https://doi.org/10.1595/205651319X15586889671013 Johnson Matthey Technol. Rev., 2019, **63**, (3), 205–207

JOHNSON MATTHEY
TECHNOLOGY REVIEW

www.technology.matthey.com

"Nanobiosensors"

Edited by Alexandru Mihai Grumezescu (Faculty of Applied Chemistry and Materials Science, University Politehnica of Bucharest, Romania), Nanotechnology in the Agri-Food Industry, Volume 8, Academic Press, an imprint of Elsevier, Cambridge, Massachusetts, USA, 2017, 926 pages, ISBN: 978-0-12-804301-1, £138.00, €153.01, US$200.00

Reviewed by Chun-Tian Zhao*
Tracerco, Tracer Technology Centre, The Moat, Belasis Hall Technology Park, Billingham, TS23 4ED, UK

Patrick Daubinger#
Johnson Matthey Piezo Products GmbH, Bahnhofstr. 43, 96257 Redwitz, Germany

Email: *chun-tian.zhao@tracerco.com and #patrick.daubinger@matthey.com

Introduction

"Nanobiosensors" is the 8th volume of Nanotechnology in the Agri-Food Industry, a series edited by Dr Alexandru Mihai Grumezescu, at the Department of Science and Engineering of Oxide Materials and Nanomaterials, Politehnica University of Bucharest, Romania, who is an experienced and well published researcher and editor in the field of nano- and biostructures. Once again, this is a large volume comprising twenty chapters authored by researchers from fifteen countries. The book has thus gathered the multi-disciplinary effort of international scientists in research and development of sensors or biosensors for food test and analysis application. Particularly, as it is entitled, the employment of nanotechnology in sensor development is highlighted in this book.

Nanotechnology has been a driving concept and has made tangible impact in sensor development. Different nanotechnologies, from nanoscale materials, nanostructured materials to nano- and microscale processing and assembly, are intertwined and overlapping. Indeed, nanoscience and technology can be substantially felt as an enabler in biosensor development in this book. Particularly overall the following aspects are well documented by the authors of the book:

- Nanomaterials, nanoparticles and nanocomposite enabled biosensors
- Nano bioactive materials
- Microarrays, microfluidics and lab-on-a-chip.

Nanoparticles for Biosensors

Nanoparticles are typical and fundamental nanomaterials and it's no surprise that they are widely used as building moieties for nanobiosensors. This is presented one way or another in many chapters of the book.

Gold, platinum and silver nanoparticles including nanowires and nanorods are some of the popular nanomaterials for sensor construction due to their unique chemical, optical, electrical and mechanical properties. Optical biosensors can be developed by exploiting the optical properties of the nanoparticles in the first instance. Chapter 4, by I. E. Paul (Vellore Institute of Technology, India) *et al.*, details the studies of using plasmonic Au and Ag nanoparticles (including nanorods) to build colorimetric sensors to detect chemical adulterants (melamine), contaminants (pesticides such as malathion) and bacteria in food, based on adsorption mechanism in an aqueous environment. Further overview of application of plasmonic Au particles for biosensors is provided in Chapter 16 by S. K. Kailasa (Sardar Vallabhbhai National Institute of Technology, India) *et al*. Additional important approaches to use Au nanoparticles including surface functionalisation with biomolecules for constructing other types of biosensors (for example, electrochemical) is discussed in Chapter 5 by F. Dridi (University of Lyon, France) *et al*.

Au nanoparticles are known to be excellent substrates for surface-enhanced Raman spectroscopy (SERS). A brief review of SERS based nanobiosensors for food is given in Chapter 14 by N. M. Kulshreshtha (Jaipur National University, India) *et al*. Quantum dots (QDs) have very distinctive size dependent fluorescence properties. An interesting development is a QDs based fluorescence biosensor, for example fluorescence resonance energy transfer (FRET) biosensors. Chapter 20 by B. Bhattacharya (National Institute of Food Technology Entrepreneurship and Management, India) *et al*., gives a concise but quite thorough theoretical background of the fluorescence and metal based QDs and describes the mechanism of QDs working as FRET probes. The use of QDs for biosensors is also mentioned in Chapter 9 by K. Rovina (University Malaysia Sabah, Malaysia) *et al*. And in Chapter 16, in addition to cadmium telluride nanoparticles, the burgeoning studies of the relative new member of QDs, carbon dots for biosensor development is introduced.

The use of other commonly studied nanoparticles, for example carbon nanotubes, magnetic particles as conjugative support of biomolecules are described in Chapter 5 too. In Chapter 7 by K. Mistewicz (Silesian University of Technology, Poland) *et al*., the gas nanosensors based on functional nanoparticles (for example, titanium dioxide, tin(IV) oxide–zinc oxide or copper) formulations are described. Particularly presented in detail are humidity sensors built on nanocrystalline antimony sulfoiodide, employing their conductive, photoconductive, impedance or capacity properties in the presence of water. Such gas nanosensors may be used for packaging, resulting in smart and intelligent packaging systems. Further, in this book, Chapter 18 by T. Caon (Federal University of Santa Catarina, Brazil) *et al*., is dedicated to discussing intelligent packaging systems carrying either bio-nano- gas sensors or radio frequency identification tags to monitor pathogens or contaminants in the packaged food.

Nano-Bioactive Materials for Sensors

Bioactive materials are often an indispensable element in many biosensors in its original sense. A notable progress in biosensor development is the use of aptamers, short oligonucleotide sequences (single-stranded DNA (ssDNA), RNA or peptide) as bioreceptors of the sensors. The development of the so-called aptasensors is reviewed in Chapter 2 by G. A. Evtugyn (Kazan Federal University, Russia) *et al*., and in Chapter 3 by B. Hussain (Sabanci University, Turkey) *et al*. Chapter 3 lists the advantages of aptamers over monoclonal antibodies such as stability, selectivity and the screening of aptamers to obtain the tightest binding sequences from random pool. The use of aptamers conjugated to nanoparticles (for example, Au, carbon nanotubes) for detecting foodborne pathogens, toxins and allergens and in some cases even multiplexed biosensors, are described in both Chapter 2, 3 as well as Chapter 19 by R. B. Dominguez (Advanced Materials Research Center, Mexico) *et al*., and Chapter 9, with the advantages such as reliability and efficiency shown.

The other type of biochemical-based sensor such as enzyme-based sensors and antibody-based sensors or immunosensors are also discussed in Chapters 19 and 2. In Chapter 3 conventional food contamination detection methods including immunoassay and polymerase chain reaction (PCR) based methods are described too, which may act as a comparison.

Microarrays, Microfluidics and Lab-on-a-Chip

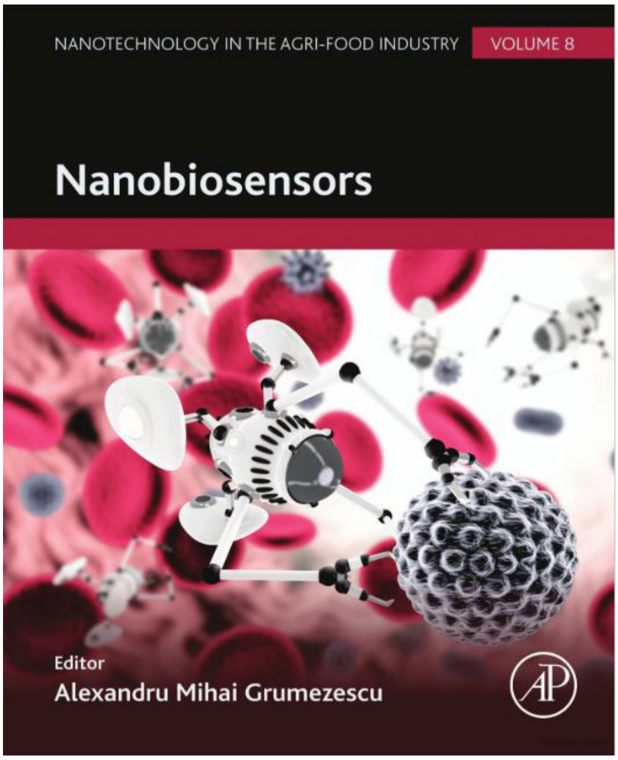
One ultimate aim and advantage of testing and analysing food is improving point of customer care at high precision, high throughput and low cost. The integration of biosensors with microfluidic components leads to lab-on-a-chip which can fulfil these combined benefits. Chapter 6 by D. S. Correa (National Nanotechnology Laboratory for Agribusiness, Brazil) *et al*., highlights the power of microfluidics enhanced with biosensing. Some developments in application in food analytics is summarised. Further review of micro- and nanotechnologies leading to progress of lab-on-a-chip detection of food pathogens is reviewed in Chapter 12 by N. C. Cady (SUNY Polytechnic Institute, USA) *et al*.

Chapter 11 by N. Adányi (National Agricultural Research and Innovation Center, Hungary) *et al*., presents the development of label-free optical biosensor techniques based on evanescent field effect biosensors. Various techniques, such as reflectometric interference spectroscopy, interferometry, optical waveguide lightmode spectroscopy, resonant mirrors, fibre optics, total internal reflection ellipsometry and total internal reflection fluorescence spectroscopy are discussed. It has been pointed out that these techniques are suitable for lab-on-a-chip application.

A complexity of food testing is that multi-analyte analysis is often required. Multi-microarray analysis is very helpful in meeting the requirements. Chapter 1 by J. V. Ros-Lis (Polytechnic University of Valencia, Spain) *et al.*, demonstrates the sensor-array approach for food quality monitoring and identification that mimics a mammalian olfactory system. This is exampled by summarising the studies of optoelectronic nose based on chromogenic arrays made of dye chemicals loaded to nano- or mesoporous inorganic support materials. The sensor arrays are used to monitor the freshness of poultry products and to identify the origin of blue cheese with the aid of multivariant analysis. Reasonably good results are obtained.

Final Remarks

Through discussing the applications of nanotechnology in biosensor development for food testing and analysis, the book presents a very full list of sensor techniques. The volume fulfils the series' aims of bringing together the most recent and innovative applications of nanotechnology in the agri-food industry and of presenting future perspectives in the design of new or alternative foods. This is a book that will benefit not only workers in food testing and analysis but also broader areas of the chemical and biosensing community, although it could have potentially been further enriched with the comments of the commercialisation status of the biosensors discussed.



"Nanobiosensors"

The Reviewers

Dr Chun-tian Zhao is a senior polymer and colloid scientist and research team leader at Tracerco, a Johnson Matthey company.

Patrick Daubinger works for Johnson Matthey in the areas of medical components technical sales and business development. He obtained his Master's degree from the University of Freiburg, Germany in 2013, where he conducted research on hierarchical platinum nanostructures for biosensor applications. His work on hierarchical nanostructures resulted in various publications and he holds a patent in this field.

