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# **INDUSTRIAL APPLICATION OF IMMOBILIZED BIOCATALYSTS**

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**edited by  
Atsuo Tanaka  
Tetsuya Tosa  
Takeshi Kobayashi**

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# **INDUSTRIAL APPLICATION OF IMMOBILIZED BIOCATALYSTS**

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## Series Introduction

Bioprocess technology encompasses all of the basic and applied sciences as well as the engineering required to fully exploit living systems and bring their products to the marketplace. The technology that develops is eventually expressed in various methodologies and types of equipment and instruments built up along a bioprocess stream. Typically in commercial production, the stream begins at the bioreactor, which can be a classical fermentor, a cell culture perfusion system, or an enzyme bioreactor. Then comes separation of the product from the living systems and/or their components followed by an appropriate number of purification steps. The stream ends with bioproduct finishing, formulation, and packaging. A given bioprocess stream may have some tributaries or outlets and may be overlaid with a variety of monitoring devices and control systems. As with any stream, it will both shape and be shaped with time. Documenting the evolutionary shaping of bioprocess technology is the purpose of this series.

Now that several products from recombinant DNA and cell fusion techniques are on the market, the new era of bioprocess technology is well established and validated. Books of this series represent developments in various segments of bioprocessing that have paralleled progress in the life sciences. For obvious proprietary reasons, some developments in industry, although validated, may be published only later, if at all. Therefore, our continuing series will follow the growth of this field as it is available from both academia and industry.

*W. Courtney McGregor*

## Preface

Environmental concerns of the approaching twenty-first century will demand worldwide development of scientific technologies that are less polluting and more energy efficient. Biotechnology, developed during the 1970s, is one such technology, and, specifically, bioreactor systems with immobilized biocatalysts—a gentle technology—have already proved to yield excellent results.

Before the recent progress in the area of bioreactor systems, much research had been conducted on the preparation and application of immobilized biocatalysts, that is, immobilized enzymes, cellular organelles, microbial cells, plant cells, and animal cells. At the same time, design and operation of bioreactors were being actively studied in the field of chemical engineering.

“Enzyme engineering,” a technology based on the application of immobilized biocatalysts, can be utilized extensively in many different fields. This technology of industrial importance, which originated in Europe and the United States, has also been developed extensively in Japan. Since the first industrial application of an immobilized enzyme in 1969, over ten processes are now commercially available in Japan.

Although many books currently exist on the fundamentals and applications of immobilized biocatalysts, they are composed mainly of articles dealing with research and techniques at the laboratory level. However, at present, many processes are being implemented at the industrial and pilot-plant levels. Therefore, it is the right time to compile information concerning the current status of these processes in one book.

As mentioned before, Japan is recognized as one of the leading countries in the field of enzyme engineering, and various processes have been

developed and founded in this country. Therefore, this book was edited solely by Japanese and derived mainly from the processes used in Japanese industries.

As this book includes a great deal of information not only on the industrialization of bioreactor systems covering the chemical, food, and medical industries but also on the solution of environmental problems, we believe that it will be very useful to scientists, researchers, and technologists who are working on or interested in biotechnology in any field. We also hope that this book will make a significant contribution to the development of biotechnology, especially of bioreactor systems, in the future.

The editors are grateful to Dr. Ichiro Chibata, President and Representative Director of Tanabe Seiyaku Co., Ltd., who strongly encouraged us to prepare this book.

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# Medicines