260
Advances in Polymer Science

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Aims and Scope

The series Advances in Polymer Science presents critical reviews of the present and future trends in polymer and biopolymer science. It covers all areas of research in polymer and biopolymer science including chemistry, physical chemistry, physics, material science.

The thematic volumes are addressed to scientists, whether at universities or in industry, who wish to keep abreast of the important advances in the covered topics.

Advances in Polymer Science enjoys a longstanding tradition and good reputation in its community. Each volume is dedicated to a current topic, and each review critically surveys one aspect of that topic, to place it within the context of the volume. The volumes typically summarize the significant developments of the last 5 to 10 years and discuss them critically, presenting selected examples, explaining and illustrating the important principles, and bringing together many important references of primary literature. On that basis, future research directions in the area can be discussed. Advances in Polymer Science volumes thus are important references for every polymer scientist, as well as for other scientists interested in polymer science - as an introduction to a neighboring field, or as a compilation of detailed information for the specialist.

Review articles for the individual volumes are invited by the volume editors. Single contributions can be specially commissioned.

Readership: Polymer scientists, or scientists in related fields interested in polymer and biopolymer science, at universities or in industry, graduate students.

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Thomas Basché • Klaus Müllen • Manfred Schmidt
Editors

From Single Molecules to Nanoscopically Structured Materials

With contributions by

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Preface

Back in 2002 the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG) has launched a Center of Research (Sonderforschungsbereich 625, SFB) with the title "From Single Molecules to Nanostructured Materials" at Johannes Gutenberg University, Mainz, together with the Max-Planck-Institute for Polymer Research, Mainz. Since 2002, more than 17 research groups were funded in order to theoretically and experimentally verify an ambitious concept comprising the design of nanostructured materials starting from a molecular basis, i.e. single molecules and single polymeric building blocks. The three overall objectives were as follows:

- To study the initial phases of self-organization
- To elucidate the formation of discrete aggregates from a defined number of molecules
- To establish complex structural hierarchies on the nanoscale and control the functions derived therefrom.

It is clear that this concept defines critical needs regarding materials and methods. Mostly synthetic polymers were at the core, however, biological polymers and small organic molecules were also considered. The disadvantage of polymers often lies in their pronounced conformational flexibility demanding a high entropy prize upon supramolecular structure formation. Shape-persistent macromolecules have helped to overcome this drawback and have therefore defined one focus of the SFB.

A second working principle relied on the defined functionalization of macromolecules and macromolecular assemblies. The basic idea was to chemically encode the building blocks, permitting better control of structure formation. The placement of ionic or hydrogen-bonding groups into well-defined positions, the definition of amphiphilic "patches" and the creation of directed as well as non-directed interactions have led to novel aggregate topologies in solution as well as on surfaces. Given the broad basis on both the macromolecule and the

particle side it became evident that a sophisticated toolbox of physical and theoretical methods was equally important, such methods including scanning probe and electron microscopy techniques, but also solid-state NMR spectroscopy, single molecule spectroscopy and scattering techniques.

Analogous considerations were initially made and obeyed throughout the project for the accompanying theoretical methods ranging from computer simulations on the basis of simplified models up to demanding *ab initio* procedures. The combined theoretical and spectroscopic analysis provided particularly valuable information on the structure and dynamics of complex assemblies as well as on fundamental questions regarding polymer chain statistics.

During the course of the project there were many scientific accomplishments, new ideas were explored and new challenges were created, all of which are summarized and reviewed in the present volume of *Advances in Polymer Science*.

We hope that the results accumulated by the SFB will stimulate new research projects not only locally in Mainz but also in the national and international polymer community.

On behalf of all our colleagues we wish to thank the DFG for its continuous and generous financial and administrative support. The invaluable judgments and critical advice of all the numerous voluntary reviewers involved in the SFB over the years are gratefully acknowledged.

Mainz, Germany
July 2013

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Contents