Functional Chitosan

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Editors

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Drug Delivery and Biomedical Applications

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Preface

The book focuses on functional chitosan for the purpose of drug delivery and biomedical applications. Chitosan is composed of α-1, 4-linked 2-amino-2-deoxy-α-d-glucose (N-acetyl glucosamine). It is a nontoxic, biodegradable, biocompatible natural amino polysaccharide with versatile applications. According to the United States Food and Drug Administration (USFDA), it is a GRAS (Generally Recognized as Safe) material and, hence, is widely used in pharmaceutical and biomedical fields, including drug delivery, food technology, and tissue engineering. It has a cationic character owing to its primary amino groups ($-NH_2$). These primary amino groups are important for synthetic modifications for controlled drug release, in situ gelation, mucoadhesion, permeation enhancement, and transfection properties. Due to its chemical modifications, most of these characteristics can even be further improved. Due to its fast dissolution in gastric fluid, its use is limited as oral sustained drug release carriers. Considering the importance and convenience of the oral route, the drug delivery properties of chitosan carriers was improved by modification of functional groups or with the use of other polymer in combination with cross-linker. By this way rigid matrix structure could be prepared to control the premature drug release. Due to the short biological half-life of the drug substance, it often requires frequent dosing, which may ultimately lead to toxicity due to the accumulation of excessive degradative products from the drugs. So, functional chitosan is promising in the area of drug delivery and biomedical engineering.

This book consists of different chapters emphasizing drug delivery and biomedical application of chitosan.

Chapter 1, "Chitosan and Its Derivatives: A New Versatile Bio-polymer for Various Applications," discusses the preparation, characterization, and various modifications of chitosan and its biomedical applications.

Oral drug delivery is the most important route of drug administration due to its safety, convenience, and cost-effectiveness. However, some drugs cannot be administered orally, mainly due to drug degradation at acidic pH in the digestive system. Chapter 2, "Application of Chitosan in Oral Drug Delivery," focuses on chitosan-based systems for oral drug delivery carriers of therapeutic molecules and drugs.

Transdermal drug delivery has been attracting attention for last few decades in the field of drug delivery and biomedical research, in compared with other

administration routes. This approach is generally accepted owing to its ease of application, allowing the drug carriers to directly enter into systemic circulation via transdermal delivery to avoid hepatic metabolism, protect from acidic pH, the enzymes effect of GIT and the fluctuating plasma drug concentrations associated with the oral delivery. Chapter 3, "Transdermal Delivery of Chitosan-Based Systems," discusses various chitosan-based systems for transdermal drug delivery.

Chitosan-based ocular drug delivery systems are widely investigated to improve the bioavailability at the anterior/posterior pole of the eye due to its mucoadhesive property that helps in increasing the efficacy of existing ocular drugs, affords stimuli-responsive/targeted-based delivery regimen, enhances the corneal permeability, and improves the accumulation of drugs in the corneal/conjunctival epithelium for an extended period of time. Chapter 4, "Chitosan-Based Ocular Drug Delivery Systems," summarizes the major ocular diseases affecting the eye, novel ocular drug delivery systems, intraocular drug transport barriers, and ocular transporters. This chapter also discusses ocular drug delivery systems, such as stimuli-responsive systems, targeted delivery systems, and gene-based delivery systems.

Using chitosan as matrix and/or coat material can protect drugs from chemical and enzymatic degradation during oral administration. It binds strongly to mucus and show a mucosal permeation enhancement property that promotes drug absorption through the intestinal epithelial cells. Oral colon-specific delivery systems have been explored for targeted drug administration for the treatment of colon cancer, ulcerative colitis, Crohn's disease, irritable bowel syndrome, Hirschsprung's disease, antibiotic-associated colitis, and other colon diseases. Chapter 5, "Functional Chitosan Carriers for Oral Colon-Specific Drug Delivery," provides an overview of the relevant physicochemical and biological properties of chitosan and its derivatives and novel formulations with respect to their use as oral colon-targeted drug delivery system.

Chitosan-based hydrogels play an important role in the development of new biomaterials for biomedical applications. Many cross-linking (or polymerization) approaches have been developed to convert chitosan into smart hydrogels, with the aim of obtaining new drug delivery devices. Such hydrogels can also undergo changes in their physicochemical properties in response to environmental changes, such as pH, ionic strength, temperature, and magnetic field. Chapter 6, "Chitosan-Based Hydrogels for Drug Delivery," focuses on the most recent progress made regarding preparation, properties, and their salient characteristics in drug delivery.

Various delivery systems, such as micelles, liposomes, or nanoparticles, are a major line of investigation to improve chemotherapeutic treatment. Chapter 7, "Recent Advances of Chitosan-Based Systems for Delivery of Anticancer Drugs," discusses chitosan-based drug delivery systems and different strategies for the treatment of cancer.

Gene therapy is a relatively new branch of medical science with huge therapeutic potential for a disorder at its genetic root. The success of gene therapy greatly depends on the vector's or vehicle's ability to selectively and efficiently deliver gene to the target site with minimal or no side effects. Chapter 8, "Chitosan-Based

Systems for Gene Delivery," highlights the chitosan-based systems for the delivery of gene.

Interpenetrating polymeric network (IPN) has gained great attention in the last decades, which involves a blend of two or more polymers in a network with at least one of the systems synthesized in the presence of the other. The development of IPN is interesting as it generates free volume space for the easy encapsulation of drugs in the three-dimensional framework, which are obtained by cross-linking of two or more polymer networks. Chapter 9, "Chitosan-Based Interpenetrating Polymer Networks: Drug Delivery Application," discusses IPN based on chitosan for drug delivery and biomedical applications.

Chitosan biomaterial attains immense interest in the field of tissue engineering owing to its biocompatibility and biodegradation. Besides, it exhibits bactericidal and fungicidal properties along with enhanced immune response. Chitosan-based materials are mainly used for fabricating the scaffolds for tissue engineering, which have been discussed in Chap. 10, "Chitosan-Based Systems in Tissue Engineering." Chapter 11, "Chitosan-Based Nanoformulation as Carriers of Small Molecules for Tissue Regeneration," focuses on nanoformulation of chitosan as carriers of small molecules for tissue regeneration.

Nowadays theranostic approach has been widely used for diagnosis and treatment with accurate targeting of cancer-specific cells. Theranostic system is very interesting and useful due to its drug targeting and molecular imaging in a single platform. Chitosan-based systems for theranostic applications are discussed in Chap. 12.

The modification of chitosan by physical or chemical methodologies is important for controlled drug delivery. Grafted chitosan is interesting as it increases active functional groups, which may react with metals, metal oxides, or other materials, such as graphene and carbon nanotube for the drug target to specific sites along with prolonged release of drug. Chapter 13, "Grafted Chitosan Systems for Biomedical applications," highlights the need for grafted chitosan and synthesis techniques to obtain the desired properties and its biomedical applications.

Chapter 14, "Chitosan-Based Systems for Controlled Delivery of Antimicrobial Peptides for Biomedical Application," discusses chitosan-based antimicrobial peptides (AMPs) and their biomedical applications. The last chapter, "Antibacterial Activity of Chitosan-Based Systems," discusses the latest development of chitosan-based systems for antimicrobial activity.

The book is useful for students, researchers, scholars, industry personnel, and scientists in the field of pharmaceuticals, material sciences, and biomedical engineering.

We express our sincere gratitude to all authors for their contributions to this book. We also thank the publisher for the continuous support for the publication of this edited book.

Asansol, India Sougata Jana
Amarkantak, India Subrata Jana

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Subrata Jana is presently working as an Associate Professor at the Department of Chemistry, Indira Gandhi National Tribal University (Central University), Amarkantak, Madhya Pradesh, India, and his current research focuses on the design and synthesis of artificial receptors for the recognition of anions, cations, and *N*-methylated protein residue. His other area of research interest is biodegradable polymeric-based carrier systems for the delivery of drug molecules. So far he has published ~40 research papers in peer-reviewed international journals and contributed more than 10 book chapters to different edited books published by internationally renowned publishers. He is also an editorial board member in the *Journal of PharmaSciTech* (ISSN: 2231 3788) and the *International Journal of Scientific and Engineering Research* (ISSN: 2229-5518) and a reviewer in the *International Journal of Biological Macromolecule* (Elsevier), the *Journal of PharmaSciTech*, and *Current Pharmaceutical Design* (Bentham). He has obtained his PhD in organic chemistry from Indian Institute of Engineering Science and Technology (IIEST), Shibpur, India. Then he moved to the University of Victoria, Canada, to work with Professor (Dr.) Fraser Hof on supramolecular and medicinal chemistry as a postdoctoral fellow. He then worked further with Dr. Kenneth J Woycechowsky at the University of Utah, USA, on protein engineering and enzyme catalysis as a postdoctoral research associate. Overall he extensively studied on the supramolecular behavior of the host–guest interaction and synthesis of heterocyclics, such as pyrimidines, naphthyridines, quinoline, and diazepines, by exploiting microwave protocol for green chemical synthesis.