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Alain Celzard, Vanessa Fierro

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book reviews

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The work edited by Müllen and Feng, entitled « *Chemistry of Carbon Nanostructures* », is a 320-pages book, divided into 10 Chapters, and gathering various contributions to the quite broad topic of carbon nanomaterials and π-conjugated molecules. Given the major importance of nanocarbons at the present time, especially in view of the rapid expansion of researches devoted to graphene and related materials, this book is timely and most welcome.

Whereas the quality of editing and printing is obvious, one may regret, like most of the time for such books, that no link appears between the Chapters. Neither foreword nor introduction is present for explaining the content, the rationale behind the order of the Chapters, and the reason for having selected the themes that have been addressed. Indeed, many more things might have been expected from the very broad and general title of the book and, in contrast, very specialized knowledge is reported along the various Chapters. One might add that, considering the topic of carbon nanostructures, it would have been rather easy to sort the Chapters and to provide a more self-consistent book, for instance gathering themes related to graphene on the one hand, themes related to nanorings, nanocages or nanoribbons on the other hand, etc. Instead of this, totally independent Chapters follow one other.

The title of Chapter 1 is "*Carbon Nanomembranes*" (29 pp.), but only membranes produced by electron-induced cross-linking of aromatic self-assembled monolayers are reviewed. Due to this, the specific case of polyaromatic thiols is considered in detail. The review is very complete and goes deep into the formation mechanisms of these materials and in the way those mechanisms were elucidated. Examples of materials prepared in various conditions are presented, showing the versatility of such membranes, as well as the various techniques used for investigating them. At the end, a few properties and potential applications are commented. Very interesting, but quite specific. The Chapter lacks subsections that would have improved the reader's experience and increased the clarity to the whole.

Chapter 2 (37 pp.), entitled "*Controlled Functionalization of Graphene by Oxo-addends*" deals with a special family of graphene oxide, called "*oxo-functionalized graphene*", corresponding to graphenic domains having an intact carbon framework. Compared to the other Chapters of the book, this one received less care at the moment of being written, as proved by various typos, flawed English here and there, and wrong section numbering listed in the introduction. A significant part is devoted to the preparation of oxo-functionalized graphenes by various routes, and to their structure and characterization tools. Chemical functionalization and modification is next considered. In this part, several figures lack clarity. However, this Chapter is of high importance regarding the worldwide interest for graphene and its relatives, especially for those prepared by simple methods in solutions, and for all related problems of defects, polydispersity, and stability.

In Chapter 3 "*Chemical Synthesis of Cycloparaphenylenes*" (37 pp.), fine organic chemistry is used for preparing carbon nanorings that might be considered as templates or building blocks for the construction of carbon nanotubes. A thorough review detailing how such nanorings can be synthesized, whether armchair, zigzag or chiral, doped or not with heteroelements, is extensively given, and constitutes the major part of the Chapter. The latter is not always easy to follow because of the very specific (and heavy) terms of organic chemistry and the reference to quite a lot of molecules numbered all along the pages. The last part is dedicated to the synthesis of carbon nanocages, but how all these structures might be combined and used in materials science is not explained, nor are perspectives given.

Chapter 4 "*Controlled Chemical Synthesis in CVD Graphene*" (42 pp.) reviews the conditions for growing monolayers, bilayers or few-layers graphene on various substrates. On may regret a significant part of too vague generalities, especially with the excessive use of words like « *high* » or « *low* », and the corresponding lack of explicit data. The multi-parameters nature and the intrinsic complexity of the CVD processes may explain this. Many figures are not always very clear, and their captions are most of the time not enough for understanding completely what those figures show. The English should also have advantageously been polished prior to publication. A large table of experimental conditions and references finally saves the day. Just like for Chapter 2, the present one is among the most important of the book for graphene scientists as it reports the problems and the successes of a very famous method for getting large and almost flawless graphene sheets. The extensive bibliography is another highlight of this section.

The 5th Chapter (27 pp.) deals with "*Chemical Functionalization of Graphene Family Members*". Very important reminders about graphene, graphene oxide and reduced graphene oxide are given, and key reactions for modifying their surface chemistry are reviewed. Thus, non-covalent and covalent functionalization reactions are explained, and a lot of very useful details are provided as for the latter. Next, a brief overview of usual physicochemical techniques for characterizing the raw and modified materials is given. Since the major part of the book deals with graphene and its relatives, this Chapter should have been the first of the series of 10: not only it introduces the topic quite well, but the reactions and the techniques are also used in the other parts of the book. Also noteworthy is that the content of this Chapter will be useful to any carbon scientist, i.e., not only working on carbon-based nanomaterials. To be read in priority.

"*Graphene via Molecule-Assisted Ultrasound-Induced Liquid-Phase Exfoliation: A Supramolecular Approach*" is examined in Chapter 6 (21 pp.), the only one of the book dedicated to a top-down approach. It explains what exfoliation of graphite induced by ultrasounds is, and why the assistance of more or less polar molecules is helpful, depending on the solvent in which the experiments are carried out. Although the molecular interactions are suitably explained, accounting for the more or less complete separation of graphene layers and for the resultant concentration of the resultant suspensions, one may regret the lack of experimental details, for instance about optimal power and duration of sonication, optimal amounts of graphite and solvents to be handled, etc. Another important Chapter for people interested in large-scale and low-cost production of graphene.

In Chapter 7, the bottom-up "*Solution Synthesis of Atomically Precise Graphene Nanoribbons*" (32 pp.) is addressed. After a definition of what are graphene nanoribbons, what are their expected properties, and why they are of high interest in various kinds of electronic devices, their possible structures are discussed. The main chemical reactions, precursors and preparation steps required for synthesizing them are then reviewed, and the corresponding advantages and drawbacks of each are given. Chemical modifications are next introduced, with emphasis on nitrogen doping due to the special tuning of semiconducting properties it can induce. Finally, the most relevant characterization methods are reviewed with examples, demonstrating their importance for concluding whether the appropriate nanoribbon structure has been obtained after synthesis. The Chapter ends with the main challenges to be faced and the first solutions, giving also perspectives and ideas for future works. Very interesting and well explained.

Chapter 8 "*Nanodiamonds for Biological Applications*" (27 pp.) is the only one dealing with (almost) purely sp_3 nanocarbon. It reviews the amazing properties and successful / potential uses of those nanomaterials having been given less exposure to the general public, but which deserve the highest interest due to their outstandingly broad range of high-technology applications. This part of the book brings many examples proving the biocompatibility of nanodiamonds, both *in vitro* and *in vivo*, and reviews the chemical modification methods for enhancing further their stability and compatibility with biological environments. Their functionalization is also considered for applying them to drug delivery, sensing and imaging. Besides, it is explained how their special magnetic properties can be used for nanoscale magnetometry, thermometry and single-molecule detection, amongst others. Progresses still to be addressed close the Chapter. Impressive. The only regret here is the lack of information about the preparation of such amazing nanomaterials and how they should be handled.

The 9th Chapter, "*Polycyclic Hydrocarbons with an Open-Shell Ground State*" (36 pp.), reports on the very rich chemistry of such kind of organic, π-conjugated molecules and on their many possible precursors, combinations and derivatives, and properties. The major part of the Chapter requires from the reader a high level in theoretical chemistry and organic chemistry, and this is the only criticism to be done here: almost no reminder is given, no outreach effort is made to familiarize the reader with the concepts, and the authors go straight into their highly specific topic. When one is not used to the concepts reported here, this Chapter is probably the most difficult to read. However, there is a lot to learn here, and the possible effort that is required is worth when considering the multiple technological applications that these organic molecules may have. High-level Chapter.

The last Chapter "*Synthesis and Use of Reactive Molecular Precursors for the Preparation of Carbon Nanomaterials*" (25 pp.) stands out by its clarity. It deals with the synthesis and the reactivity of polyynes, or, more exactly oligoynes due to their limited molecular sizes, for preparing carbon nanostructures in amazingly mild conditions, i.e., slightly above room temperature. This Chapter fairly acknowledges the difficulty of identifying positively the new carbon nanostructures that may form from such precursors, but the reader will promptly be convinced of the interest of such topic of growing interest. One might have welcomed a short section about theoretical predictions that have been made on sp-hybridized carbons, making them sometimes be called the next miracle material (implicitly after fullerenes, nanotubes, and now graphene).

In conclusion, we here deal with an eclectic book based on a series of Chapters of uneven quality, not linked to one other and sometimes lacking conclusions and perspectives, but all correctly referring to the general term of "*carbon nanostructures*". Surprisingly,

no Chapter mentions or even considers the chemistry of fullerenes and carbon nanotubes, but this is probably due to the fact that those topics have already been extensively addressed in a number of former monographs. However, their complete absence makes the title of the book somewhat misleading since one may expect that these topics are also considered, but are actually not.

Whereas several Chapters address similar questions by different means, no reference is made to each other that would have helped the reader, for instance for comparing materials and methods. Moreover, some very similar reminders about graphene in several introductions might have been avoided. The book must thus be considered as a collection of independent, sometimes highly specific, reviews. Due to this, it is poorly likely that readers will be evenly interested in all Chapters. However, this criticism applies to many books nowadays, and from this point of view, the work edited by Müllen and Feng is certainly not worse than others. In contrast, the style is self-consistent, the illustrations are most of the time of very high quality, and the text is very clear and helpful. Most importantly, this is a book in which anyone will find something to learn, whether physicist, chemist, nano-technologist, etc. What the title doesn't explicitly explain, but what the Chapters' content shows, is that this book mainly deals with graphene and its relatives. Any researcher deeply involved in the "*graphene*" topic should therefore have it on his/her shelf. It thus appears that the present book is a must-have in the library of any specialist of nanotechnology and/or carbon scientist.

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Alain Celzard and Vanessa Fierro

Université de Lorraine, CNRS, IJL, F-88000 Epinal, France. E-mail: alain.celzard@univ-lorraine.fr; vanessa.fierro@univ-lorraine.fr