Contemporary Food Engineering Series
Da-Wen Sun, Series Editor

$$\text{Glucose} + O_2 \xrightarrow{\text{Glucose oxidase}} \text{D-glucono-}\delta\text{-lactone} + H_2O_2$$

$$H_2O_2 \xrightarrow[650\ mV]{Pt} O_2 + 2H^+ + 2e^-$$

BIOSENSORS in FOOD PROCESSING, SAFETY, and QUALITY CONTROL

EDITED BY
Mehmet Mutlu

CRC Press
Taylor & Francis Group

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BIOSENSORS in FOOD PROCESSING, SAFETY, and QUALITY CONTROL

Contemporary Food Engineering

Series Editor

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Series Preface

CONTEMPORARY FOOD ENGINEERING

Food engineering is the multidisciplinary field of applied physical sciences combined with the knowledge of product properties. Food engineers provide the technological knowledge transfer essential to the cost-effective production and commercialization of food products and services. In particular, food engineers develop and design processes and equipment in order to convert raw agricultural materials and ingredients into safe, convenient, and nutritious consumer food products. However, food engineering topics are continuously undergoing changes to meet diverse consumer demands, and the subject is being rapidly developed to reflect market needs.

In the development of food engineering, one of the many challenges is to employ modern tools and knowledge, such as computational materials science and nanotechnology, to develop new products and processes. Simultaneously, improving food quality, safety, and security continue to be critical issues in food engineering study. New packaging materials and techniques are being developed to provide more protection to foods, and novel preservation technologies are emerging to enhance food security and defense. Additionally, process control and automation regularly appear among the top priorities identified in food engineering. Advanced monitoring and control systems are developed to facilitate automation and flexible food manufacturing. Furthermore, energy saving and minimization of environmental problems continue to be important food engineering issues, and significant progress is being made in waste management, the efficient utilization of energy, and the reduction of effluents and emissions in food production.

The *Contemporary Food Engineering Series*, consisting of edited books, attempts to address some of the recent developments in food engineering. Advances in classical unit operations in engineering applied to food manufacturing are covered as well as such topics as progress in the transport and storage of liquid and solid foods; heating, chilling, and freezing of foods; mass transfer in foods; chemical and biochemical aspects of food engineering and the use of kinetic analysis; dehydration, thermal processing, nonthermal processing, extrusion, liquid food concentration, membrane processes, and applications of membranes in food processing; shelf life, electronic indicators in inventory management; sustainable technologies in food processing; and packaging, cleaning, and sanitation. The books are aimed at professional food scientists, academics researching food engineering problems, and graduate-level students.

The books' editors are leading engineers and scientists from many parts of the world. All the editors were asked to present their books to address the market need and pinpoint the cutting-edge technologies in food engineering.

All contributions are written by internationally renowned experts who have both academic and professional credentials. All authors have attempted to provide critical,

comprehensive, and readily accessible information on the art and science of a relevant topic in each chapter, with reference lists for further information. Therefore, each book can serve as an essential reference source to students and researchers in universities and research institutions.

Da-Wen Sun
Series Editor

Preface

A healthy life, a suitable environment, sustainable high-quality food, and inexpensive energy are inevitable components of a better life for human beings. With respect to food, the utmost level of health standards in the process "from field to fork" is vital. Due to this fact, along with other fields, food engineering and technology are also being transformed by continually increasing levels of automation. While the objective in other sectors of industry is simply to increase efficiency in food technology due to system theory and safety considerations, a high level of automation is required. The processes are complex; generally multifunctional control with feedback is employed, safety requirements allow for only a small degree of tolerance in the measurements, and human error as a risk factor needs to be eliminated.

During the last two decades, a rapid technological evolution has occurred in the field of chemical sensors in general, and biorecognition element–based sensors, or *biosensors*, in particular. It is fueled by an ever-growing need for improved sensors for early detection, which would allow remedial steps in a shortened time period for biomedical, industrial, environmental, and military applications. The success in biosensors is owed as much to the fundamental research in finding novel biorecognition mechanisms as to a number of rapidly evolving technologies, such as micro/nanofabrication of sensors and the production and immobilization of enhanced biorecognition elements.

A biosensor consists of two main parts: *biorecognition agent*(s) and *physical transducer*(s). The biological part of a biosensor is the unique part of the "instrument" that separates it from other sensors. Enzyme–substrate, antibody–antigen, DNA–DNA, and aptamer–target interactions are the most well known interactions used in biosensor design. The transducers, ranked in order of importance, include: electrochemical, optical, mass (piezoelectric), electrochemical/optical combination, and calorimetric (enzyme thermistor).

This book gives a brief summary about the past, present, and future of biosensors with an emphasis on food technology. Although we will see more advances in biosensors in the future, I believe this comprehensive and authoritative text will continue to serve the intended users for many years.

Food and chemical engineers, food technologists, and biochemists will find this book useful, as well as graduate students working in biosensor-related fields. It might also serve as a reference textbook for schools offering graduate courses in food technology and biosensors. With the help of leading scientists, I am most pleased to bring this book to the readership.

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Mehmet Mutlu

Series Editor

Professor Da-Wen Sun, Ph.D., was born in Southern China and is a world authority on food engineering research and education. His main research activities include cooling, drying, and refrigeration processes and systems; quality and safety of food products; bioprocess simulation and optimization; and computer vision technology. His innovative studies on vacuum cooling of cooked meats, pizza quality inspection by computer vision, and edible films for shelf-life extension of fruits and vegetables have been widely reported in the national and international media.

Dr. Sun received first-class B.Sc. honors and an M.Sc. in mechanical engineering, and a Ph.D. in chemical engineering in China before working at various universities in Europe. He became the first Chinese national to be permanently employed in an Irish university when he was appointed college lecturer at the National University of Ireland, Dublin (University College Dublin) in 1995, and was then continuously promoted in the shortest possible time to senior lecturer, associate professor, and full professor. Dr. Sun is now professor of food and biosystems engineering and director of the Food Refrigeration and Computerized Food Technology Research Group at the University College Dublin.

As a leading educator in food engineering, Dr. Sun has contributed significantly to the field of food engineering. He has trained many Ph.D. students who have made their own contributions to the industry and academia. He has also, on a regular basis, given lectures on the advances in food engineering at academic institutions internationally and delivered keynote speeches at international conferences. As a recognized authority in food engineering, Dr. Sun has been conferred adjunct/visiting/consulting professorships from 10 top universities in China including Zhejiang University, Shanghai Jiaotong University, Harbin Institute of Technology, China Agricultural University, South China University of Technology, and Jiangnan University. In recognition of his significant contribution to food engineering worldwide and for his outstanding leadership in the field, the International Commission of Agricultural and Biosystems Engineering (CIGR) awarded him the CIGR Merit Award in 2000 and again in 2006; the Institution of Mechanical Engineers based in the United Kingdom named him Food Engineer of the Year 2004; in 2008 he was awarded the CIGR Recognition Award in recognition of his distinguished achievements as the top 1% of agricultural engineering scientists around the world; in 2007, Dr. Sun was presented with the AFST(I) Fellow Award by the Association of Food Scientists and Technologists (India); and in 2010, he was presented with the CIGR Fellow Award,

the title of "Fellow" is the highest honor in CIGR, and is conferred to individuals who have made sustained, outstanding contributions worldwide.

Dr. Sun is a fellow of the Institution of Agricultural Engineers and a fellow of the Institution of Engineers of Ireland. He has also received numerous awards for teaching and research excellence, including the President's Research Fellowship, and has received the President's Research Award from the University College Dublin on two occasions. He is editor-in-chief of *Food and Bioprocess Technology—An International Journal* (Springer); series editor of the *Contemporary Food Engineering Series* (CRC Press/Taylor & Francis); former editor of the *Journal of Food Engineering* (Elsevier); and an editorial board member for the *Journal of Food Engineering* (Elsevier), the *Journal of Food Process Engineering* (Blackwell), *Sensing and Instrumentation for Food Quality and Safety* (Springer), and the *Czech Journal of Food Sciences*. Dr. Sun is also a chartered engineer.

On May 28, 2010, Dr. Sun was awarded membership to the Royal Irish Academy (RIA), which is the highest honor that can be attained by scholars and scientists working in Ireland. At the 51st CIGR General Assembly held during the CIGR World Congress in Quebec City, Canada, in June 2010, he was elected as incoming president of CIGR, and will become CIGR president in 2013–2014, the term of the presidency is six years, two years each for serving as incoming president, president, and past president.

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Mehmet Mutlu

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İsmail Hakki Boyaci and Mehmet Mutlu

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