Preface

In the pursuit of efficient and sustainable chemical processing technologies, people have seen a growing emphasis on synthetic biotechnology in recent R&D efforts. In particular, industrial enzyme technologies are attracting enormous attention. Having been traditionally developed for food processing and detergent applications, industrial enzyme technologies are being re-examined and tested to their capability limits in order to keep abreast of the challenges in drug, biochemical, and the emerging biorenewable energy industries. Toward that, enzymes are required to function in non-conventional conditions, such as organic solvents, extreme pH, and temperatures; they also have to compete against alternative chemical technologies in terms of costs and efficiency. Accordingly, enzymic biocatalyst systems are being tackled dynamically at all size levels through efforts ranging from molecular-level protein engineering and modification, nanoscale structure fabrication, intracellular reaction pathway controls and regulation, and microenvironment manipulation to the construction of micro-chip devices and macroscopic industrial bioreactors and devices.

Nanoscale science and engineering, which deal with size-dependent properties and phenomenon at nanometer scale, are unveiling new mechanisms that people have to rely on heavily nowadays to achieve such efficiencies. Advances in nanoscale science and technology are fueling a new wave of development in almost all the major areas of science and engineering such as electronics, sensors, energy harvesting and storage, and life science. Although it is hitherto only at a very early stage, their impetus on biocatalysis is evidently powerful and greatly promising.

To capitalize on the power of nanoscale technologies, it is becoming a common need to understand and design complex systems of multi-scale structures. In most cases, natively evolved biocatalysts, either in the form of enzymes or microbes, are not optimized for use in industrial reactors. Recent advances in genetic engineering have made it possible to design and produce more efficient industrial biocatalysts. The use of isolated enzymes provides the chance to further improve the performance of biocatalysts through various after-isolation chemical and physical manipulations. Nano-structured materials provide desirable features in balancing the key factors that determine the efficiency of biocatalysts, including specific surface area, mass transfer resistance, and effective enzyme loading. Various nanomaterials such as nanoparticles, nanofibers, nanotubes, and nanoporous matrices have demonstrated promising potentials in revolutionizing the preparation and use of biocatalysts. Extending from there, people are exploring broadly enzyme-based assemblies, micro-scale structures, and new types of bioreactors for biotransformation and biosynthesis. It is probably reasonable to say that synthetic biotechnology is entering a new phase of development that integrates biocatalysts' structural and functional features that exhibit at different size scale, ranging from atomic–molecular-level, nanometer structure scale to a degree of micro- and macro-size bioreactors.

This current book gathers methodologies and procedures that have been developed from recent research in this burgeoning area of nanoscale technology-enabled biocatalysis. Chapters 1 and 2 demonstrate concepts in preparing unique and dynamic protein structures for biocatalysis. Methods for preparation of enzyme assembles or complexes that maintain molecular-like Brownian mobility are provided in Chapters 3, 4, and 5. Chapters 6 through 15 show examples in developing protein–nanostructure complexes using carbon nanotubes (CNTs) and nanoparticles. The last three chapters describe methodologies that have great potential for scale-up preparation of nano-structured biocatalysts.

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