

## Preface and Acknowledgements

All matter is made up of *atoms*. The term *molecule* is used to describe groups of atoms that tend to exist together in a stable form. As the term implies, *macromolecule* refers to a molecule of large size. *Intelligent macromolecules* are those large molecules, including certain polymers, dendrimers, fullerenes and carbon nanotubes, with the capability to change their conformational structures and/or properties in response to an external stimulus.

Polymers have long been used as electrically insulating materials: after all, metal cables are coated in plastic to insulate them. The visit of MacDiarmid to Shirakawa at Tokyo Institute of Technology in 1974 and, later, Shirakawa to MacDiarmid and Heeger at University of Pennsylvania, however, led to the discovery of conducting polyacetylene in 1977 - a prototype conducting polymers with the so-called *conjugated* structure of alternating single and double bonds for delocalization of  $\phi$ -electrons. This finding opened up the important new field of polymers for electronic applications and was recognized by the 2000 Nobel Prize in Chemistry. The subsequent discovery of the electroluminescent light emission from conjugated poly(*p*-phenylene vinylene), by Friend's group at Cavendish Laboratory in 1990, revealed the significance of the use of conjugated polymers in photonic devices. Various conjugated polymers can now be synthesized to show the processing advantages of plastics and the optoelectronic properties of inorganic semiconductors or metals.

With DNA, proteins, and polysaccharides comprising the most important components of a living cell, life is polymeric in its essence. The self-assembly of lipids contributes to even larger *supramolecular* structures. Nature handles these biomacromolecular and supramolecular in a mysterious way to create various nanostructures/nanomachines that enable creatures to function. The salient feature of biomacromolecules is that they can adopt unique, well-defined conformations according to specific environmental conditions. Human beings have done

remarkable work and learned a lot from nature. Recent decades have witnessed the appearance of synthetic polymers, including dendrimers, which can respond reversibly to a change in solvent, pH, temperature, electric or optical fields, or other stimuli. These *stimuli-responsive* biomacromolecules and synthetic polymers are of significance to various potential applications, ranging from sensors/actuators to controlled release of drugs.

Sometimes history repeats itself. The visit made by Kroto in 1985 to Smalley and Curl at Rice University led also to the Noble-Prize-winning discovery of *buckminsterfullerene*  $C_{60}$  - a conjugated molecule with a soccerball-like structure consisting of 12 pentagons and 20 hexagons facing symmetrically. Just as the discovery of  $C_{60}$  has created an entirely new branch of carbon chemistry, the subsequent discovery of *carbon nanotubes* by Iijima in 1991 opened up a new era in material science and nanotechnology. These elongated nanotubes consist of carbon hexagons arranged in a concentric manner with both ends normally capped by fullerene-like structures containing pentagons. Having a conjugated all-carbon structure with unusual molecular symmetries, fullerenes and carbon nanotubes also show interesting electronic, photonic, magnetic, and mechanical properties, which make them attractive for various applications, including optical limiters, photovoltaic cells and field emitting displays.

This book deals with the synthesis, fundamentals, and device applications of a wide range of intelligent macromolecules. The diversity both in the synthesis/fabrication of intelligent macromolecules and in the development/application of various smart devices appeals to a broad group of students, teachers, scientists and engineers with backgrounds in physical, chemical, material, biological, and medical sciences and engineering. The main objective of this book is to bridge the gap between the synthesis of intelligent macromolecules and the development of smart devices through a broad treatment of the field by covering not only the materials' synthesis and structure study, but also the device construction and application. In order to cover the multidisciplinary field of such diversity, the text has been divided into three major parts after the introductory chapter. The first part from Chapter 2 to Chapter 5 deals with the basic science of various intelligent macromolecular systems. Chapters 6 and 7 follow the first part of the text to present an overview of various methodologies developed for assembling these intelligent macromolecules into multi-dimensional structures, which have been so crucial to the development of smart devices. A large variety of smart devices based on these intelligent macromolecules and functional structures are then described in the final part of the book. The above approach, I hope, will allow the reader to first review the scientific basis for intelligent macromolecules. The basic knowledge is then extended to functional devices; many of them are of practical importance. While many self-explanatory illustrations could provide an overview understanding even to those who are new to the field, the large number of updated references cited in each of the chapters should enable advanced readers to quickly review the multidisciplinary and challenging field with information on the latest developments.

At this place I wish to express my sincere thanks to Mr Oliver Jackson for his suggesting and encouraging me to write this book and also his very kind and patient

cooperation during its completion, without which this book would never have been appeared. I would also like to thank my colleagues who contributed in one way or the other to the text and authors whose work was cited, in particular: Vardhan Bajpai, Yoseph Bar-Cohen, Ray Baughman, Bruce Crissinger, Mei Gao, Zhixin, Guo, Hans Griesser, Sinan Li, Albert Mau, Darrell Reneker, Chris Strauss, Chris Toprakcioglu, Alfred Uhlherr, Gordon Wallace, Zhonglin Wang, John White, Paul White, Berthold Winkler, Junbing Yang and Zhi Yu. Last, but not the least, I thank my parents, wife Lin Zhu and two sons, Quanbin Kevin Dai, and Quanzhe Alvin Dai, for their love, unceasing patience, and continuous support. This book is dedicated to my father, who passed away from a heart attack in July, 2000.

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February 2003

<http://www.springer.com/978-1-85233-510-6>

Intelligent Macromolecules for Smart Devices  
From Materials Synthesis to Device Applications

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2004, XVI, 496 p., Hardcover

ISBN: 978-1-85233-510-6