Microwave-assisted synthesis of novel catalysts for the oxygen reduction reaction starting from graphene oxide and metallic precursors

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Abstract

An easy, fast, eco-friendly and reliable method for the synthesis of reduced graphene oxide (rGO)-Metal (M) based catalysts (M = Sn, Fe, Mn) as cathode materials for fuel cell application is here presented. We focused our attention in developing noble metal-free catalysts, alternative to Pt-based materials nowadays used in such systems.

Different materials were prepared by one pot process starting from graphene oxide (GO), which has been reduced to graphene while the hydrothermal synthesis and functionalization was carried out in a microwave system.

Various samples were prepared as a function of the initial metal precursor. Their morphology, chemical composition and structural properties were fully characterized by means of X-ray Photoelectron Spectroscopy (XPS), Field Emission Scanning Electron Microscopy (FESEM) and Transmission Electron Microscopy. The morphological characterizations evidenced the formation of rGO sheets for all the developed materials together with, depending on the metal precursor used, the metal functionalization, or the presence of metal oxide crystals of few nm integrated in the rGO matrix, as also witnessed by the XPS analysis.

As example, in Fig. 1 a FESEM image for the rGO/SnO_2 composite ~~in~~ is reported.

Electrical and electrochemical characterizations were performed in order to investigate the functional properties of the prepared materials, and in particular to verify their ability to catalyze the four electrons oxygen reduction reaction (ORR), that represents the key reaction at the cathode compartment of fuel cell systems. These characterizations put in evidence the ability of all the obtained materials to be effective catalysts, exploiting also a co-catalysis mechanism provided by the presence of both metal atoms and nitrogen. Furthermore, it was found a dependence of the catalyst performance on the initial metal precursor concentration, giving in such a way an indication on the best catalyst loading conditions to obtain the optimal electrode for the ORR in all the studied rGO-Metal combinations. Outstanding ORR performances near the theoretical optimum were obtained.

We demonstrated how the microwave-assisted hydrothermal synthesis should be a promising and versatile route for the preparation of different rGO-based noble metal-free catalysts, with excellent electrochemical properties as new generation cathodic electrode materials for application in fuel cells (i.e. Microbial Fuel Cells).

References

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Figure 1