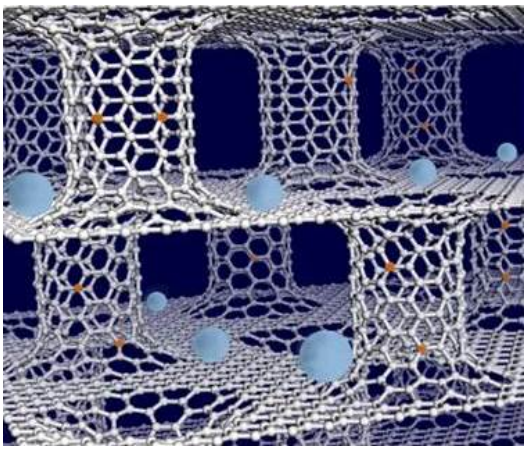
ITALY AND CHINA MEET FOR STRENGTHENING THEIR EFFORTS ON GRAPHENE RESEARCH

Gaetano Granozzi - Stefano Agnoli
Dipartimento di Scienze Chimiche
Università di Padova
gaetano.granozzi@unipd.it



Last September the first bilateral meeting between Italy and China on graphene was held in Dalian, at the Dalian Institute of Chemical Physics of the Chinese Academy of Sciences (CAS). The meeting was focused mainly on interesting properties and applications presented by graphene based materials, either chemically modified and/or developed in three dimensions. The Italian delegation, made up of 15 researchers from various institutions (Universities, National Research Council and IIT), and organized by the Italian Embassy in Beijing, met with as many colleagues of the best Chinese institutions (Universities and CAS), thus reinforcing the synergies existing and creating new ones. In this context we have identified some areas of common interest on which center future research

Italia e Cina si incontrano per rafforzare i loro sforzi di ricerca sul grafene
Il 20 e 21 settembre 2014 si è svolto a Dalian, presso il Dalian Institute of Chemical Physics della Chinese Academy of Sciences (CAS), il primo meeting bilaterale Italia-Cina sul grafene, focalizzato principalmente sulle interessanti proprietà ed applicazioni presentate dai materiali a base grafenica modificati chimicamente e/o sviluppati tridimensionalmente. La delegazione italiana, formata da 15 ricercatori di varie istituzioni (Università, CNR e IIT), ed organizzata dall'Ambasciata Italiana a Pechino, si sono incontrati con altrettanti colleghi delle migliori istituzioni cinesi (Università e CAS), rinforzando così le sinergie già esistenti e creandone di nuove. In questo contesto sono state individuate alcune aree di interesse comune sulle quali centrare le future ricerche.

The first bilateral workshop between Italy and China on graphene research has been held in Dalian from 20th to 21th September 2014. Such event has been organized by the Scientific Office of the Italian Embassy in Beijing in cooperation with the Dalian Institute of Chemical Physics of the Chinese Academy of Sciences (CAS) and the Department of Chemical Sciences of the University of Padova. The workshop was actively attended by about 30 researchers, among the most representative of the two countries, and a large number of local students. The chairpersons of the conference were Gaetano Granozzi (University of Padova) and Xinhe Bao (CAS). Plinio Innocenzi, Scientific Counsellor of the Italian Embassy in Beijing was also attending the meeting as an active researcher in the field.
The Italian delegation was composed by 15 researchers whose institutions are outlined in Fig. 1. The Chinese delegation was composed by 15 researchers from the most renowned Chinese institutions (Beijing, Nanjing, Tianjin, Sichuan Universities and several CAS institutes, see Fig. 2).

Fig. 1

Fig. 2

Graphene is an extremely intriguing material that is arousing a formidable interest in many different fields since it was first produced in a conscious manner in a lab in 2003. Since then, it has gained a clear prominence among materials thanks to its exceptional properties, e.g. superb carrier mobility, high surface area, excellent thermal conductivity, elevated intrinsic mechanical strength. It has been anticipated that graphene will withstand the normal seven-step sequence for any new technology: hope-hype-boom-bust-disillusionment-shakeout-profitability and meet expectations for profitability even faster than the other carbon allotropes. Nowadays, the forefront of research has progressed from the simple graphene preparation and characterization toward *second generation* graphene-based materials, e.g. chemically-modified graphene, and *third generation* 3D systems based on the assembly of graphene and/or chemically-modified graphene sheets. In the meantime, other 2D materials have entered into the focus, often referred as graphene-related materials, e.g. h-BN, transition metal chalcogenides, topological insulators.
Because of these extraordinary and tuneable properties, these systems can be used as an advanced platform in many technological fields, e.g. energetics, catalysis and electro- and photo-catalysis, sensing, microelectronics... This is the reason why there is a worldwide race toward either technological implementations with *first generation* graphene or a deeper understanding of the innovative properties of *second* and *third generation* graphene-based materials.

The recent start of the European Graphene Flagship is witnessing the strategic interest of Europe in this field. Within this initiative, Italy can boast a large number of Research Units.
On its side, China is the country that is investing by far the largest resources in this field and has built one of the most advanced graphene-based platforms in the world. China in 2013 filed 40% of the world patent applications on graphene, compared to 9% of the European Union. Similarly, the number of scientific publications in 2013 originated in China is about 12,000 against 300 in Italy, 300 in France and 600 in Germany.
The industrial investments on graphene in China have developed with great speed: in October 2013, the first factory of the production of graphene, the Hebei Jianhua Tanshan with a capacity production of 500 tons per year, was set up, followed in November 2013 by Changzhou Sixth Element (100 tons), in December of 2013 by Ningbo Moxi (300 tons), and finally in February of 2014 by the New Materials Hongna (1,000 tons), for a total of 1,900 tons of capacity of graphene production per year. So far the investment has been of ca. 1 billion Yuan, about 125 million euro. The estimate is to reach a capacity to produce more than 10,000 tons per year within the next three years, becoming by far the largest producer of graphene in the world. The expected reduction in price could make graphene competitive in many innovative applications.
During the workshop the most recent advancements in the two countries in the research on graphene and chemically-modified graphene-based materials were discussed, and also advocated and delineated some viable routes of collaboration between the two countries.
In particular, during the very interesting Round Tables dedicated to tailor the future scientific and technological *scenarios*, it emerged that the next generation (2D and 3D) graphene-based and graphene-related materials are most suitable for reinforcing the many efforts nowadays spent on reaching the goal of a sustainable energy growth. This allowed to single out the following main fields were the target materials can play a relevant role: catalysis, electro-catalysis, photo-catalysis, photovoltaics, fuel cells, batteries, supercapacitors and sensors.
In particular, the following topics have been considered as strategic:

- innovative and scalable preparation routes for chemically-modified , 2D and 3D organized, graphene-based materials;
- innovative tools for the characterization of their structural, chemical and functional properties;
- surface science based approaches to prepare and characterize complex interfaces and exotic heterostructures formed by artificially 2D stacking of chemically-modified and graphene-related nanosheets (i.e. graphene/h-BN, graphene/chalcogenides);
- new routes for their integration into composites with oxides and polymers, such as plastics and ceramics;
- development of advanced electrodes based on 3D materials that could combine chemical activity with high surface area and superior electrical conductivity to be used in photovoltaic, battery supercapacitor and fuel cell technologies;
- study of the catalytic activity of chemically-modified graphene-based materials that could be exploited as low costs and sustainable catalysts as an alternative to precious metals for the production of strategic chemical commodities.