Morphology of deposits formed from electrospraying liquid suspensions

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The preparation of nanostructured materials from the deposition of electrosprayed liquid suspensions leads to granular deposits whose roughness and porosity should be properly controlled as these morphological deposit features play a crucial role in many practical applications. This is the case of the performance of such materials when used as catalytic enhancers (Martin *et al*, 2013, Castillo *et al*, 2014). Subtle changes in the liquid composition and in the electrospray working parameters affect the stability of the cone-jet mode (Martin *et al*, 2012) and therefore influence the particle arrival to the collecting surface which indeed determine the deposit structure (Rodriguez-Perez *et al*, 2007).

This experimental work aims to characterize and to control the structure of fuel cell electrodes formed by Pt/C nanoparticles (with 10% of their mass being platinum supported on carbon) and ionomer (Nafion®). A proper combination of nanoparticles and Nafion in the electrodes is needed to accommodate the electronic and protonic currents in the fuel cell whereas a large porosity is required to achieve a large exposition of catalytic active sites to the reacting gases.

A suspension of nanoparticles and Nafion in ethanol is electrosprayed toward a collecting surface where the solid residue forms a porous structure. All the particles emitted at the electrospray tip are collected on the substrate; therefore the relative amounts of the solid constituents are the same in the liquid suspension as in the deposit. Changes in the relative amount of Nafion (% of weight of Nafion with respect to the total amount of carbon, platinum and Nafion in the liquid suspension) modify the liquid conductance and promote noticeable differences on the deposit structure.

Figure 1 gathers some SEM images of deposits formed with $20\%_{wt}$ Nafion (images a&c) and $50\%_{wt}$ Nafion (b&d) and the same total mass. It becomes clear that the building blocks of the material formed with the higher amount of Nafion (SEM images b&d in Fig,1) are smaller aggregates which consist of a lower number of nanoparticles (see top views a&b). Moreover, for $50\%_{wt}$ Nafion the deposit is much higher (cross section views, c&d), and, as a consequence, its porosity is even larger.

Figure 2 depicts the deposit porosity as a function of the relative amount of Nafion in the suspension. The porosity is rather high in any case (>90%) but shows a maximum value when the mass of nanoparticles and Nafion in the deposit are equivalent. It is worthwhile to point out that when these materials are used as fuel cell electrodes, also the maximum performance was achieved for electrodes with $50\%_{wt}$ Nafion.



Figure 1. Top view (a&b) and cross section (c&d) SEM images of granular deposits from suspensions containing $20\%_{wt}$ Nafion (a&c) and $50\%_{wt}$ Nafion (b&d) with the same total mass (5.7 mg) deposited on a 5 cm² colleting surface.



Figure 2. Deposit porosity versus Nafion content.

As a conclusion, the electrodynamic atomization of liquid suspensions can be used to control the porosity of nanostructured materials according to the application needs.

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