

WOODHEAD PUBLISHING SERIES IN BIOMATERIALS



POLYSACCHARIDE-BASED NANOCOMPOSITES FOR GENE DELIVERY AND TISSUE ENGINEERING



Edited by
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Polysaccharide-Based Nanocomposites for Gene Delivery and Tissue Engineering

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Woodhead Publishing Series in Biomaterials

Polysaccharide-Based Nanocomposites for Gene Delivery and Tissue Engineering

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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

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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: 978-0-12-821230-1

ISBN: 978-0-12-823218-7

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

Publisher: Matthew Deans
Acquisitions Editor: Glyn Jones
Editorial Project Manager: Rafael G. Trombaco
Production Project Manager: Vignesh Tamil
Cover Designer: Miles Hitchen

Typeset by SPi Global, India



Dedication

The editors are honored to dedicate this book to Dr. Kishwar Usmani (Aunty of Dr. Mohammad Jawaaid), who left this worldly life on January 14, 2021.

Allah SWT forgive her small and big mistakes and Give her a Higher Place in Jannatul Firdous. Ameen.

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Jawaid received the Excellent Academic Award in the Category of International Grant-Universiti Putra Malaysia—2018 and also the Excellent Academic Staff Award in Category of industry High Impact Network during Community and Industry Network (ICAN 2019). Beside that he also won Gold Medal during JINM Showcase under Community and Industry Network Category at Universiti Putra Malaysia, Malaysia. He also received the Publons Peer Review Awards 2017, and 2018 (Materials Science), Certified Sentinel of Science Award Recipient—2016 (Materials Science) and 2019 (Materials Science and Cross Field). He is the winner of the Newton-Ungku Omar Coordination Fund: UK-Malaysia Research and Innovation Bridges Competition 2015. Recently he was recognized with a Fellow and Chartered Scientist Award from the Institute of Materials, Minerals and Mining (IOM), UK. He is also a lifetime member of the Asian Polymer Association, and the Malaysian Society for Engineering and Technology. He has professional membership of the American Chemical Society (ACS) and the Society of Plastics Engineers (SPE), USA.

Preface

This book provides solid, quantitative descriptions and reliable guidelines, reflecting the maturation and demand of the field and the development of new polysaccharide nanocomposites. It focuses on the different types of polysaccharide nanocomposites of cellulose, chitosan, alginate, etc. for gene delivery and tissue engineering. The book also covers polysaccharide hydrogels for tissue engineering and polysaccharide magnetic nanocomposites for gene delivery and highlights the most exciting applications in the field of gene delivery and tissue engineering. This book will be of interest to researchers working in the fields of material science, biomaterials, regenerative medicines, drug delivery, tissue engineering, polymer science/chemistry, and chemical engineering, and in the polymer industry. It will be useful for scientists working on polysaccharide nanocomposites for gene delivery and tissue engineering. The book will be very helpful for students in the development of new polysaccharide nanocomposites as well as graduates in polymer technology, biomedical science, and biotechnology.

The two introductory chapters cover basic information about polysaccharides and nanocomposites, to provide a foundational understanding. The second section of this book covers chitosan and its derivatives-based dimensional frameworks as carriers for gene delivery, alginate- and hyaluronic-based hydrogels for tissue engineering, heparin- and cellulose-based nanocomposites for and dextran, pullulan, gellan, xanthan, and xanthun gum-based nanocomposites for tissue engineering applications. The last section describes polysaccharide-based 3D bioprinter inks for tissue engineering, polysaccharide-based nanocomposites for gene delivery, chitosan- and starch-based nanocomposites for gene delivery, and hyaluronic acid magnetic nanocomposites for gene delivery.

Finally, we assure the readers that the information provided in this book can serve as a very important tool for anyone wishing to select/design polysaccharide-based nanocomposites to fulfil the requirements of gene delivery and tissue engineering applications. We are grateful to all the authors who contributed chapters to this book and who helped to turn our thoughts into reality. Lastly, we are grateful to the Elsevier team for their continuous support at every stage to make it possible to publish on time.

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Hyaluronic acid-based hydrogel for tissue engineering

5

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5.1 Introduction to tissue engineering

The past 30 years have seen increasingly rapid advances in the field of tissue engineering, an interdisciplinary field that involves biomaterials science, cell biology, cell-material interaction, as well as surface characterization. Tissue engineering plays an important role in the restoration, preservation of damaged tissues or whole organs, as well as in the construction of new tissues to replace the lost tissues. Restoration or creation of new tissues normally involves four components, which are progenitor or stem cells, biomaterial scaffold, signaling proteins, and bioreactors. To develop a tissue, usually, the stem cells are first isolated from the tissue of interest, normally obtained from patients' small tissue biopsy. The isolated cells are then cultured and harvested in vitro. The isolated cells are then loaded into a three-dimensional biomaterial scaffold that has similar properties with the normal extracellular matrices (ECMs) of the selected tissues. Subsequently, the cell-implanted scaffolds are injected into the patient either through a needle or other minimally invasive delivery procedure. The fabricated tissue can also be transplanted into a patient's body through surgery. Of all the key components, the design of biomaterial scaffold with optimum characteristics is very crucial to ensure success in tissue engineering. Over the years, the role of hydrogels as a biomaterial scaffold in tissue engineering has received increased attention thanks to their desirable framework for cell growth and survival, on top of their unique properties and resemblances with the natural extracellular matrices (ECMs).

5.2 Overview of hydrogel

A hydrogel is referred to as three-dimensional (3D) cross-linked polymer scaffolds that form a macromolecular network capable of maintaining high water content. The hydrogel can be prepared from natural polymers such as collagen, gelatine, alginate, hyaluronic acid, and chitosan [1], as well as from synthetic materials such as polyethylene glycol (PEG) [2, 3], polyacrylamide (PAA) [4–6], polydimethylsiloxane (PDMS). Hydrogels can either be formed through physical or chemical cross-linking methods. To mimic the ECM and regenerate new tissue, the design of hydrogel must adhere to several criteria. For instance, a hydrogel scaffold should contain 3D