Development of graphene-based assemblies designed for electrochemical storage

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PhD may follow: Yes

Summary :

This project is focused on the use of graphene based materials (GBMs) in supercapacitors (SC) applications as graphene theoretical surface area, mechanical resistance and conductivity are attractive to obtain performant SCs. However the expected high surface area for single layer graphene (~3000 m2/g) is never achieved as graphene sheets restack to each other by Ï€-Ï€ stacking; hence the electrolytic ions sorption surface obtained experimentally is drastically lower than theoretically expected and leads to average device performances.

The group recent researches deal with the preparation of graphene oxide derived samples designed to limit this phenomenon or get around it to enhance storage capacitance in SCs. Hence, the goal of the internship project is to develop structured graphene matrixes in order to achieve improved storage performances in supercapacitor (SC) cells . Methodologies will be based on graphene functionalization with bi-functional pillar molecules selected to form graphene galleries and to promote ions intercalation and transport. The student will perform the material preparation/characterization and will conduct electrochemical evaluation in SC cells.

Full description :

Electrochemical double-layer capacitors (EDLC), also known as supercapacitors (SCs), are devices that store energy through charge separation from electrolytic ion sorption on charged electrode surfaces. Porous carbons such as activated carbons (ACs) are traditionally used as electrode materials due to their high surface areas and low costs. In parallel to ACs, various graphene derivatives have been proposed as potential materials for SCs owing to their high electrical conductivities, large surface areas and mechanical flexibilities. Reduced graphene oxide (RGO), readily prepared from graphene oxide (GO), is extensively studied as a model graphene-like material. RGO displays good power capability but suffers from low capacitances as the reduced graphene sheets partially restack through Ï€- Ï€ interactions.

It has been shown that graphene sheets could be assembled to form structured graphene frameworks to limit this restacking but also translate the properties of individual sheets to functional materials and allow practical applications. The key features of these frameworks in terms of electrochemical storage applications are their graphitization level, their structural or textural disorder, and their porosity.

Exploring the layered structures of graphene derivatives for ion sorption is another approach followed to avoid graphene layers restacking. The graphitic stack with 3.3 Ã… inter-layer separation is too small for ion sorption but could be tuned with an intercalant to exhibit an expanded layer structure. Recently, in our group, we synthesized a class of pillared graphene materials with varied inter-layer separation using alkyl diamines as pillars (Fig. 1), speculating that such expanded layered structures could offer additional ion sorption sites and improve storage performances in supercapacitors (SCs). These pillared graphene materials have then been assembled into graphene hydrogel to optimize the ions transport inside electrode bulk porosity. The impressive storage performances achieved demonstrated the success of this strategy.

The specific objectives of this internship are to synthesize and characterize such pillared graphene materials. New pillar molecules chosen to facilitate and promote the ions transport inside the graphene galleries will be tested. Graphene assemblies with varying bulk porosity will be prepared. Physico-chemical characterization will be performed on all samples to allow a comprehensive comparison of the various materials properties. The most interesting grapheneâ€"based assemblies will be selected and tested electrochemically in supercapacitor cells.

This internship will hence involve i) to perform basic synthetical steps, ii) to conduct selected characterization on the carbon architectures (TGA, IR, SEM) ii) to take part to specific analysis (XPS, XRD) and iii) to do electrochemical characterization of the materials. The student will have an active part in the laboratory life and will be asked to report on his work.

Requested skills :

To carry out this project we are looking for students with a background in chemistry and who are now in a Nanoscience related Master Research.
Surface chemistry/characterization knowledge and an interest for the energy storage field would be appreciated.