Doped Graphene as a Noble Metal-Free Electro-catalyst for the oxygen reduction reaction (ORR)

Lionel Dubois[a]
C. Gheorghiu[a], P. Maldivi[a], S. Gambarelli[a], S. Pouget[a], A. Benayad[b]
[a] : *CEA-LITEN*
[b] : *CEA-INAC*
CEA ; 17, avenue des Martyrs, 38054 Grenoble Cedex 9

Lionel.dubois@cea.fr

One of the most efficient energy conversion technologies, the Polymer Electrolyte Membrane Fuel Cells (PEMFCs), which converts the energy of a fuel such as hydrogen or methanol into electricity, with zero waste emission, has been proven to be as a clean energy supply and environmentally friendly. However, on an industrial scale, several drawbacks limit the production and commercialization of the fuel cells, mainly due to the high cost and insufficiencies of platinum catalyst, used in the active layer, or due to the insufficient durability of the electrocatalysts caused by the corrosion of the carbon support.
Therefore, our present work has been directed towards the development of an efficient Noble Metal-Free Graphene-based catalyst for the ORR reaction, as an alternative to Pt-catalyst.

Graphene was proposed as the catalyst support considering its high specific surface area, high electronic conductivity, robust mechanical properties and low cost. Moreover, the electronic structure and properties of graphene sheets could be remarkably modified by sustitutional doping. In this matter, graphene oxide (GO) was synthesized in our laboratory [1], followed by heteroatom doping (nitrogen, boron, sulfur) using different doping methods and conditions, and therefore, improving the electronic conductivity and offering more active sites (defects). Additionally, in order to increase their catalytic activity, doping with 1st line transition metals (iron, cobalt) was additionally performed onto the doped graphene catalysts (Figure 1).
The characterization of the support and catalysts was carried out by: EPR, FT-IR, EA, XPS, UV-VIS, XRD, SEM and TGA.

The synthesized doped graphene catalysts showed a promising ORR activity for a non-precious-metal catalyst. Among them, nitrogen and sulfur co-doped graphene showed the highest ORR activity, whereas additional doping with non-precious metals in nitrogen-doped graphene improved their catalytic activity by 0.16V. New application for these catalyst as electrode in implantable biofuel cell will be also discuss.

References

[1] Kumar, N. A.; Gambarelli, S.; Duclairoir, F.; Bidan, G.; Dubois, L. Journal of Materials Chemistry A (2013), 1, 2789-2794.

Figures

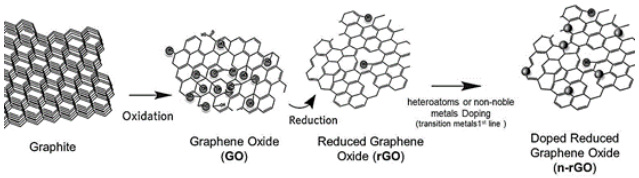

Figure 1: Synthesis of the noble metal-free graphene-based catalysts.