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Editors

Functional Biopolymers

With 221 Figures and 19 Tables

Springer

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Preface

Biopolymers are polymeric biomolecules usually obtained from living organisms or produced from renewable sources that might require polymerization and indicated to be as biodegradable polymer. When functionalized (naturally or synthetically), the biopolymer contains monomeric units that covalently bonded to form larger structures, show uniformly distributed set of molecular mass, and appear with chemically bound functional groups, which can be utilized as reagents, catalysts, reservoirs, and carriers. Functionalized polymer plays an essential role in the preservation and transmittance of genetic information and cellular construction in nature and function like storage of energy, micelle, hydrogel, and drug delivery carrier. Based on their well-marked chemical structures, biopolymers are classified in terms of their monomeric structure, polymer backbone, viability, degradability, and application. Even though many of these polymers were in use from the prehistoric time, but with the development of human technologies, designed biopolymeric systems have received increasing utilization in medical, pharmaceutical, food, and electronic industry, for applications such as encapsulation and delivery systems or to modulate the physicochemical and sensory properties of high-performance engineering polymeric materials. Biopolymers are currently used as a substitute of conventional synthetic polymeric materials due to their sustainable, renewable, and, more importantly, eco-friendly nature. The major advantages of the functional biopolymers have attracted huge attentions due to their ease of functional modifications either by chemical reactions on pendant groups, side chains, or by changing the physicochemical properties of the polymers so that they can show the required functional attributes such as high thermal stability, mechanical and chemical resistance, biodegradation, and oxygen barrier for the subsequent applications. However, it is very difficult to achieve all these properties within a single polymer molecule; therefore, there is an increasing demand for the preparation of composites along with biopolymers for improving the properties of the materials.

This reference book covers major areas of functional biopolymers that offer a comprehensive overview of the synthesis, properties, process, and biomedical applications of functional biopolymers as innovative sustainable materials. The primary focus of this book is to review the theoretical advances as well as experimental results and open up new windows for researchers in the field of polymers and sustainable materials. We believe this book will not only be useful for senior

researchers but also help senior undergraduate- and graduate-level students as a reference book. Chapters received from expert contributors cover various topics such as synthetic biopolymers, polymer micelles, blood-compatible polymers, and stimuli-responsive polymers. An up-to-date review of cell encapsulation strategies and cell surface and tissue engineering is also included in this work. The readers will discover more about hydrogels and polymers from renewable resources and specialty applications of functional biopolymers.

Chemistry Department, King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia — Mohammad Abu Jafar Mazumder, Ph.D.
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We are thankful to all contributing authors and coauthors for their valued contribution to this book. The project would never have been possible without their sincere supports and contributions. We would also like to express our gratitude to the publisher, authors, and others for granting us the copyright permission to use their illustrations. Although sincere efforts were made to obtain the copyright permissions from the respective owners to include the citation with the reproduced materials, we would like to offer our sincere apologies to any copyright holder if unknowingly their right is being infringed. Among the editors, Dr. Mohammad A. Jafar Mazumder would like to take this opportunity to express his sincere thanks to Drs. Abdulaziz A. Al-Saadi (Dean, College of Sciences, KFUPM) and Khalid R. Alhooshani (Chairman, Chemistry Department, KFUPM) and also to his colleagues at the King Fahd University of Petroleum and Minerals (KFUPM), Saudi Arabia. Dr. Amir Al-Ahmed would like to take this opportunity to express his sincere thanks to Dr. Fahad Al-Sulaiman (Director CORE-RE, KFUPM) and also to his colleagues at the King Fahd University of Petroleum and Minerals, Saudi Arabia. Without their continuous encouragement, this book would have not been brought into its final form. We would also like to acknowledge the sincere efforts of the Springer team, especially Dr. Sylvia Blago, Dr. Sofia Costa, and Dr. Judith Hinterberg and others who were always so helpful and provided us their assistance in evolving this book into its final shape. We are most grateful to all of them.

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About the Editors

Dr. Mohammad Abu Jafar Mazumder is an Associate Professor of Chemistry at King Fahd University of Petroleum and Minerals (KFUPM), Saudi Arabia, who has a wide experience in design, synthesis, modification, and characterization of various organic compounds and ionic and thermo-responsive polymers using various spectroscopic and chromatographic techniques. Dr. Jafar Mazumder earned his Ph.D. in Chemistry) (2009) from McMaster University, Canada, followed by 2 years MITACS Postdoctoral Fellowship in Chemical and Biomedical Engineering at McMaster University, Canada.

In 17 years of academic research, Dr. Jafar Mazumder has had the opportunity to work with several international collaborative research groups and has exposed himself to a broad range of research areas, including chemistry, engineering, and material sciences where he developed and engineered synthetic and natural organic and polymeric materials for various applications.

Dr. Jafar Mazumder secured 5 US patents, edited 2 books, and published more than 50 peer-reviewed journal articles/invited book chapters. He had an opportunity to present his research in more than 25 international conferences. Dr. Jafar Mazumder has conducted and completed several internally and externally funded research projects from KFUPM, Saudi Aramco, KACST, and NSTIP. Currently, he is actively involved in a number of ongoing university and client-funded research projects in which he is responsible for the synthesis and characterization of various materials including modification of monomers and polymers for their potential use as corrosion inhibitors and for the removal of heavy metal ions and organic contaminants from aqueous samples.

Heather Sheardown is a Professor in the Department of Chemical Engineering with a cross-appointment to the Department of Pathology and Molecular Medicine and an adjunct appointment with the School of Optometry at the University of Waterloo. She holds a Tier 1 Canada Research Chair in Ophthalmic Biomaterials and Drug Delivery and has published more than 140 peer-reviewed papers on this subject. She is currently the Scientific Director of C20/20, an ORF-funded incubator aimed at the commercialization of ophthalmic biotechnologies. Sheardown was previously the Scientific Director of the 20/20 NSERC Ophthalmic Materials Research Network which brought together 12 researchers and more than 10 companies aimed at the early-stage development of novel materials-based treatments for ophthalmic conditions. Sheardown is the Associate Director of Biomedical Engineering and Advanced Manufacturing (BEAM), a McMaster partnership with the Fraunhofer IZI which partners with companies for incubation and commercialization of cell-based therapies, diagnostics, and biomaterials. She holds 18 patents or provisional patents and is currently the Chief Scientific Officer of 20/20 OptimEyes, a McMaster-based spinout focused on developing and commercializing a micelle-based technology developed in her laboratory. She runs a large and vibrant research group with more than ten postdoctoral fellows and graduate students.

Dr. Amir-Al-Ahmed is working as a Research Scientist-II (Associate Professor) in the Center of Research Excellence in Renewable Energy (CoRE-RE) at King Fahd University of Petroleum and Minerals (KFUPM), Saudi Arabia. He graduated in Chemistry from the Department of Chemistry, Aligarh Muslim University (AMU), India, and then completed his M.Phil. (2001) and Ph.D. (2003) in Applied Chemistry from the Department of Applied Chemistry, AMU, India, followed by three consecutive postdoctoral fellowships in South Africa and Saudi Arabia. During this period, he worked on various multidisciplinary projects, in particular, electrochemical sensors, nano-materials, proton-exchange membranes, direct methanol fuel cell (DMFC), electro-catalysis, and solar cells. At present, his research activity is fundamentally focused on third-generation solar cell devices

such as low band gap semiconductor quantum dot structures, perovskite cells, and silicon nanowire-based tandem cells. At the same time, he is also having projects on PCM-based latent heat energy storage, evaluation of electricity storage devices, and dust repellent coating for harsh Saudi Arabian weather condition. He has worked on different KACST-, NSTIP-, and Saudi Aramco-funded projects in the capacity of a co-investigator and principle investigator. Dr. Amir has 2 US patents, over 60 journal articles, invited book chapters, and conference publications. He has edited nine books with Trans Tech Publications and Elsevier, and several other books are in progress. He is also the Editor in Chief of an international journal *Nano Hybrids and Composites* along with Professor Y. H. Kim.

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