

Chemical modification of carbon xerogels to improve the stability of PEMFCs

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Proton Exchange Membrane Fuel Cells (PEMFCs) are devices able to generate electricity through an electrochemical reaction between dihydrogen and dioxygen, with numerous applications, mainly in the transportation sector. One of the major challenges in their deployment is to improve their lifetime. To achieve this, many studies focus on the electrodes, i.e. the catalytic layers, usually made of a carbon material onto which platinum or Pt-M (M being a transition metal) nanoparticles are supported [1].

Commercially, carbon black is the most used catalyst support, however carbon corrosion causes the platinum particles to detach and/or agglomerate, resulting in a decrease of the ElectroChemically active Surface Area (ECSA). To overcome this problem and improve the catalyst stability, previous studies focused on carbons with the most crystalline structure possible [2]; however, crystalline surfaces usually lead to more mobile Pt particles, resulting also in agglomeration and loss of ECSA. The main goal of this work is therefore to improve the stability and durability of the carbon material used in PEMFCs. To achieve this, carbon xerogels [3] were synthesized and used as main support. Their advantage is their tuneable pore texture, from small mesopores to large macropores, enabling to manage mass transport within the electrode [4]; however, as disordered carbons, they are prone to oxidation upon cell operation. To tackle that issue, a more crystalline layer of carbon was firstly deposited on their surface using the Chemical Vapor Deposition (CVD) method [5]. The main advantage of this method is to block only micropores, not useful for mass transport, and to keep the mesoporosity unchanged. As a result, the material still displays enough surface (~150-200 m²/g) to deposit platinum particles. Secondly, functionalization processes were applied to these carbons (CVD-coated or not) using nitrogen-rich compounds to improve the anchoring of metal particles [6], subsequently deposited onto the carbon surface. In order to avoid the use of platinum, efforts have been made in parallel to synthesize iron-nitrogen doped carbon xerogels; indeed, those structures are well known in the field of single atom catalysts but remain to be fully exploited in PEMFCs [7].

To correlate the carbon properties with the catalyst stability, physicochemical properties and electrochemical performances were studied before and after ageing using Accelerated Stress Tests (ASTs) on Rotating Disk Electrode (RDE) configuration, in 0.5 M H₂SO₄ electrolyte. In a further step, electrochemical characterization and ASTs will be performed in complete Membrane-Electrodes Assemblies with the most promising catalysts.

References

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