Book Review

Functional Molecular Nanostructures. Topics in Current Chemistry, 245 Edited by A. Dieter Schlüter (ETH-Honggerberg, Zürich). Springer: Berlin, Heidelberg, New York. 2005. x + 328 pp. $265.00. ISBN 3-540-21926-9.

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BOOK REVIEWS

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The area of supramolecular chemistry has now reached a critical point in which the significance of function per se has surpassed the importance of synthetic methodology and design principles. Many in-depth reviews and monographs have been published in this area over the past 5−10 years, yet there are very few books that focus on the emergence of functional properties in complex molecular entities. In this respect, Schlüter's book is particularly timely and should be of great interest to a large and diverse community of researchers working at the interface of chemistry, physics, and materials science. It covers a very broad range of systems, but each of the eight chapters strongly accentuates examples of truly *functional* nanostructures, regardless of their dimensionality and the type of noncovalent interactions employed.

In Chapter 1, Schmittel and Kalsani provide an excellent overview of cagelike nanostructures that are based on metal−ligand coordinative bonds and H-bonds and that exhibit high catalytic activity, responsiveness to external stimuli, and rapid switching of physical properties. As a logical continuation, Chapter 2 by Drain et al. is a review of how finite nanosized aggregates and functional zeolite-like organic crystals can be engineered to near perfection by introducing orthogonal recognition moieties in porphyrins. Many fascinating examples of tubular nanostructures based on helices, macrocycles, rosettes, and wedge-shaped amphiphiles are described by Hecht and coworkers in Chapter 3. It was particularly interesting to read this chapter because the authors not only reviewed the most impressive examples, but also clearly outlined the challenges facing self-assembly and nanotechnology. For instance, monodisperse (in terms of length) one-dimensional nanostructures of any kind remain unknown, and there still seems to be no solution to that important problem. Hecht et al. also emphasize the necessity of finding reliable and efficient methods for covalent stabilization of tubular assemblies and discuss several specific strategies available today.

The following chapter by Schlüter on dendronized polymers provides an outstanding example of a purely covalent approach to the construction of functional nanostructures. In a detailed introduction, he very clearly describes various synthetic strategies, their advantages, and limitations. The reader will find this chapter particularly inspiring because it raises some provocative questions. The author looks at the fundamental challenges in this area from a completely different perspective. It is indeed not clear yet whether supramolecular construction of nanostructures is the most efficient way to achieve functional properties. The most sophisticated biological structures are unimolecular objects, and the covalent approach may certainly help researchers to obtain mechanically robust and well-defined functional analogues. Schlüter provides an extensive description of the factors that influence the molecular weight and conformational rigidity of denpols and points toward new directions that might be taken in the future, e.g., the incorporation of catalytic sites with extremely high surface density and the synthesis of dendronized polymer brushes.

Two other chapters in this book are related to dendritic materials as well. A short review by Likos and Ballauff (Chapter 6) addresses one common misconception about the shape of dendrimers in solution. The latest investigation by small angle neutron scattering combined with molecular simulation methods leaves no doubt that dendrimers containing flexible units adopt a dense-core structure due to back-folding of terminal groups. This is in stark contrast to the theoretical predictions made by de Gennes et al. two decades ago. Nonetheless, a dense-shell conformation is also possible, and it has been experimentally observed for rigid dendrimers. Such systems are described in Chapter 7 by Müllen and co-workers. Here, the authors provide an overview of efficient synthetic approaches and describe the influence of conformational rigidity of polyphenylene dendrimers on their photophysical, electrochemical, and catalytic properties. To their credit, the authors present an unbiased view of several unresolved issues.

A comprehensive review of functionalization of carbon nanotubes is given in Chapter 5 by Hirsch and Vostrowsky. They describe virtually every covalent and noncovalent method known to date and focus on recent advances in this unique area of chemistry. In fact, this reviewer was not able to find any subject pertaining to CNT functionalization that was not treated to some extent in this chapter. The authors provide clear distinction between terminal, sidewall, and defect functionalization using the most recent and highly sophisticated examples, e.g., addition of carbenes and azomethine ylides, halogenation and Diels−Alder reactions, osmylation and electrochemical functionalization, to name a few.

The final chapter on nanoscale objects by Wooley and Hawker is a beautifully written, highly authoritative review that highlights recent advances in the preparation of well-defined macromolecular structures. This is one of only two chapters in the book that describes self-assembly based on the hydrophobic effect. Whereas an individual hydrogen bond or metal−ligand bond is much stronger than a given van der Waals interaction, the micelle-like aggregates of amphiphilic block copolymers often exhibit much higher stability than any H-bonded molecular cage or metal-coordinated nanostructure known to date. In addition, very large and well-defined structures of various morphologies can form spontaneously by entropically driven solvent−solute interactions. The authors also outline the advantages of covalent capture of micellar aggregates for creating unimolecular objects and shape-persistent nanostructures. This appears to be the most productive and least expensive way to obtain functional materials.

Overall, this book is a must for all active supramolecular chemists and researchers interested in nanoscience and self-

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assembly in general. The editor and all 19 contributing authors are to be congratulated for their excellent work in putting together this impressive collection of recent advances in the preparation of *functional* molecular nanostructures.

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Molecules in Interaction with Surfaces and Interfaces. Lecture Notes in Physics, 634. Edited by Reinhold Haberlandt, Dieter Michel, Andreas Pöppl, and Rolf Stannarius (Universität Leipzig). Springer-Verlag: Berlin, Heidelberg. 2004. xviii + 512 pp. $129.95. ISBN 3-540-20539-X.

These Lecture Notes provide a description of results generated from the collaborative research center *Molecules in Interaction with Interfaces,* which was founded at the University of Leipzig in 1994. The main themes of the research activities that are reflected in the various chapters of this book include, to paraphrase from the preface, theoretical studies of the interactions of guest molecules with surfaces, diffusion and dynamics of molecules adsorbed in zeolites, reactivity of internal surfaces and catalytic activity, interactions of thin films, membranes, and biopolymers with interfaces, and supramolecular organization and biological compartmentation.

The first three chapters present a comprehensive overview of theoretical and experimental methods for studying adsorption, diffusion, and reactions of molecules in confined spaces, such as zeolite pores. Chapters 4−7 cover magnetic resonance studies of zeolites to investigate structure, dynamics, and confinement effects in zeolites. In Chapters 8−14, studies of thin, ordered molecular structures are described.

A particular strength of this book is its focus on magnetic resonance techniques (NMR and EPR) as spectroscopic tools to investigate molecular interactions at interfaces. Examples of state-of-the-art NMR (pulsed field gradient NMR, two-dimensional NMR, multiple-quantum magic-angle spinning NMR, and double rotation NMR) and EPR studies (including pulsed EPR) of zeolites, liquid crystals, and cartilage are included. These chapters will be of particular interest to scientists who are involved in or initiating research related to applications of modern magnetic resonance techniques.

Overall, the individual chapters provide independent, comprehensive overviews of important research projects related to experimental and theoretical aspects of molecular interactions at interfaces, and the book as a whole accurately reflects the interdisciplinary nature of the research. Despite the fact that the book consists of chapters written by different authors, it is remarkably cohesive, in that specific research threads are developed and recur throughout the individual chapters. As suggested by the authors in the preface, this book will give non-expert readers a perspective of this complex research field and should be an excellent reference for students in this area of research.

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