Institut Jean Lamour

April, 25th, 2017

PhD position at Institut Jean Lamour starting October 2017

Elaboration and electrocatalytical properties of Nitrogen-doped graphenic foams as oxygen reduction reaction materials for PEMFC

Carbon-based material research team

A PhD position is available under the supervision of **Dr Claire Hérold** at the Institut Jean Lamour (IJL), Nancy, France, and **Dr François Lapicque** at the Laboratoire Réactions et Génie des Procédés (LRGP), Nancy, France, starting October 2017.

Abstract:

Proton exchange membrane fuel cells (PEMFC) have attracted world-wide research, because of their advantages, including zero/low emissions, high energy efficiency, and high power density. At the current technological stage, platinum-based nanoparticles supported by microporous carbon materials are the most efficient catalysts in terms of catalytic activity and lifetime stability, but also induce a high cost of fuel cells. It is admitted that the properties of the carbon support exert a strong influence on the performance of the metal supported catalysts, related to their morphology, size distribution and stability. Carbon blacks are the most commonly used supports in many studies and commercial applications but they are subject to corrosion under PEMFC cathode conditions. During the last years, the IJL group has developed three-dimensional graphene based-structures, because of their outstanding properties. Their preparation is based on an original bottom-up method of elaboration developed by the IJL group, which consists in solvothermal reaction between metallic sodium and ethanol, followed by a thermal treatment. The obtained material is a graphenic foam combining the properties of graphene and micro- and mesoporous texture with a large specific surface area (2630 $m^2.g^{-1}$). During this project, this promising material will first be used as a catalyst support. Platinum nanoparticles will be deposited by a chemical vapor transport method already successfully used in the IJL group for preparation of Mo-based and W-based nanoparticles. Gaseous $PtCl_4$ is put in contact with the graphenic foam, under chlorine atmosphere. After impregnation, the platinum-based particles are reduced under controlled partial pressure of H_2 into metal Pt. In a second phase, the catalytic activity of the graphene foams will be increased by functionalization of this material with nitrogen: for this purpose, ethanol will be replaced by ethanolamine. The synthesis conditions will be determined in such a way that the N doping atoms are inserted in the graphitic network rather than grafted in the form of amine

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functions. This will allow the amount of platinum to be drastically reduced. The obtained electroactive material (substrate + catalysts) will be analyzed using various complementary bulk techniques e.g. XRD, TEM, Raman spectroscopy, adsorption, TGA together with surface characterization by XPS in order to optimize the elaboration conditions. The measurement of the water sorption isotherms and kinetics will be carried out to determine the affinity of the material towards water. Their electrochemical performances will be first evaluated in a half-cell device in a preliminary screening for oxygen reduction reaction. In a second stage, the most promising materials will be tested in a real fuel cell in terms of energy conversion performance, then durability using various ageing techniques developed by LRGP.

Candidate profile:

The candidate is expected to be highly motivated and capable of working independently, with a qualification of a Master's level in Materials Science/Inorganic or Physical Chemistry. Ground knowledge of electrochemistry would be appreciated, since the work will concern novel materials, chemical/electrochemical characterization plus *in situ* validation of the materials in electrochemical cells. This PhD student will participate in project meetings and international conferences. High level in French or/and English language is essential.

To apply for the PhD position, please send a CV, the names of two referees and a cover letter not later than May 30th, 2017 to:

- Dr C. Hérold, claire.herold@univ-lorraine.fr
- Dr S. Fontana, sebastien.fontana@univ-lorraine.fr
- Dr F. Lapicque, francois.lapicque@univ-lorraine.fr

For further details and questions, please contact Dr S. Fontana.

In collaboration with :

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