

Woodhead Publishing Series in Biomaterials

Polysaccharide Carriers for Drug Delivery

Edited by

Sabyasachi Maiti
Sougata Jana



ELSEVIER

WP

WOODHEAD
PUBLISHING

An imprint of Elsevier

Woodhead Publishing is an imprint of Elsevier
The Officers' Mess Business Centre, Royston Road, Duxford, CB22 4QH, United Kingdom
50 Hampshire Street, 5th Floor, Cambridge, MA 02139, United States
The Boulevard, Langford Lane, Kidlington, OX5 1GB, United Kingdom

Copyright © 2019 Elsevier Ltd. All rights reserved.

No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or any information storage and retrieval system, without permission in writing from the publisher. Details on how to seek permission, further information about the Publisher's permissions policies and our arrangements with organizations such as the Copyright Clearance Center and the Copyright Licensing Agency, can be found at our website: www.elsevier.com/permissions.

This book and the individual contributions contained in it are protected under copyright by the Publisher (other than as may be noted herein).

Notices

Knowledge and best practice in this field are constantly changing. As new research and experience broaden our understanding, changes in research methods, professional practices, or medical treatment may become necessary.

Practitioners and researchers must always rely on their own experience and knowledge in evaluating and using any information, methods, compounds, or experiments described herein. In using such information or methods they should be mindful of their own safety and the safety of others, including parties for whom they have a professional responsibility.

To the fullest extent of the law, neither the Publisher nor the authors, contributors, or editors, assume any liability for any injury and/or damage to persons or property as a matter of products liability, negligence or otherwise, or from any use or operation of any methods, products, instructions, or ideas contained in the material herein.

Library of Congress Cataloging-in-Publication Data

A catalog record for this book is available from the Library of Congress

British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library

ISBN: 978-0-08-102553-6

For information on all Woodhead publications
visit our website at <https://www.elsevier.com/books-and-journals>

Publisher: Matthew Deans
Acquisition Editor: Sabrina Webber
Editorial Project Manager: Leticia M. Lima
Production Project Manager:
Joy Christel Neumarin Honest Thangiah
Cover Designer: Greg Harris

Typeset by SPi Global, India



Contents

Contributors	xiii
About the Editors	xix
1 Natural polysaccharides: Structural features and properties	1
<i>Harsh Yadav and Chandrabose Karthikeyan</i>	
1.1 Introduction	1
1.2 Polysaccharides of plant origin	2
1.3 Polysaccharides of algal origin	5
1.4 Polysaccharides of animal origin	8
1.5 Polysaccharides from microorganisms	10
1.6 Concluding remarks	12
References	12
2 Bioactive and drug-delivery potentials of polysaccharides and their derivatives	19
<i>Ashok K. Singh, Archana S. Bhadauria, Pranesh Kumar, Hriday Bera and Sudipta Saha</i>	
2.1 Introduction	19
2.2 Polysaccharides for the delivery of nucleic acid-based drugs	32
2.3 Pharmacological significance of bioactive polysaccharides	33
2.4 Conclusion	35
Acknowledgment	40
Conflict of interest	40
References	40
Further reading	48
3 Glycosaminoglycans as potential carriers for drug delivery	49
<i>Sabyasachi Maiti</i>	
3.1 Introduction	49
3.2 Chondroitin sulfate-derived carriers	50
3.3 Conclusion	73
References	73
4 Chitosan-based nanocarriers for ophthalmic applications	79
<i>Rishi Paliwal, Shivani Rai Paliwal, Kunjbihari Sulakhiya, Balak Das Kurmi, Rameshroo Kenwat and Aanjaneya Mamgain</i>	
4.1 Introduction	79
4.2 Anatomical and physiological barriers for ocular drug delivery	79

4.3	Formulation characteristics for ocular drug delivery	80
4.4	Role of biomaterial in ocular drug delivery	82
4.5	Chitosan: A natural, biocompatible material for ocular therapeutics	82
4.6	Chitosan-based drug-delivery systems in ophthalmic applications	83
4.7	Safety, biocompatibility, and regulatory issues with chitosan-based ocular drug-delivery systems	97
4.8	Conclusion	97
	Acknowledgment	98
	References	98
5	Alginate for delivery of sensitive molecules and cells for diabetes treatment	105
	<i>Awanish Kumar and Ashwini Kumar</i>	
5.1	Introduction to diabetes mellitus	106
5.2	Cellular microencapsulation	107
5.3	Alginate as functional biopolymer	112
5.4	Alginate and antidiabetic peptide delivery	116
5.5	Alginate and β -cell microencapsulation	119
5.6	Conclusions	121
	References	123
	Further Reading	126
6	Biocompatible injectable polysaccharide materials for drug delivery	127
	<i>Anca Niculina Cadinoiu, Delia Mihaela Rata and Leonard Ionut Atanase</i>	
6.1	Introduction	127
6.2	The interaction of polysaccharide-based materials with blood	129
6.3	Physicochemical properties of injectables drug delivery systems	135
6.4	Injectable drug delivery systems based on chitosan	137
6.5	Injectable drug delivery systems based on cellulose	139
6.6	Injectable drug delivery systems based on starch	143
6.7	Injectable drug delivery systems based on other polysaccharides	145
6.8	Conclusions	147
	Acknowledgment	148
	References	148
7	Polysaccharide-based stimuli-sensitive graft copolymers for drug delivery	155
	<i>Raghavendra V. Kulkarni, Syed Z. Inamdar, Kusal K. Das and Mallanagouda S. Biradar</i>	
7.1	Introduction	155
7.2	Grafting reaction	156
7.3	Principle of grafting reaction	157
7.4	Different types of grafting techniques	157
7.5	Polysaccharides in drug delivery	160

7.6	Stimuli-sensitive polysaccharides in drug delivery	161
7.7	Stimuli-sensitive polysaccharide hydrogels	161
7.8	Electrically-sensitive polysaccharides	162
7.9	pH-sensitive polysaccharides	164
7.10	Temperature sensitive polysaccharides	170
7.11	Conclusions	172
	References	172
8	Magnetic-responsive polysaccharide-inorganic composite materials for cancer therapeutics	179
	<i>Munther Alomari, Dana Almohazey, Sarah Almofty, Amani Alhibshi, Iman Almansour, Chariya Kaewsaneha, Waisudin Badri, Hatem Fessi and Abdelhamid Elaissari,</i>	
8.1	Introduction	179
8.2	Preparations and properties of bare magnetic nanoparticles	180
8.3	Preparations and properties of coated and functionalized magnetic nanoparticles	184
8.4	Conclusion	205
	References	206
	Further reading	216
9	Thermo- and ultrasound-responsive polysaccharides for controlled drug delivery	217
	<i>Saundray Raj Soni and Animesh Ghosh</i>	
9.1	Introduction	217
9.2	Field responsive systems: A potential approach in targeted drug delivery applications	219
9.3	Thermoresponsive polymers: Applications in targeted drug delivery systems	239
9.4	Ultrasound responsive polymers: Applications in targeted drug delivery systems	248
9.5	Targeted drug delivery via dual thermo- and ultrasound-responsive systems: An overview of the synthesis approach and efficacy improvement	260
9.6	Concluding remarks	261
	Acknowledgments	262
	References	262
	Further reading	270
10	Polysaccharide-based amorphous solid dispersions (ASDs) for improving solubility and bioavailability of drugs	271
	<i>Saleha Rehman, Bushra Nabi, Shavej Ahmad, Sanjula Baboota and Javed Ali</i>	
10.1	Introduction	272
10.2	Solid dispersion	273

Chitosan-based nanocarriers for ophthalmic applications

4

Rishi Paliwal*, Shivani Rai Paliwal[†], Kunjbihari Sulakhiya*, Balak Das Kurmi[†], Rameshroo Kenwat*, Aanjaneya Mamgain*

*Department of Pharmacy, Indira Gandhi National Tribal University, Amarkantak, India,

[†]Institute of Pharmaceutical Sciences, Guru Ghasidas University, Bilaspur, India

4.1 Introduction

Ocular drug delivery is one of the most interesting and challenging endeavors for formulation development fraternity. The vast anatomical, physiological, and biochemical features of the eye limit or restrict the easy entry of drug molecules at the site of action. Therefore, it is always advisable to fulfill basic and mandatory features in an ocular formulation to efficiently counterbalance such associated limitations. Drug delivery for the treatment of ocular problems or diseases can be achieved by any one of the popular routes of administration such as topical, local ocular, oral, or systemic. Currently available means of oral and systemic delivery for ocular therapy require high doses of drugs/active ingredients to maintain therapeutic effective concentration but not advisable or are less popular due to severe adverse effect to the other organs/tissues as a result of biodistribution followed by administration through these routes [1]. On other hand, local as well systemic delivery through ocular route provides better platform to ocular therapeutics along with patient compliance and psychological satisfaction. The majority of difficulties arise in ocular therapeutics especially in order to achieve the therapeutic level of drug concentration at the site of action for an appropriate duration of time to attain the desired pharmacological action. The need of ophthalmic medication is increasing day by day due to the population of industrialization environment and popularization due to patient compliances [2].

4.2 Anatomical and physiological barriers for ocular drug delivery

The human eye can be broadly structured into two large segments: anterior and posterior, the latter representing about two-thirds of the total area. The anterior segment includes the cornea, the conjunctiva, the iris, the lens, the ciliary body, and the aqueous humor. Sclera, choroid, retina, vitreous humor, and optic nerve are parts of the posterior segment [3]. For anterior-segment, common routes of drug-delivery administration are topical instillation and subconjunctival injection, whereas for posterior segment common routes include systemic dosing, periocular and intravitreal injections, and topical dosing [4]. The topical administration of drug in ophthalmic route is well accepted