**PhD proposal**

**PhD title: Pillared-graphene materials for supercapacitors: from material development to electrical double-layer characterization**

***PhD project description:***

A PhD position is open in IRIG at the CEA Grenoble to work on the development of porous carbon materials for electrochemical storage.

Exploring expanded graphene structures for ion sorption is an approach followed to improve the storage performances of electrochemical double-layer capacitors (EDLC), also known as supercapacitors (SCs). Compared to standard reduced graphene oxide, these assemblies allow to tune two key parameters of EDLC: 1) increasing adsorption active surface area, and 2) enabling a matching between pore sizes and electrolytic ions size. Recently, in our group, such a class of pillared graphene materials - using alkyl diamines as pillars – has been synthesized and showed improved storage performances.

The goal of the PhD project is to develop a 2nd generation of pillared graphene assemblies to obtain further improved performances . These architectures will be obtained using pillar molecules selected to promote ions intercalation and transport (polarity modification or electrolyte nature). Redox active pillars will also be tested/synthesized to try to add a faradic component to the system in order to provide increased energy density. The electrochemical evaluation of the materials will be performed in order to qualify these new systems with respect to other existing non-expanded carbon materials. Characterization of these materials in pristine and in electrode form will be conducted to evidence possible relationship between chemical/structural/morphological properties of the materials and electrochemical performances. The ion transport inside these structures is truly a key aspect that will be studied notably by means of ex-situ ss NMR. This in-depth investigation of the electrical-double layer formation mechanism inside these materials will allow to optimize further the materials and cells providing the next generation of energy storage devices.

***Technical content of the PhD project:***

The tasks of the PhD will be to design, synthesize and characterize the next generation of pillared graphene materials. Physico-chemical characterization will be performed on all samples to allow a comprehensive comparison of the various materials properties. The most interesting graphene–based assemblies will be selected and tested electrochemically in supercapacitor cells. The formation of the electrochemical double-layer as well as the ionic charge transfer will be investigated by means of ss NMR.

***Outcome for the student:***

The PhD student will take part to a project in link with the societal challenge of energy storage. He/She will also gain extensive multidisciplinary knowledge on electrochemical storage, supercapacitors, and graphene-based materials, as well as hands-on operating skills on a lot of characterization equipment. In the course of this PhD work, the student will have been trained to be an active member of laboratory life reporting their work, taking part in manuscript writing, and presenting work to various audiences.

***Information about host laboratory***

The PhD will take place in the CEA Grenoble, in the Interdisciplinary Research Institute of Grenoble (IRIG), where researches in biology, health, nanosciences, cryotechnologies and new technologies for energy and environment are conducted.
The student will be part of the SyMMES/CAMPE laboratory. CAMPE team designs and studies molecular systems, macromolecular or materials with targeted electronic properties through multidisciplinary approaches combining synthesis, physico-chemistry, spectroscopy and theoretical chemistry. The main research topics of the team are focused on energy conversion and storage (batteries, PV, photocatalysis, fuel-cell) as well as on the study of complex paramagnetic systems (magnetic polymers, metalloproteins).
The student will also spend time in the MEM/RM laboratory to work on the ssNMR analyses and understanding of the samples. This laboratory combines targeted methodological developments with theoretical advances and instrumentational breakthroughs to permit the atomic-level characterization of systems of interest for both health and energy. Solution- and solid-state NMR spectrometers for routine and advanced analyses are available and notably, dynamic nuclear polarization (DNP) combined to solid-state NMR.

***Student profil***

The student should be about to graduate from a M2 Research in a topic related to chemistry, electrochemistry or material chemistry. The student should also be interested by the field of energy storage.

***Contact information***

Please send CV, cover letter and L3/M1/M2 marks to: florence.duclairoir@cea.fr