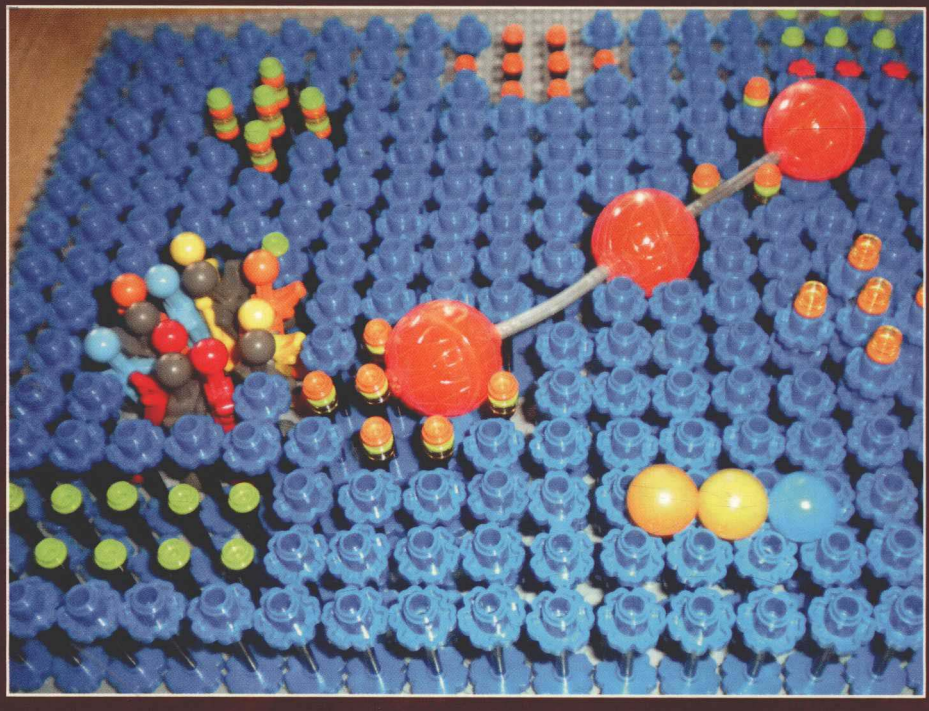
Self-Assembly and Nanotechnology Systems

Design, Characterization, and Applications



YOON S. LEE

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Self-Assembly and Nanotechnology Systems

I had my ear close to her lips.
She whispered, "My son, I missed you so much last night, so, I cried."
Those were the last words my mother left for me.
She was forty-six.
And I am now forty-six.

This is for my mother.

Preface

Nanotechnology is now experiencing a nice expansion toward its full potential. Early promises from scientific discoveries are being actualized in engineering stages, and diverse products are beginning to show up in the marketplace. This is possible because we now have some good methods for the assembly of nanotechnology systems and an improved understanding of how they behave at the nanoscale.

Self-assembly is a key scientific principle behind nanotechnology. Many of the seemingly complex self-assembly systems from different origins are well understood. They can help assemble nanotechnology systems effectively and efficiently, and provide practical tools to control the structures and properties of nanotechnology systems. This marriage of self-assembly and nanotechnology systems is important for the maturation of nanotechnology and promises fruitful outcomes. A main goal of this book is to offer comprehensive coverage of how to use self-assembly systems for the design, characterization, and applications of nanotechnology systems. The four key objectives are:

1. Show how to identify assembly building units.
2. Provide detailed assembly principles for the design of nanotechnology systems.
3. Establish practical assembly methods to focus on when developing nanomaterials, nanostructures, nanoproperties, nanofabricated systems, and nanomechanics.
4. Show how to characterize/model self-assembly and nanotechnology systems.

This book is divided into four parts. The first part shows the assembly building units, and how diverse their origins and structures can be. It also presents how

to analyze the building unit structures in a systematic manner. This will be called *segmental analysis*, which is used as an underlying concept for the discussions throughout the book. The second and third parts show the design and applications of nanotechnology systems, respectively, and how to select proper assembly principles and methods. The last part shows how to select proper characterization techniques and predictive models. This book is structured as follows:

1. Clear questions at the beginning of each chapter help readers stay focused.
2. Each chapter offers an algorithmic diagram for a general overview.
3. Schematics are designed to link the assembly principles with actual systems.
4. Case studies are provided for the in-depth analysis of actual systems.
5. All chapters (except for the final one) provide a collection of examples.
6. All chapters in the second and third parts follow the same format, making it easy to understand different assembly principles and methods.

Those who are studying the disciplines of science and engineering with a general chemistry level of knowledge should not have too much difficulty using this book. Occasional trips to common biology, physics, or materials science textbooks might be necessary. This book will be useful for:

1. Students, researchers, and professionals who want to acquire a general picture of how self-assembly systems are used in nanotechnology systems.
2. College teachers who need a convenient source for teaching and for design of experiments for nanotechnology-related courses.
3. Nanoscientists and nanotechnologists who need a handbook for their daily activities and for publishing the results of their studies.

Acknowledgments

I am deeply grateful to all the reviewers. Their valuable advice greatly helped me shape this book. I can never thank enough professors Kyu Whan Woo at Seoul National University and James F. Rathman at Ohio State University. It was Professor Woo who introduced me the term *self-assembly* on my first day of graduate school. This word has been imprinted on my mind ever since. With the guidance of Professor Rathman, I widened my view on self-assembly and explored a good deal of nanotechnology. My deep thanks extend to Dr. Oksik Lee at Chemical Abstracts Service. Without her companionship, thoughtfulness, and all the discussions I have had with her over the years, it would have been much more difficult to write this book. As always, my deepest thanks go to my wife, Jee-a, and my son, Jong-hyeok, for their endless support and love. I always miss my parents and my parents-in-law, who live far away.

Dublin, Ohio
ylee@cas.org

YOON SEOB LEE

Abbreviations

The following abbreviations are used in the figures and tables. Full terms are used in the text.

attractive segment: **A**
repulsive segment: **R**
directional segment: **D**
asymmetric packing segment: **AP**
external force-specific functional segment: **EF-F**

attractive force: **AF**
repulsive force: **RF**
directional force: **DF**
asymmetric packing process: **APP**
external force-induced directional factor: **ED**

self-assembly: **SA**
self-assembled aggregate: **SAA**
self-assembly building unit (primary): **SA-BU**
primary self-assembly process: **P-SA**
primary self-assembled aggregate: **P-SAA**
secondary self-assembly building unit: **S-SA-BU**
secondary self-assembly process: **S-SA**
secondary self-assembled aggregate: **S-SAA**

tertiary self-assembly building unit: **T-SA-BU**
tertiary self-assembly process: **T-SA**
tertiary self-assembled aggregate: **T-SAA**

nanoassembly: **NA**
nanoassembled system: **NA-S**
nanoassembly building unit: **NA-BU**
fabrication building unit: **F-BU**
reactive building unit: **R-BU**
nanostructural element: **N-SE**
nanoproperty element: **N-PE**
nanomechanical element: **N-ME**
nanocommunication element: **N-CE**

nanofabrication: **NF**
nanofabricated system: **NF-S**
nanointegrated system: **NI-S**
nanodevice: **NaD**
nanomachine: **NaM**

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