

## RESEARCH CONFERENCES

### ESF Research Conference

**Nanocarbons 2011: Carbon Nanotubes and Related Materials: From Physico-Chemical Properties to Biological and Environmental Effects**

**6 - 11 September 2011**

**Hotel Villa del Mare, Acquafredda di Maratea, Italy**

**Chaired by:**

Dr. Sophie Lanone, Inserm U955 - Équipe 04, FR

**Co-Chairs:**

Dr. Pascale Launois, CNRS-Université Paris 11, FR  
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## Conference Highlights

*Please provide a brief summary of the conference and its highlights in non-specialist terms (especially for highly technical subjects) for communication and publicity purposes. (ca. 400-500 words)*

Nanomaterials (with one or more dimension in the 1-100 nm range) have specific properties mainly governed by quantum physics or surface effects, and significantly different from those of macroscopic objects. Emblematic nanomaterials are carbon nanotubes, which have generated a worldwide, and highly competitive, scientific research activity. Because of the particular properties associated with one-dimensional objects, numerous potential applications of nanotubes are envisaged in areas such as aerospace, automobile, nanoelectronics and medicine. Assessing the risk of carbon nanotubes for health and environment is a strong matter of concern having many scientific and societal implications. A major issue is that the physico-chemical determinants of such biological or environmental effects of nanotubes are not well understood yet.

Handling these questions efficiently requires the training of scientists through an interdisciplinary approach benefiting from interactions between experts in biology, medicine, environmental and materials science (dealing with synthesis and characterization of nanotubes). This problematic was extended to other nanotubes (titanium oxide and imogolite nanotubes, which, compared to carbon nanotubes, have similar size and shape but different chemistry) and to other emerging carbon based nanomaterials such as graphene (different size and shape, similar chemistry).

We therefore proposed an interdisciplinary research conference on 'Carbon nanotubes and related materials; from physico-chemical properties to biological and environmental effects'. This conference offered young scientists both state-of-the-art plenary lectures, essential for the interdisciplinary approach proposed, and specialized seminars, which included the most recent development in different fields. A particular attention was given to accessibility and exchange of competences between the different disciplines.

The program of Nanocarb'11 conference focused on four general topics that were considered by the scientific committee as major axes of CNT research.

The first topic was synthesis/characterization of CNT. Here, we defined the main synthesis procedures, and methods for CNT characterization allowing for a reliable physico-chemical knowledge of CNT. The second topic was about CNT chemistry, with a focussed on their surface modification, and chemistry of catalyst nanoparticles. The third topic was toxicity of carbon nanotubes. The issue of what are the critical determinants of carbon nanotubes effects on health, their *devenir* and occupational exposure was addressed. Finally, the fourth topic was related to the environmental effects of carbon nanotubes. A state of art on what is currently known on CNT environmental effects and life cycle was provided, with the aim of linking them to physico-chemical characteristics of CNT.

I hereby authorize ESF – and the conference partners to use the information contained in the above section on 'Conference Highlights' in their communication on the scheme.

# Scientific Report

## Executive Summary

(2 pages max)

The conference took place at Acquafredda di Maratea (Italy), from September 6 to 11, 2011. There were 74 participants total, including 16 speakers (30% female) and 4 organizers (50% female). 67% of them came from European Union countries and 36% were female. Participants came from very different scientific communities: there were chemist, physicists, biologists and physicians who met and discussed together. In our opinion, this is one of the important achievements of the meeting.

The program was organized as follows:

- 17 lecture of 1 hour each (45 minutes talk, 15 minutes questions). Five of them were on CNT synthesis and characterization, 3 on pure chemistry of CNT, 4 on toxicity aspects of CNT, and 3 on environmental effects of CNT. Finally, one lecture was on imogolite CNT, and one lecture was on nanoribbons, as other types of carbon materials;
- 1 round table addressed the connection between CNT and asbestos;
- 10 short talks of 15 minutes each, selected among the abstracts from the participants;
- 1 poster session on the second evening, the posters being held during the whole duration of the conference.

We tried to first have general lectures on the different topics, in order to get an overview of each field, and then, along the days, to focus on more specific matters, with more specialized lectures.

At their arrival, each participant received a booklet containing the program, speaker abstracts and addresses of all participants.

We were able to raise a total of 45.5 k€, including 2 k€ obtained from ESF. The funding were obtained from ADEME (28k€), CNRS (8 k€), French research ministry (3 k€), Inserm, (2.5 k€), C'Nano Île de France (3 k€). With these funds, we were able to pay full grants (travel + accommodation) for speakers and organizers. Moreover, some participants were granted with partial (375 €, n=32) or full (750 €, n=13) accommodation grants, and full (n=40) or partial (n=5) travel grants, based on age, status and country criteria. These travel grants were of a maximum of 500 € (full) or 250 € (partial) for participants form Europe, and of 1000 € (full) or 500 € (partial) for farther countries.

## Scientific Content of the Conference

(1 page min.)

▪ *Summary of the conference sessions focusing on the scientific highlights*

The program of Nanocarb'11 conference focused on four general topics that are considered by the scientific committee as major axes of CNT research. To stress the interdisciplinary approach of the conference, no thematic session was organized as such, but rather all topics were broached every day. The lectures were arranged so as to get a progressive focused knowledge on each topic during the 4 days of the conference. Each topic was firstly broached by the mean of at least one general lecture, aimed to bring basic knowledge in the field for scientists coming form other field(s). The subsequent lectures of each topic were more focused on particular matters.

The first topic was **synthesis/characterization of CNT**. Here, we defined the main synthesis procedures, and methods for CNT characterization allowing for a reliable physico-chemical knowledge of CNT. Different aspects of synthesis and growth of CNT were mentioned in the context of 4 different lectures, as well as description of the various methodological issues on how to relevantly characterize CNT. It appeared that there are many kinds of nanocarbons (0d, 1d, 2d), many types of defects, many physical states (isolated, mix of chiralities, agglomerated, entangles, suspended, ...), many "everything" in CNT samples. It is more or less easy to produce CNT in sizable quantities, but it is truly difficult to control the homogeneity, purity, monodispersity, quality, ... of the sample. On the characterization side, a general remark was that not so many easy-to-use techniques are available: optical confocal microscope combined with micro-Raman, photo-thermal optical microscopy, fluorescence microscopy, scanning electron microscopy, cryo-transmission electron microscopy, X-ray fluorescence or nuclear micro-probe technique (with isotopic markers). The take-home message here was that it is very important to characterize the nanomaterials one is playing with.

The second topic dealt with **CNT chemistry**, with a focus on their surface modification, and chemistry of catalyst nanoparticles. Three lectures were devoted to that subject, including a general one on different functionalization processes (the point of view of a chemist). CNT may have plenty of surface defects that may help for functionalization, but that may also have a role in the toxicity of raw material. An important point was raised regarding the fact that the majority, if not all the CNT used for toxicity studies are pristine (not intentionally functionalized).

The third topic was **toxicity of CNT**. The issue of what are the critical determinants of carbon nanotubes effects on health, their *devenir* and occupational exposure was addressed. A state of the art on what is currently known on CNT biological effects was provided, with the aim of linking these effects to the physico-chemical characteristics of CNT. The question of what property really matters has been raised; it is size (length, width), shape (aspect ratio), surface reactivity, agglomeration, ...? Moreover, similar issue has been raised regarding the question of what metric is the good one (mass per volume, dose per time, cumulative number of nanoparticles ...)?

Finally, the fourth topic was related to the **environmental effects of CNT**. A state of art on what is currently known on CNT environmental effects and life cycle has been provided, with the aim of linking them to physico-chemical characteristics of CNT.

▪ *Assessment of the results and their potential impact on future research or applications*

A major issue of the conference was to put together different actors of CNT research (physicists, chemists, biologists and physicians) to get them to discuss together and exchange point of views, with an interdisciplinary approach. The conference was a large success on this matter, as a large amount of time was spanned on interdisciplinary discussions among participants. This should have a great impact on future research on the field.

One consensus thought that has been issued during the conference is the crucial need, for every scientist (whatever his/her field of expertise), to extensively characterize what he/she is dealing with. This is a very important issue and it was essential that researchers from various fields of competence (beside physicists, who are in charge of this characterization) became aware of this need. This should have a large impact on future research, too, and allow a better understanding and management of nanocarbon research.

Four major take-home messages have been given to the participants:

- Compared with other nanomaterials, CNTs and fullerenes are characterized by low hazard and low risk; by comparison, both are much higher for ZnO nanoparticles
- Applying a risk management policy may reduce the concentration of airborne nanoparticles in a laboratory below the detectable level
- There is a real need for more and more communications between scientists working in different disciplines
- It should be nice to rely on standard nanoparticles produced by a provider, the same for everyone, with well-documented properties

## Forward Look

(1 page min.)

- *Assessment of the results*
- *Contribution to the future direction of the field – identification of issues in the 5-10 years & timeframe*
- *Identification of emerging topics*

An important methodological issue has been raised regarding the lack of standardization in toxicological and ecotoxicological studies. Such a lack limits the usefulness of the results obtained so far. Discussions during the conference helped scientists from all topics to understand this absolute need for standard protocol. Moreover, a point made by physicist and chemists was to develop standardized methods of synthesis and characterization. Another methodological issue that everyone agreed on was the need to extensively characterize the nanomaterials one is working with. It is the only way to understand and trust the results obtained with the nanomaterials, in terms of biological, toxicological, ... effects. Those two methodological issues should be worked on ASAP, as they are essential for the comprehensive and systematic understanding of the topic as a whole.

An important issue essentially for biologists is to be able to localize nanomaterials, and their evolution inside the cells: nucleus, cytoplasm, membrane? Tools that are available so far are very time-consuming and not always easily accessible (X-ray microfluorescence for example, available only in synchrotron facilities). Moreover, a general remark was that care must be taken when looking at nanomaterials in general, and CNT in particular, inside cells: "What appears black in a histological section does not mean that there are nanoparticles agglomerated there !".

- Is there a need for a foresight-type initiative?

Yes. NanoCarb'11 is the second edition of such Conference (see ESF report on NanoCarb'09 held in Acquafredda di Maratea in September 2009), and we had very positive feed-backs from former as well as current participants.

When organizing the conference, the chair and co-chairs felt, that there was a strong need in the field of nanotechnologies for interdisciplinary approaches. Discussions during the meeting (at the end of each talk as well as in specialized discussion sessions, and the round table) reinforced us in this conviction. Indeed, there have been several 'naïve' questions from scientists of another field showing the need for clarifications by specialists, as well as many fruitful exchanges between people belonging to different fields.

At the end of the meeting and after the meeting, participants as well as speakers declared that it would be necessary to continue organizing interdisciplinary conference on the subject. The detailed project has still to be refined. A proposal for a new event was therefore deposited in the current call for ESF Conference.

## Atmosphere and Infrastructure

- *The reaction of the participants to the location and the organization, including networking, and any other relevant comments*

The participants were pleased by the wonderful location of Acquafredda di Maratea and by the organization ESF helped us to provide. We had a last-minute issue (general transport strike in Italy) which made us have an almost 24 hours delay at the begin the Conference, but everything went smooth, thanks to our ESF officer Anne Blondeel-Oman.

We really felt that the conference was more than just a meeting on nanomaterials, or a collection of lectures. There was much more an atmosphere conducive to easy exchange information. A few participants already present at NanoCarb'09 were there, and they were still very enthusiastic regarding the new edition of NanoCarb. Some of them presented results that were obtained thanks to collaborations established after the first NanoCarb conference, and we are confident that NanoCarb'11 will give birth to more collaborations of that type.

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