

Electrodes from nanostructured carbons: a journey full of obstacles

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Countless carbon-based materials are used in electrochemical applications, given the versatility of their crystallography, morphology, pore texture and surface chemistry to name just a few of the key properties. In that global landscape, manufacturing electrodes from specific materials remains a challenge, whatever the targeted size or purpose. Electrodes may be necessary to characterize the properties of materials in a specific environment, or as a final component in a functional device. But in most cases, the electrodes include conductive additives, binders, electrolyte, etc. Building an electrode in such a way that the properties of the sample are fully addressed or exploited is not an obvious task, especially when it comes to nanostructured materials. Simply transferring an existing method can lead to misinterpretation of the results or underutilization of the material properties.

In this work, this quite general problem will be highlighted *via* three concrete examples in battery/supercapacitors, electrocatalysis and Proton Exchange Membrane fuel cells. In all three cases, the development of the method for assembling the material into a functional electrode was part of the research given the huge impact of the carbon structure on the observed results.

In batteries and supercapacitors, the choice of binder/solvent pair for coating the carbon onto the current collector can be crucial: indeed, the carbon microporosity can be totally covered by the binder [1], which precludes any contact between the micropore surface and the electrolyte. This effect may be desired or not, depending on the goal; it may also lead to very scattered results on similar materials in literature if the electrode manufacturing methods are different [2].

For analysing electrocatalysts supported on porous carbons on Rotating Disk Electrode, relatively thick electrodes have to be prepared compared to the standard carbon-black supported samples. Indeed, it is not possible to decrease the electrode thickness to ideal values given the granulometry of the carbon particles. If both electrocatalysts are analysed following standards established for carbon black-supported catalysts, results obtained with nanostructured carbons are flawed by errors due to mass transport limitations within the electrode [3]. As a consequence, the catalyst performance is underestimated.

Finally, for PEM fuel cells, suitable manufacturing strategies can be implemented to produce electrodes with specific architectures aiming at decoupling ion and gas transport within the catalytic layer. It is also shown that, depending on the carbon used, electron transport can become limiting, contrary to what is commonly accepted for electrodes made of carbon black.

References

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