Electrochemical and Physico-Chemical Investigation of New Promising N-Functionalized Carbon Nanotubes for Oxygen Reduction Reaction

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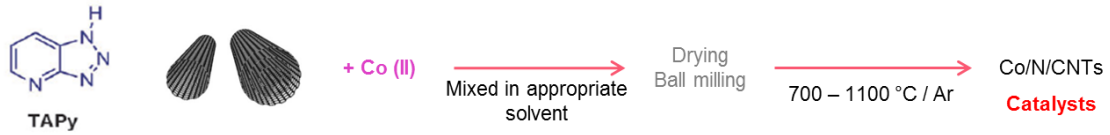
Polymer electrolyte membrane fuel cell (PEMFC) is a very promising technology that could be used for electrical transportation and/or as a stationary energy supplier (e.g. domestic applications). In such devices, chemical reactions that lead to the production of an electric current involve the oxidation of hydrogen (HER) at the anode and the reduction of oxygen (ORR) at the cathode. PEMFC operate under acidic conditions and unfortunately the conventional catalysts currently used for O_2 reduction as for H_2 oxidation are based on Pt which is scarce and very expensive. In order to meet the industrial requirements, and particularly when electrical vehicle applications are targeted, development of new efficient catalysts that could replace platinum is crucial [1].

Nitrogen-doped carbon nanotubes (NCNTs) are low cost promising alternative materials in fuel-cell catalysis [2]. We recently demonstrated that such compounds could compete with platinum in alkaline media [3] but unfortunately electrochemical activities remains unsatisfying in acidic media [4]. Thus, in order to enable a practical application of NCNTs materials (i.e. to be the closest of the performances reached with Pt), new synthetic methods must be developed allowing to obtain structural and architectural features providing enhanced electrochemical performances (high electrocatalytic activity, good stability and resistance to corrosion).

We report herein the synthesis [5] and the characterizations at different length scale of promising catalysts for the ORR prepared through the annealing treatment under inert conditions of a carefully chosen azole derivative, used as nitrogen precursors, supported on multi-wall carbon nanotubes.



Scheme 1: Method for preparing N-functionalized CNTs catalysts

This project involves advanced electrochemical analysis of the performances, combined with BET (macroscopic external surface as well as microporosity), XPS (atomic composition), SEM (macro-scale morphology) and TEM (nano-scale morphology). It leads to a better understanding of the performances (electrocatalytic activity, stability and resistance to corrosion) of designed catalysts regarding its electrochemical surface area, its porosity, its amount of nitrogen and/or cobalt, the size and the repartition of Co NPs etc... This work permits to identify key parameters that have to be considered to further improve non noble-metal catalysts that aim to replace platinum for the ORR.

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