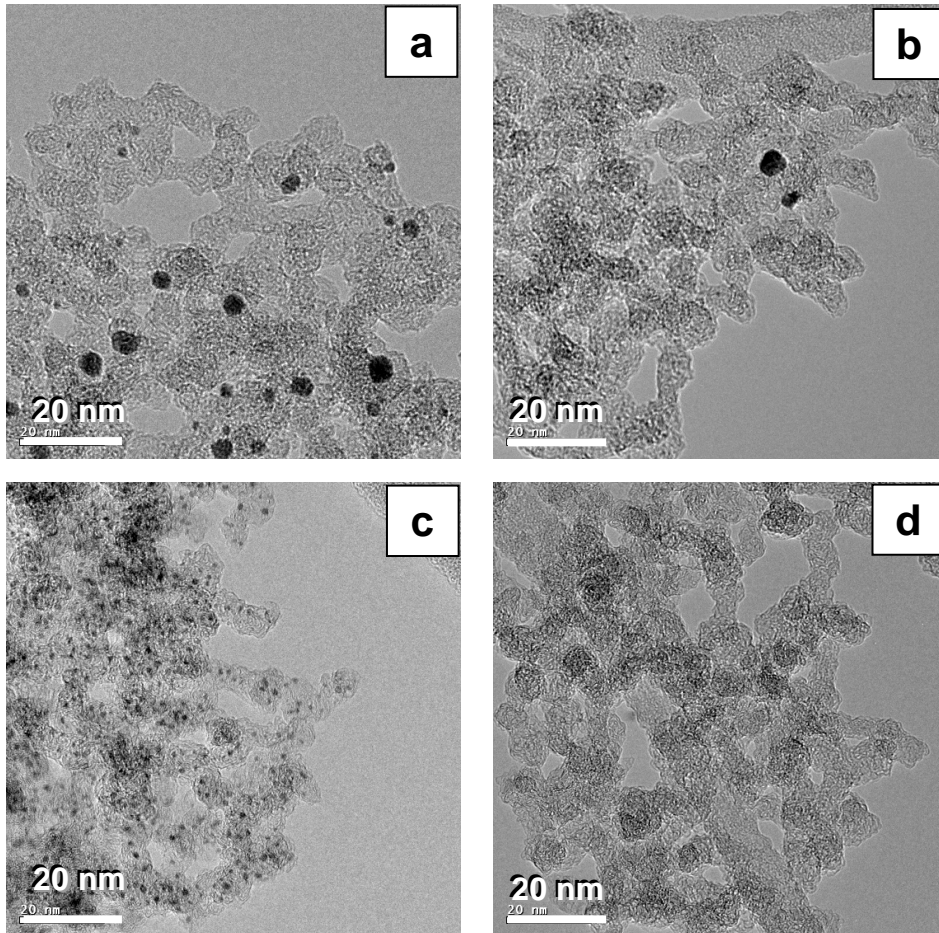


Figure 1: TEM micrographs of Pt/carbon aerogel electrocatalysts. (a) reference deposit method, (b) controlled reduction method, (c) SEA method, (d) UV method.

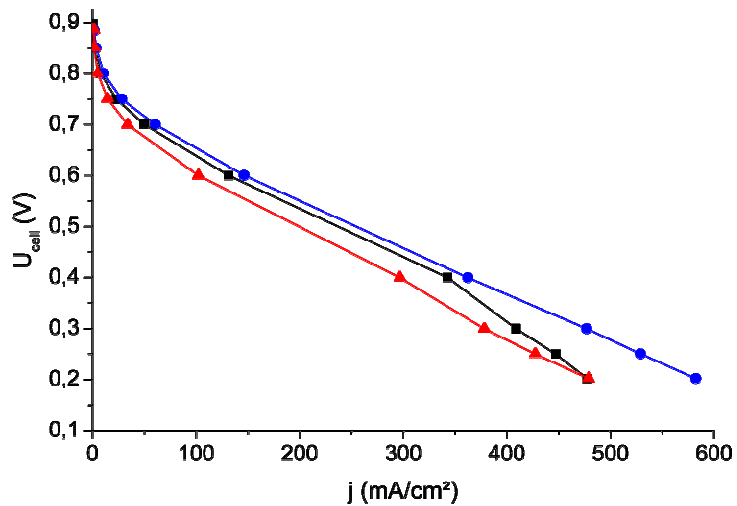


Figure 2: Polarization curves at 70°C obtained for the electrocatalysts used in MEA cathodes. (■) reference deposit method, (●) controlled reduction method, (▲) SEA method.

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