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"Nanomaterials and Environmental Biotechnology"

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Introduction

This book is a fascinating account of how nanoparticles and nanotechnology are increasingly employed in a diverse array of applications ranging from plant growth to food packaging, biosensing, enzyme immobilisation and more. The book is divided into 20 chapters, each dealing with a specific application of nanotechnology and written by a different group of eminent academics from Indian universities and research institutes.

Each chapter is a review of its own topic area and the literature citations at the end of each chapter make it easy for the reader to use this book as a reference volume from which further in-depth reading can be pursued by following the cited literature.

Safety of Nanoparticles in Plants and Packaging

Chapter 1 deals with the phytotoxicity of nanoparticles in plants which can lead to both positive and negative outcomes. For example, improvement in germination rate and growth have been reported in seeds of rice exposed to carbon nanotubes; on the other hand, toxicity has also been widely reported, including studies on aluminium oxide and zinc oxide nanoparticles hindering root growth rate.

Chapter 2 considers an entirely separate but equally important area of use of nanomaterials in food packaging. It concludes that "it is essential to perform safety assessment of nanomaterials before their application in food packaging or processing" and provide a citation on how to do this using a "decision tree".

Biosensors from Nanobiotechnology

Chapter 7 introduces how biosensors derived from nanobiotechnology can be used to monitor the environment and gain information relating to its health and the detrimental effects that modernisation and industrialisation have had on the planet. Biosensors need to be specific, rapid, sensitive and cost-effective. The advent of nanotechnology and biosensors has made this possible and the authors of this chapter (Gupta and Kakkar) explore the different types of biosensors that have been developed over recent years. The authors give a brief explanation of how different types of sensors work using a combination of bio-recognition components and different transduction principles. Types include: (a) immunosensors; (b) enzymatic biosensors; (c) whole-cell based sensors; (d) biosensors; (e) genosensors; (f) aptasensors and (g) biomimetic biosensors. The role of the transducer is to convert the biochemical response into an analysable and measurable signal. The outputs can be electrochemical, optical, piezoelectric, thermometric or magnetic.

Enzyme Immobilisation

Chapter 10 tackles the interesting area of enzyme immobilisation and the use of chitosan nanoparticles therein. The biopolymer's distinct physicochemical properties have been described to offer an excellent microenvironment for enzyme immobilisation through adsorption, covalent binding or cross-linking, to achieve desirable enzymatic activity and stability. On the other hand, nanoparticles as materials of enhanced properties, owing to their high surface to volume ratio, have been introduced as attractive candidates for enzyme immobilisation. The chapter briefly discussed various methods for the preparation of chitosan nanoparticles for enzyme immobilisation including reverse micelle, coprecipitation, ionotropic gelation and ionic or emulsion cross-linking methods. Different methods for enzyme immobilisation such as support binding, cross-linking and entrapment, as well as different materials used as supports have been explained too. This section is then closed by presenting some examples for immobilisation of different enzyme families (for example, α-amylase, β-galactosidase, cellulase, laccase, lipase or protease) through applying chitosan nanoparticles.

Solid Lipid Nanoparticles

Chapter 13 offers an overview of solid lipid nanoparticles (SLN) as pharmaceuticals delivery systems whereas Chapter 19 gives a review of the most commonly used nanocarriers for drug delivery systems, with a focus on vesicular, polymeric and inorganic carriers.

SLN are lipid-based formulations, containing typically non-toxic biodegradable polymers forming a solid hydrophobic core suspended in an aqueous phase, the whole structure being stabilised by surfactants. The therapeutic agent is dissolved or dispersed in the solid lipid core, the SLN being suitable for incorporation and delivery of both hydrophilic and hydrophobic drugs. SLN present significant advantages over conventional drug delivery systems, including but not limited to biocompatibility and bioavailability, reduced drug leakage and increased physical stability of the drugs. In addition, they have been used successfully in various drug delivery techniques.

Novel applications of SLN as drug carriers are described in the field of gene therapy, peptide drug delivery and vaccines. SLN production methods use low mechanical force, allowing successful incorporation and delivery of nucleic acids in gene therapy. Overall, SLN are promising alternatives to traditional drug delivery systems, offering multiple advantages in terms of drug delivery and bioavailability, as well as being economically efficient and easy to produce on scale.

FDA-Approved Nanomedicines

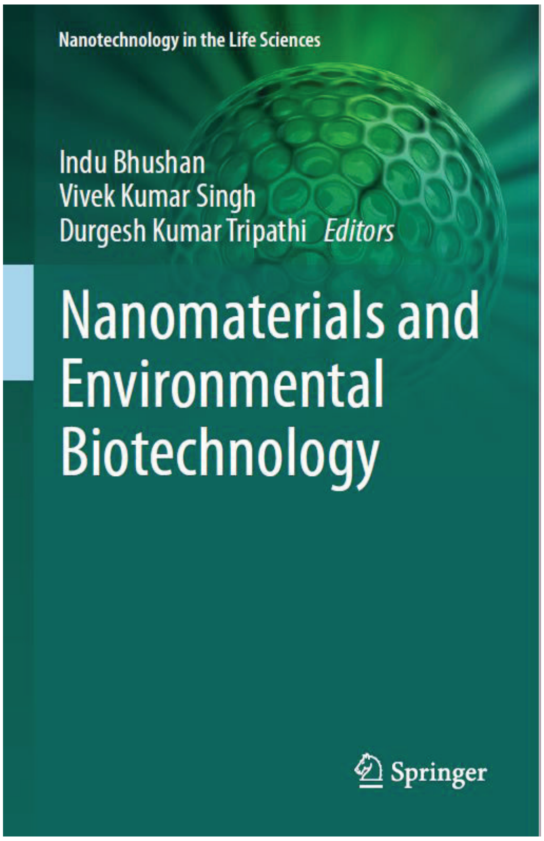
An extensive summary of FDA-approved nanomedicines is included in Table 19.1 (Chapter 19), which also summarises the advantages of these specific formulations. The main types of nanocarriers described in Chapter 19 are vesicular carriers (liposomes and niosomes), polymeric nanoparticles and inorganic carriers (silica, gold and calcium nanoparticles). Liposomes and solid lipid nanoparticles (see also Chapter 13) are suitable for the delivery of drugs by any route, either oral or parenteral and can be used with both hydrophilic and lipophilic drugs. Their main advantages reside in protecting labile drugs, limited toxicity and a sustainable targeted release of the drug.

Inorganic nanocarriers exhibit higher stability and resistance to microbial growth, while having a low toxicity and allowing facile surface modifications. Mesoporous silica nanoparticles allow encapsulation of the therapeutic agent and targeted delivery to tumour cells in cancer therapy. Gold nanoparticles are biocompatible and bio-inert and have been successfully used in covalent conjugation with protein antigens in developing vaccines for cancer immunotherapy. Calcium phosphate nanoparticles are excellent candidates for developing ceramic-based carriers for peptide drugs prone to degradation, such as insulin.

Summary

In conclusion, I consider this book to be a positive contribution to the biotechnology literature, although I do not recommend reading this book sequentially from Page 1 as the variety of topics introduced is too great and each individual topic is not explored in depth. It is best used (and deserves recommendation) as a reference source from which each chapter can be used as the starting point to a more in-depth study or review of a particular topic. There are some negative aspects of the presentation of this work which do, unfortunately, detract from its enjoyment. These are exemplified in the poor quality of the diagrams, the grammatical errors and the somewhat odd references of Chapter 7.

Overall, though, this book is a positive addition to the biotechnology reference bookshelf.



"Nanomaterials and Environmental Biotechnology"

The Reviewer

Martin Hayes is Biotechnology Lead at Johnson Matthey based in Cambridge, UK. He has worked with Johnson Matthey since 1997 and has held multiple research, development and customer-facing technical roles across the company. He holds a PhD in heterogeneous catalysis and is interested in the application of biology as a technology to realise circular chemical processing and accelerate the transition to "Net Zero".

