Graphene and few layer graphene (FLG) synthesis methods

Izabela Janowska[a], Ovidiu Ersen[b], Kambiz Chizari[a], Spyridon Zafeiratos[a], Dominique Bégin[a], Marc-Jacques Ledoux[a], Cuong Pham-Huu[a]

[a] Laboratoire des Matériaux, Surface et Procédés pour la catalyse (LMSPC),
UMR 7515 CNRS-Université de Strasbourg, France
[b] Institut de Physique et Chimie des Matériaux de Strasbourg (IPCMS)
UMR 7504 CNRS- Université de Strasbourg, France
janowskai@unistra.fr

Three new different synthesis methods of graphene and few layer graphene (FLG) materials were developed.
Two of them were based on the use of the microwaves irradiation, the first one: to induce the catalytic unzipping of the carbon nanotubes and an exfoliation of the expanded graphite in the second one [1, 2]. The last method, very recently developed, was based on the use of the mechanical thinning of graphite based materials [3]. All methods have different advantages: unzipping of the carbon nanotubes allows the control of the number of the graphene sheets in the final products, the FLG obtained from the expanded graphite consist of big size (up to few tenth micrometers) sheets and finally the third method results in high yield (up to 60%), low cost and process simplicity which make it very promising for the industrial scale applications. The obtained graphene and FLG were characterized by different microscopic and spectroscopic techniques such as TEM, TEM-SAED, TEM-DF-SAED AFM, XPS, IR. The theoretical simulations using Reactive Forcefields show that the presence of the catalyst nanoclusters and oxygen at the carbon nanotubes decreases the energy barrier during their unzipping process. An example of the TEM of few micrometer size graphene sheets and TEM-DF-SAED are presented on the figure below.

References

[1] I. Janowska, O. Ersen, T. Jacob, P. Vennégues, D. Bégin, M.-J. Ledoux, C. Pham-Huu, App. Catal.A, **371** (2009) 22.
[2] I. Janowska, K. Chizari, O. Ersen, S. Zafeiratos, D. Soubane, V. Da Costa, V. Speisser, Ch.

Boeglin, M. Houllé, D. Bégin, D. Plee, M.-J. Ledoux, C. Pham-Huu, Nano Research, **3** (2010) 126-137.

[3] Préparation de graphène par amincissement mécanique de matériaux graphitiques.
Janowska I., Bégin D., Chizari K., Ersen O., Bernhardt P., Romero Th., Ledoux M. J., Pham-Huu C.
PCT/FR2010/000730 (2010).

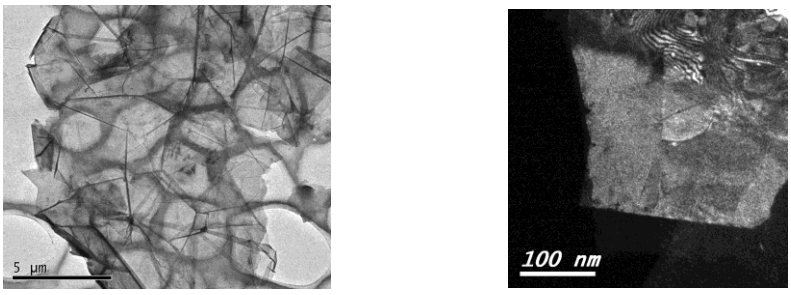

Figure: *TEM (left) and TEM-DF-SAED (right) images of the graphene materials obtained by exfoliation of the expanded graphite under microwaves irradiation.*