Topics in Current Chemistry Collections

Aims and Scope

The series *Topics in Current Chemistry Collections* presents critical reviews from the journal *Topics in Current Chemistry* organized in topical volumes. The scope of coverage is all areas of chemical science including the interfaces with related disciplines such as biology, medicine and materials science.

The goal of each thematic volume is to give the non-specialist reader, whether in academia or industry, a comprehensive insight into an area where new research is emerging which is of interest to a larger scientific audience.

Each review within the volume critically surveys one aspect of that topic and places it within the context of the volume as a whole. The most significant developments of the last 5 to 10 years are presented using selected examples to illustrate the principles discussed. The coverage is not intended to be an exhaustive summary of the field or include large quantities of data, but should rather be conceptual, concentrating on the methodological thinking that will allow the non-specialist reader to understand the information presented.

Contributions also offer an outlook on potential future developments in the field.

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Chunhai Fan • Yonggang Ke
Editors

DNA Nanotechnology

From Structure to Functionality

With contributions from

Ying Bao • Jie Chen • Jinyi Dong • Jinwei Duan • Jinglin Fu
Xiaoyi Fu • Oleg Gang • Alexandra Hoff • Ezry St. Iago-McRae
Min Ji • Guoliang Ke • Megan E. Kizer • Gezhi Kong • Yuhan Kong
Hua Kuang • Jungyeon Lee • Feng Li • Xiao Hua Liang • Huajie Liu
Jiliang Liu • Yizhen Liu • Ningning Ma • Hong-min Meng
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Preface

The double helix structure of deoxyribonucleic acid (DNA) was discovered in 1953 by James D. Watson and Francis H. C. Crick [1]. Thirty years later, Nadrian C. Seeman proposed the concept of utilizing the highly specific Watson-Crick base-pairing to construct self-assembled DNA nanostructures [2]. Since then, the vital role of DNA in the development of novel materials has been explored by many prominent researchers throughout the following decades. In 2006, Paul W. K. Rothemund pioneered DNA origami technique [3], which ushered in a new era of DNA nanotechnology. Up to date, DNA nanotechnology has enabled precise construction of nanomaterials with various patterns and different components in a highly programmable manner, which can be further used in many applications such as nanophotonics and theranostics. This topical collection addresses the recent advances in the field of DNA nanotechnology, focusing on the two essential issues of structure design and functionality.

Zhou and colleagues discussed dynamic DNA assembly systems from the perspective of free energy change in the reaction process, including passive assembly–disassembly systems, autonomous assembly systems, sophisticated artificial metabolism and time-clocking oscillation systems (1 Towards Active Self-Assembly Through DNA Nanotechnology). H. Liu and colleagues summarized the progress in the field of DNA hydrogels, including the gelation mechanisms, various synthetic strategies and applications of DNA hydrogels (2 Tailoring DNA Self-assembly to Build Hydrogels).

DNA nanotechnology has dramatically contributed to nanoscale materials of various components, such as biomolecules, polymers and nanoparticles. The contribution by Y. Wu and colleagues summarized recent advances in nanomaterials synthesis of polymers and inorganic nanomaterials using DNA nanostructures as scaffolds, and discussed the current challenges and future outlook (3 DNA-Programmed Chemical Synthesis of Polymers and Inorganic Nanomaterials). H. Xing and co-workers reviewed the research progress of synthetic DNA–protein conjugates over the past decades, by summarizing DNA–protein conjugation chemistries and the applications (4 Engineering Functional DNA–Protein Conjugates for Biosensing, Biomedical, and Nanoassembly Applications). J. Fu and colleagues discussed the recent progress in the field of DNA scaffold-directed assembly of multienzyme reactions, including proximity assembly, confinement, biomimetic substrate channeling and regulation circuits, as well as bioconjugation techniques of hybrid DNA–protein structures (5 DNA-Scaffolded Proximity Assembly and Confinement of Multienzyme Reactions). The contribution by Y. Tian and O. Gang covered the progress in the development of the self-assembly of nanoparticles using DNA shapes, and discussed a broad range of applications of these architectures (6 Directional Assembly of Nanoparticles by DNA Shapes: Towards Designed Architectures and Functionality). The contribution by Y. Bao and L. Tian categorized oligonucleotide–polymer conjugates by the structures of the polymer blocks, and discuss the synthesis, purification, and applications for each category (7 Oligonucleotide–Polymer Conjugates: From Molecular Basics to Practical Application).

DNA-based nanoplatforms have shown great promise in numerous biological or biomedical applications. The contribution by J. Duan, X. Wang and M. E. Kizer discussed the structural characteristics, biological prevalence, and function of both DNA and RNA structural motifs found in natural biological systems, and highlighted the biotechnological and therapeutic applications of these structural motifs, including catalytic nucleic acids, non-coding RNA, aptamers, G-quadruplexes, i-motifs, and Holliday junctions (8 Biotechnological and Therapeutic Applications of Natural Nucleic Acid Structural Motifs). Y. Zhao and colleagues analyzed the progress of DNA-driven nanoparticle assemblies for biosensing and bioimaging, focusing on the discussion of the tunable configurations and tailorable optical properties of these spatial structures (9 DNA-Driven Nanoparticle Assemblies for Biosensing and Bioimaging). The contribution by G. Ke and colleagues introduced the features of aptamer-functionalized DNA nanostructures, and discussed the recent progress, challenges and future directions in biological applications of these nanostructures (10 Aptamer-Functionalized DNA Nanostructures for Biological Applications). F. Wang and colleagues introduced various autonomous enzyme-free DNA circuits, explained their underlying molecular reaction mechanisms, and discussed their biosensing applications in terms of sensing performance, challenges and outlook (11 High-performance biosensing based on autonomous enzyme-free DNA circuits). F. Li and Y. Liu offer a systematic survey of current emerging strategies using DNA strand displacement to detect single-nucleotide variants (SNVs), with an emphasis on the molecular mechanisms and their applicability to in vitro diagnostics (12 DNA Strand Displacement Reaction: A Powerful Tool for Discriminating Single Nucleotide Variants).

We are greatly indebted to all contributing authors, reviewers, and editorial staff of this topical collection for their effort and support. Contributions in this topical collection include the pioneering works published decades ago, as well as state-of-the-art reports published over the recent three years, covering from molecular basics to practical applications. We hope this comprehensive collection can present the readers both a historical overview and cutting-edge advancements in the booming field of DNA Nanotechnology.

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