Chemistry of Nanocarbons

Fullerenes and carbon nanotubes (CNTs) are synthetic carbon allotropes that have cage (quasi-0-dimensional) and cylindrical (quasi-1-dimensional) nanostructures, respectively. Since they were discovered (in 1985 and 1991, respectively), fullerenes and CNTs have attracted great attention due to their unique physical properties. In particular, organic chemists became fascinated by the possibility of tailoring the properties of these nanocarbons, by means of chemical synthesis, to develop new materials for applications in optoelectronic devices, nanotechnology, composites, biology, and medicine. The recent developments in organic solar cells have further stimulated research on the synthesis and application of new fullerene derivatives that can act as vital components with favorable energy levels for accepting electrons from photoexcited p-type materials. In fact, up to now no other compound class has surpassed fullerenes as electron acceptors in photovoltaic devices.

Graphene, a one-atom-thick planar sheet of sp^2-bonded carbon atoms in a hexagonal lattice, which can be considered as the basic structural element of fullerenes and CNTs, was obtained for the first time by mechanical exfoliation of graphite in 2004. The pioneering experiments on this two-dimensional material revealed that it behaves as a zero-band-gap semi-metal with exceptional physical properties, such as a quantum Hall effect and ballistic charge transport, which led to the award of the Nobel Prize in Physics for 2010. Undoubtedly, this significant event will further stimulate the exploration of the chemical, physical, and materials properties of these nanocarbons, as well as the search for entirely new allotropic forms of carbon.

Wiley has responded to the vigorous recent progress in carbon research by publishing a book on the chemistry of nanocarbons edited by Takeshi Akasaka, Fred Wudl, and Shigeru Nagase, who are all distinguished chemists in the field of fullerenes and other nanocarbons. The book consists of 19 chapters by chemists, who are internationally well-known in the relevant fields, with emphasis on the chemistry aspects of nanocarbons ranging from fullerenes, CNTs, nanodiamonds, and graphene to nanocarbon onions.

The first two chapters of this book deal with noncovalent functionalization of carbon nanotubes (Hirsch) and with supramolecular coupling of fullerenes and CNTs with the potent tetrathiafulvalene donors (Martín), with the aim of processing the carbon materials in solution without disrupting their intrinsic properties, and thereby developing a new family of photo- and electro-active conjugates. The next chapter describes recent developments in the molecular engineering of fullerene dendrimers, and is followed by a chapter summarizing progress with hybrids that consist of electron donors with fullerenes or CNTs as acceptors for photo-electrochemical devices and solar cells.

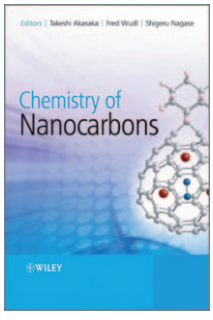
In the following few chapters, several groups give reviews of work on fullerene chemistry. Thilgen and Diederich introduce new cage isomers of higher fullerenes and describe their chirality. Nakamura discusses the synthesis and self-assembly of metal–fullerene complexes, and describes their use to generate photocurrents. Komatsu describes achievements obtained by performing "molecular surgery" on the fullerene cage to provide new endohedral fullerenes encapsulating molecular hydrogen.

Subsequently, Dorn describes the synthesis and reactive properties of new endohedral metallofullerenes, with particular emphasis on fullerenes that incorporate trimetallic nitrides. Nagase and Akasaka summarize recent progress in the chemical derivatization of endohedral metallofullerenes produced by the encapsulation of metal species. Wilson reviews gado-fullerenes and gado-nanotubes that are formed by the encapsulation of magnetically active gadolinium salts and have applications as high-performance contrast agents in magnetic resonance imaging.

In the following two chapters, Nakashima and Prato report on the processing and functionalization of CNTs for a number of potential applications, such as electrodes that are electrically conducting and transparent, field effect transistors, and biosensors. Nagase describes various postsynthetic modifications to disperse and separate single-walled carbon nanotubes (SWNTs). The following two chapters describe experiments on the encapsulation of various molecules and fullerenes within SWNTs and the visualization of their motions.

In contrast to the parts of the book described above, in which fullerenes and CNTs are the dominant nanocarbon species, Osawa introduces nano-diamonds that consist solely of sp^3-hybridized carbon atoms. Personally, I am glad to see that the nanographenes and graphene nanoribbons, as the new nanocarbon family, are discussed in this book, even though the authors provide only a theoretical point of view on this subject. And finally, the carbon nano-onions, which are mainly produced by thermal annealing of nano-diamonds, are reviewed, covering their production, physical properties, and chemical reactivities.

To conclude, this book provides a solid overview of the vigorous developments in the chemistry of nanocarbons in the past two decades. It covers experimental and theoretical aspects of fullerenes, CNTs, nanodiamonds, and graphene, as well as their potential applications across a broad range,



Chemistry of Nanocarbons
Edited by Takeshi Akasaka, Fred Wudl and Shigeru Nagase. John Wiley & Sons, Hoboken 2010. 526 pp., hardcover € 129.00.—ISBN 978-0470721957

from molecular electronics to biology and medicine. I have enjoyed reading this book very much and believe that it will provide useful guidance, both for experts and for nonspecialists who are interested in nanocarbons research.

Xinliang Feng
Max Planck Institute for Polymer Research
Mainz (Germany)

DOI: 10.1002/anie.201101108