

RESEARCH CONFERENCES

ESF Conference

Nanocarbons: From Physicochemical and Biological Properties to Biomedical and Environmental Effects

Hotel Villa del Mare, Acquafredda di Maratea • Italy
8-13 September 2009

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Highlights & Scientific Report



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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)

Nanotechnologies, defined as techniques aimed to conceive, characterize and produce materials at the nanometer scale, are a fully emerging domain. Among nanomaterials, carbon nanotubes (CNT), discovered in 1991, have amazing technical, thermal and electrical conductivity, as well as excellent field emission properties. Actual uses of CNT are already about to be numerous (car industry, sport accessories, etc), and future applications are foreseen to be in constant development (in the biomedical field for example). The very same properties that make CNT very attractive for chemists, physicists and biologists also raise questions about their potential toxicity, possible long-term secondary effects, and/or biodegradability. Physico-chemical properties of CNT, such as size, aggregation, functionalization, etc seem to be critical not only for their potential uses and applications, but also for their biological and toxicological effects. However, a comprehensive and systematic understanding of this subject as a whole still needs to be acquired, particularly when considering the very promising biomedical applications of CNT (as drug delivery systems for example).

We therefore set up a pluridisciplinary conference, aimed to give the different actors of CNT research (physicists, chemists, biologists, physicians) the proper level of knowledge required to discuss with the other participants and understand each other correctly. A particular attention has been given to accessibility and exchange of competences between the disciplines.

The program of Nanocarb'09 conference focused on four general topics.

- The first topic was synthesis/characterization of CNT. Different aspects of synthesis and growth of CNT were broached, as well as description of the various methodological issues on how to relevantly characterize them. It appeared that there are many types, many shapes, many compositions, many "everything" in CNT samples. The take-home message here was that it is very important to characterize the nanomaterials one is playing with.
- The second topic was about CNT chemistry, with a focus on their functionalization, and its consequences in terms of physical and chemical characteristics, and applications/uses of CNT in the medical field. A large discussion was opened between chemists and biologists concerning the meaning of "functionalization" and the definition of "biocompatibility". An important point was raised regarding the fact that the majority, if not all, of the CNT used for toxicity studies are pristine (not intentionally functionalized).
- The third topic was biomedicine, with the issue of CNT use in medicine, and more specifically as diagnosis or therapeutic tools. One promising issue that has been the most discussed is cancer therapy.
- Finally, the fourth topic was about biological and environmental effects of CNT. A state of the art on what is currently known on CNT biological and environmental effects has been provided, with the aim of linking them to physico-chemical characteristics of CNT. Effects of agglomeration or bundling on the internalization of CNT by a cell were underlined, as well as the critical role of functionalization in toxicological effects and biocompatibility.

x 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 8 to 13, 2009. There were 75 participants total, including 16 speakers and 4 organizers. 67% of them came from European Union countries and 45% were female. Participants came from very different scientific communities: there were chemist, physicists, biologists and physicians who met and discussed. In our opinion, this is one of the important achievements of the meeting.

The program was organized as such:

- 21 lecture of 1 hour each (45 minutes talk, 15 minutes questions). Four of them were on CNT synthesis and characterization, 3 on pure chemistry of CNT, 8 on biological/ecological aspects of CNT, and 5 on biomedical applications of CNT. Finally, one lecture was on CNT applications and commercial opportunities;
- 5 short talks of 15 minutes each, selected among the abstracts from the participants;
- 1 poster session on the first 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: (1) a booklet containing the program, speaker abstracts and addresses of all participants, and (2) a USB key with the abstracts of all participants and speakers slides (in pdf format).

We were able to raise a total of 107 k€, including 20 k€ obtained from ESF. The funding were obtained from ADEME (50 k€), CNRS (16 k€), French research ministry (10 k€), Inserm, (2 k€), CEA (2 k€), C'Nano Île de France (4 k€), GDR-I (3 k€). With these funds, we were able to pay full grants (travel + accommodation) for speakers and organizers. Moreover, 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 conference was organized about 4 topics: synthesis/characterization of CNT, chemistry of CNT, biomedical use of CNT, and biological/environmental effects of CNT. As the conference was based on an interdisciplinary approach, no thematic session was organized as such, but rather all topics were broached every day. We arrange lectures so that 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. Different aspects of synthesis and growth

of CNT were broached 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 types, many shapes, many compositions, many “everything” in CNTS samples. It is more or less easy to produce CNT in sizable quantities, but it is difficult to control the homogeneity, purity, monodispersity, quality, etc of the sample. Characterization tools such as Raman spectroscopy, electron microscopy and electron diffraction were presented and discussed. The take-home message here was that it is very important to characterize the nanomaterials one is playing with.

- The second topic was about CNT chemistry, with a focus on their functionalization, and its consequences in terms of physical and chemical characteristics, and applications/uses of CNT in the medical field. Three lectures were given on that subject, including a general one on different functionalization processes (the point of view of a chemist). A large discussion was opened between chemists and biologists concerning the meaning of "functionalization" and the definition of "biocompatibility". Recent progresses in solubilization in water using surfactants (such as bile salts) or in functionalization for targeted carrier delivery have been reviewed. 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 biomedicine, with the issue of CNT use in medicine, and more specifically as diagnosis or therapeutic tools. Five lectures were given on the relevance of CNT in biomedicine. The promising issue that has been the most discussed is cancer therapy. Also, potential use of CNT in the context of replacement and regeneration of tissues and organs has been broached.

- Finally, the fourth topic was about biological and environmental effects of CNT. A state of the art on what is currently known on CNT biological and environmental effects was provided, with the aim of linking these effects to the physico-chemical characteristics of CNT. Biological aspects and ecotoxicological aspects were reviewed within 4 lectures each. Effects of agglomeration or bundling on the internalization of CNT by cells were underlined, as well as the critical role of functionalization in toxicological effects and biocompatibility. Mechanical interferences (steric or hindrance effects, etc) have also been shown to be important. Concerning environmental issues, and because raw CNT have no surface charge (unlike oxide and metallic nanoparticles), their special behavior in water was underlined.

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

A major issue of the conference was to put together the 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 occupied by interdisciplinary discussion among participants. This should have a great impact on future research on the field.

An important point that was brought to the fore is the notion of biocompatibility. It occurred that pharmacologists and toxicologists (mainly) didn't share the same concepts for those words. It was interesting to confront the different points of view, which helped participants to understand each other, thanks to an accessibility and exchange of competences between the disciplines. It also enabled scientists from other domains (physicists, chemists) to get a rather deep understanding on the questions in play in these domains.

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 field 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, and allow a better understanding and management of nanocarbon research.

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. 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 the results obtained with the nanomaterials, in terms of biological, toxicological, etc effects. Those 2 methodological issues should be work on ASAP, as they are essential for the comprehensive and systematic understanding of the topic as a whole. It has been shown by one of the speaker that one single defect could be added to CNT. Although it was successfully done using a very specific-high tech experimental set-up, this opens the doors to the mastery of the various functionalities of CNT, and their specific applications and uses. An important issue essentially for biologists is to be able to localize nanomaterials, and their evolution inside the cells: nucleus, cytoplasm, membrane? This is an issue for the next 5 years. Finally, biomedical field is maybe the most under construction, and the most emerging of all topics broached during the conference. For example, the idea of targeting delivery of very aggressive drugs directly to the site where they have to be effective is very challenging and will certainly represent a major issue in the next 10 years.

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

Yes. To the question “should the conference be repeated” asked in the questionnaire given to the participants, 92% of them answered “yes”.

We felt, when organizing the conference, 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 devoted discussion sessions) 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. A forum discussion allowing each participant to go on with discussions that begun during the meeting is under construction and should be opened soon.

At the end of the meeting and after the meeting, participants as well as speakers told us that it would be necessary to organize another interdisciplinary conference on the subject. The detailed project has still to be refined.

Atmosphere and Infrastructure

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

All participants were very happy from the beautiful conference site, as is illustrated in the meeting photograph below.



Concerning “scientific atmosphere”, 76 % of the participants answered that they agree completely with to the statement “ The conference was more than “just a meeting”, or a collection of lectures” and 16% mild agree. 82 % of them said that they fully agree with the statement “There was an atmosphere conducive to easy exchange information” and 14% mild agreed. These conclusions are very positive.

Among the points to improve if there should be a second meeting, we’d like to underline that only 61% of participant fully agree with the statement “The schedule allowed ample time for informal discussion” (25% mild agree). It shows that the program was probably a little bit too overwhelming, and that we should be more careful about it. However, this answer can also be viewed in a positive way: despite the large time devoted to discussions (at the end of each talk and in special evening sessions), participants would have liked to exchange even more with the speakers and with each others.