

Review

Natural and Synthetic Polymers for Biomedical and Environmental Applications

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Abstract: Natural and synthetic polymers are a versatile platform for developing biomaterials in the biomedical and environmental fields. Natural polymers are organic compounds that are found in nature. The most common natural polymers include polysaccharides, such as alginate, hyaluronic acid, and starch, proteins, e.g., collagen, silk, and fibrin, and bacterial polyesters. Natural polymers have already been applied in numerous sectors, such as carriers for drug delivery, tissue engineering, stem cell morphogenesis, wound healing, regenerative medicine, food packaging, etc. Various synthetic polymers, including poly(lactic acid), poly(acrylic acid), poly(vinyl alcohol), poly(ethylene glycol), etc., are biocompatible and biodegradable; therefore, they are studied and applied in controlled drug release systems, nano-carriers, tissue engineering, dispersion of bacterial biofilms, gene delivery systems, bio-ink in 3D-printing, textiles in medicine, agriculture, heavy metals removal, and food packaging. In the following review, recent advancements in polymer chemistry, which enable the imparting of specific biomedical functions of polymers, will be discussed in detail, including antiviral, anticancer, and antimicrobial activities. This work contains the authors' experimental contributions to biomedical and environmental polymer applications. This review is a vast overview of natural and synthetic polymers used in biomedical and environmental fields, polymer synthesis, and isolation methods, critically assessing their advantages, limitations, and prospects.

Keywords: polymers; natural; synthetic; biomedical; environmental

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1. Introduction

Natural polymers extracted from organic sources such as microorganisms, algae, plants, or animals have been widely used for decades in biomedical applications such as pharmaceuticals, tissue regeneration scaffolds, drug delivery, and imaging [1]. Polysaccharides, proteins, and polyesters derived from plant and animal kingdoms are part of the family of natural polymers. Several of these polymers comprise our diet and have been used in various human applications [2]. These polymers are recognized by the biological environment and directed into metabolic degradation. Natural polymers are similar to extracellular matrix (ECM) components, enabling them to avoid chronic immunological reactions and toxicity, which are frequently observed with synthetic polymers [2].

Natural polymers are components of biological systems responsible for performing various essential functions [3]. For instance, specific natural polymers, such as cellulose and chitin, play a vital role in maintaining the structural integrity of cells in plants and animals. In contrast, others, such as lysozymes, offer biological protection against surrounding environments [4]. The diversity in their origin and composition provides these natural polymers with distinct physicochemical and biological properties and are of interest in various fields, e.g., in the manufacture of paper goods and textiles, as additives in food products, in the formulation of nutraceuticals and functional foods, and in the biomedical

Natural And Synthetic Biomedical Polymers

**Kunal Pal, Sarika Verma, Pallab
Datta, Ananya Barui, S.A.R.
Hashmi, Avanish Kumar Srivastava**

Natural And Synthetic Biomedical Polymers:

Natural and Synthetic Biomedical Polymers Sangamesh G. Kumbar, Cato Laurencin, Meng Deng, 2014-01-21

Polymers are important and attractive biomaterials for researchers and clinical applications due to the ease of tailoring their chemical physical and biological properties for target devices. Due to this versatility they are rapidly replacing other classes of biomaterials such as ceramics or metals. As a result the demand for biomedical polymers has grown exponentially and supports a diverse and highly monetized research community. Currently worth 1.2bn in 2009 up from 650m in 2000 biomedical polymers are expected to achieve a CAGR of 9.8% until 2015 supporting a current research community of approximately 28,000. Summarizing the main advances in biopolymer development of the last decades this work systematically covers both the physical science and biomedical engineering of the multidisciplinary field. Coverage extends across synthesis characterization design consideration and biomedical applications. The work supports scientists researching the formulation of novel polymers with desirable physical chemical biological biomechanical and degradation properties for specific targeted biomedical applications. Combines chemistry biology and engineering for expert and appropriate integration of design and engineering of polymeric biomaterials. Physical chemical biological biomechanical and degradation properties alongside currently deployed clinical applications of specific biomaterials aids use as single source reference on field. 15 case studies provides in depth analysis of currently used polymeric biomaterials aiding design considerations for the future.

Biomedical Polymers Vinod B. Damodaran, Divya Bhatnagar, N. Sanjeeva Murthy, 2016-05-24 This book presents a comprehensive review on the various processing and post processing methodologies for biodegradable polymers. Written by professionals with hands on experience on polymer processing this book provides first hand knowledge of all contemporary processing techniques. The current status and future challenges in the field are described as well as a framework for designing novel devices for desired applications.

Advances in Biomedical Polymers and Composites Kunal Pal, Sarika Verma, Pallab Datta, Ananya Barui, S.A.R. Hashmi, Avanish Kumar Srivastava, 2022-09-14 *Advances in Biomedical Polymers and Composites: Materials and Applications* is a comprehensive guide to polymers and polymer composites for biomedical applications bringing together detailed information on their preparation properties cutting edge technologies innovative materials and key application areas. Sections introduce polymers and composites in biomedical applications and cover characterization techniques preparation and properties of composites and gel based systems. Innovative technologies and instruments used in the fabrication of polymer composites for biomedical applications are then presented in detail including 3D bioprinting 4D printing electrospinning stimuli responsive polymers and quantum dots. This is a valuable resource for anyone looking to gain a broader understanding of polymers and composites for biomedical applications. In addition it is ideal for readers who want to conduct interdisciplinary research or explore new avenues for research and development. Provides broad systematic and detailed coverage of preparation methods properties technologies structures and applications. Explores

the state of the art in biomedical polymers including gene delivery oleogels bigels 3D bioprinting 4D printing and antiviral materials Offers analysis and comparison of experimental data on physical properties and explains environmental ethical and medical guidelines Polymer Science and Nanotechnology Ravin Narain,2020-06-16 Polymer Science and Nanotechnology Fundamentals and Applications brings together the latest advances in polymer science and nanoscience Sections explain the fundamentals of polymer science including key aspects and methods in terms of molecular structure synthesis characterization microstructure phase structure and processing and properties before discussing the materials of particular interest and utility for novel applications such as hydrogels natural polymers smart polymers and polymeric biomaterials The second part of the book examines essential techniques in nanotechnology with an emphasis on the utilization of advanced polymeric materials in the context of nanoscience Throughout the book chapters are prepared so that materials and products can be geared towards specific applications Two chapters cover in detail major application areas including fuel and solar cells tissue engineering drug and gene delivery membranes water treatment and oil recovery Presents the latest applications of polymers and polymeric nanomaterials across energy biomedical pharmaceutical and environmental fields Contains detailed coverage of polymer nanocomposites polymer nanoparticles and hybrid polymer metallic nanoparticles Supports an interdisciplinary approach enabling readers from different disciplines to understand polymer science and nanotechnology and the interface between them Antibiotic Materials in Healthcare Kokkarachedu Varaprasad,Vimala Kanikireddy,Rotimi Sadiku,2020-05-22 Antibiotic Materials in Healthcare provides significant information on antibiotic related issues accurate solutions and recent investigative information for health related applications In addition the book addresses the design and development of antibiotics with advanced physical chemical and biological properties an analysis of materials in vivo and in vitro applications and their biomedical applications for healthcare Provides information on all aspects of antibiotic related issues Offers a balanced synthesis of basic and clinical science for each individual case presenting clinical courses and detailed microbiological information for each infection Describes the prevalence and incidence of global issues and current therapeutic approaches **Development, Properties, and Industrial Applications of 3D Printed Polymer Composites** Keshavamurthy, R.,Tambrallimath, Vijay,Davim, J. Paulo,2023-02-17 Polymer composite materials are of prime importance and play a vital role in numerous applications 3D printed polymer composites have been adopted by the aerospace medical and automobile industries However many challenges and opportunities for the development and application of 3D printed polymer composites have yet to be covered Development Properties and Industrial Applications of 3D Printed Polymer Composites concentrates on cutting edge technologies and materials as well as processing methods and industrial applications It further discusses case studies process issues challenges and more Covering topics such as additive manufacturing medical engineering and fused deposition modeling this premier reference source is essential for manufacturers engineers business leaders and executives hospital administrators students and faculty of higher education

librarians researchers and academicians **Hydrogels Based on Natural Polymers** Yu Chen, 2019-10-23 Hydrogels Based on Natural Polymers presents the latest research on natural polymer based hydrogels covering fundamentals preparation methods synthetic pathways advanced properties major application areas and novel characterization techniques The advantages and disadvantages of each natural polymer based hydrogel are also discussed enabling preparation tactics for specific properties and applications Sections cover fundamentals development characteristics structures and properties Additional chapters cover presentation methods and properties based on natural polymers including physical and chemical properties stimuli responsive properties self healing properties and biological properties The final section presents major applications areas including the biomedical field agriculture water treatments and the food industry This is a highly valuable resource for academic researchers scientists and advanced students working with hydrogels and natural polymers as well as across the fields of polymer science polymer chemistry plastics engineering biopolymers and biomaterials The detailed information will also be of great interest to scientists and R D professionals product designers technicians and engineers across industries Provides systematic coverage of all aspects of hydrogels based on natural polymers including fundamentals preparation methods properties and characterization Offers a balanced assessment of the specific properties and possibilities offered by different natural polymer based hydrogels drawing on innovative research Examines cutting edge applications across biomedicine agriculture water treatments and the food industry **Advances and Challenges in Pharmaceutical Technology** Amit Kumar Nayak, Kunal Pal, Indranil Banerjee, Samarendra Maji, Upendranath Nanda, 2021-02-09 Advances and Challenges in Pharmaceutical Technology Materials Process Development and Drug Delivery Strategies examines recent advancements in pharmaceutical technology The book discusses common formulation strategies including the use of tools for statistical formulation optimization Quality by design QbD process analytical technology and the uses of various pharmaceutical biomaterials including natural polymers synthetic polymers modified natural polymers bioceramics and other bioinorganics In addition the book covers rapid advancements in the field by providing a thorough understanding of pharmaceutical processes formulation developments explorations and exploitation of various pharmaceutical biomaterials to formulate pharmaceutical dosage forms Provides extensive information and analysis on recent advancements in the field of pharmaceutical technology Includes contributions from global leaders and experts in academia industry and regulatory agencies Uses high quality illustrations flow charts and tables to explain concepts and text to readers along with practical examples and research case studies *Biomaterials and Nanotechnology for Tissue Engineering* Swaminathan Sethuraman, Uma Maheswari Krishnan, Anuradha Subramanian, 2016-10-26 Nanotechnology and high end characterization techniques have highlighted the importance of the material choice for the success of tissue engineering A paradigm shift has been seen from conventional passive materials as scaffolds to smart multi functional materials that can mimic the complex intracellular milieu more effectively This book presents a detailed overview of the rationale involved in the choice of

materials for regeneration of different tissues and the future directions in this fascinating area of materials science with specific chapters on regulatory challenges tissue engineered medical products **Biomaterials** Véronique Migonney,2014-10-13 Discovered in the 20th century biomaterials have contributed to many of the incredible scientific and technological advancements made in recent decades This book introduces and details the tenets of biomaterials their relevance in a various fields practical applications of their products and potential advancements of the years to come A comprehensive resource the text covers the reasons that certain properties of biomaterials contribute to specific applications and students and researchers will appreciate this exhaustive textbook **Tissue Engineering** Rajesh K. Kesharwani,Raj K. Keservani,Anil K. Sharma,2022-05-18 This new volume on applications and advances in tissue engineering presents significant state of the art developments in this exciting area of research It highlights some of the most important applied research on the applications of tissue engineering along with its different components specifically different types of biomaterials It looks at the various issues involved in tissue engineering including smart polymeric biomaterials gene therapy tissue engineering in reconstruction and regeneration of visceral organs skin tissue engineering bone and muscle regeneration and applications in tropical medicines Covering a wide range of issues in tissue engineering the volume Provides an overview of the efficacy of the different biomaterials employed in tissue engineering such as skin regeneration nerve regeneration artificial blood vessels bone regeneration Looks at smart polymeric biomaterials in tissue engineering Discusses the hybrid approach of tissue engineering in conjunction with gene therapy Explores using tissue engineering in the management of tropical diseases Considers various skin tissue engineering applications including wound healing methods skin substitutes and other materials Reports on the use of various biomaterials in bone and muscle regeneration Describes the use of tissue engineering in reconstruction and regeneration of visceral organs Covers polysaccharides and proteins based hydrogels for tissue engineering applications Providing an abundance of advanced research and information Tissue Engineering Applications and Advancements will be a valuable resource for medical researchers pharmaceutical manufacturers healthcare personnel and academicians **Pharmaceutical Polymer Formulations and its Applications** Raj K. Keservani,Eknath D. Ahire,Rajesh Kumar Kesharwani,2025-07-22 The book is an essential resource for anyone in the pharmaceutical field as it provides in depth insights into the versatile roles of polymers in controlled drug delivery highlighting their critical applications in product innovation development and manufacturing Pharmaceutical Polymer Formulations and Its Applications provides an overview of the applications of pharmaceutical polymers in the vast field of controlled drug delivery Polymers have the potential for a range of uses in the design of pharmaceutical dosage forms They can be used as suspending emulsifying binding or flocculant agents as well as adhesives and packaging and coating materials They can be used to make gels nanoparticles microparticles and various capsules Polymers have played an indispensable role in the manufacture of pharmaceutical products This volume includes various polymers used in pharmacy based on their

applications The overviews focus on the use of pharmaceutical polymers for controlled drug delivery applications Examples of pharmaceutical polymers and the principles of controlled drug delivery are outlined and applications of polymers for controlled drug delivery are also discussed Readers will find the book Explores the latest tactics utilized for the application of polymers in the healthcare industry Showcases the numerous innovations of polymers in manufacturing of pharmaceuticals Provides essential elements for the conceptualization and comprehension of polymer products by highlighting their aspects and overcoming manufacturing regulatory and quality control obstacles Audience The book will interest chemists and healthcare professionals interested in pharmaceutical innovation using polymers

Introduction to Polymer Chemistry, Fourth Edition Charles E. Carraher Jr., 2017-01-06 Introduction to Polymer Chemistry provides undergraduate students with a much needed well rounded presentation of the principles and applications of natural synthetic inorganic and organic polymers With an emphasis on the environment and green chemistry and materials this fourth edition continues to provide detailed coverage of natural and synthetic giant molecules inorganic and organic polymers elastomers adhesives coatings fibers plastics blends caulks composites and ceramics Building on undergraduate work in foundational courses the text fulfills the American Chemical Society Committee on Professional Training ACS CPT in depth course requirement

Introduction to Polymer Chemistry Charles E. Carraher Jr., 2012-12-17 Continuing the tradition of its previous editions the third edition of Introduction to Polymer Chemistry provides a well rounded presentation of the principles and applications of natural synthetic inorganic and organic polymers With an emphasis on the environment and green chemistry and materials this third edition offers detailed coverage of natural and synthetic giant molecules inorganic and organic polymers biomacromolecules elastomers adhesives coatings fibers plastics blends caulks composites and ceramics Using simple fundamentals the book demonstrates how the basic principles of one polymer group can be applied to all of the other groups It covers reactivities synthesis and polymerization reactions techniques for characterization and analysis energy absorption and thermal conductivity physical and optical properties and practical applications This edition addresses environmental concerns and green polymeric materials including biodegradable polymers and microorganisms for synthesizing materials Case studies woven within the text illustrate various developments and the societal and scientific contexts in which these changes occurred Now including new material on environmental science Introduction to Polymer Chemistry Third Edition remains the premier book for understanding the behavior of polymers Building on undergraduate work in foundational courses the text fulfills the American Chemical Society Committee on Professional Training ACS CPT in depth course requirement

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inorganic and organic polymers biomacromolecules elastomers adhesives coatings fibers plastics blends caulks composites and ceramics Using simple fundamentals the book demonstrates how the basic principles of one polymer group can be applied to all of the other groups It covers reactivities synthesis and polymerization reactions techniques for characterization and analysis energy absorption and thermal conductivity physical and optical properties and practical applications This edition addresses environmental concerns and green polymeric materials including biodegradable polymers and microorganisms for synthesizing materials Case studies woven within the text illustrate various developments and the societal and scientific contexts in which these changes occurred Now including new material on environmental science Introduction to Polymer Chemistry Third Edition remains the premier book for understanding the behavior of polymers Building on undergraduate work in foundational courses the text fulfills the American Chemical Society Committee on Professional Training ACS CPT in depth course requirement

Engineering Applications of Polymer based Nano Blends P. M. Visakh, 2025-08-04 This book presents engineering applications of polymer based nano blends It discusses the recent developments in the area of engineering applications and summarizes many of the important polymer based nano blends In particular it looks into more advanced topics like blends in biomedical applications biorecognition of anticancer drug daunorubicin application binders for particle board packaging applications thermoplastic starch based LLDPE films for active packaging and optical and antibacterial applications

Microbial Approaches for Sustainable Green Technologies Jata Shankar, Pradeep Verma, Maulin P. Shah, 2024-06-06 Microbial systems have a strong potential to develop green and sustainable technologies including sources of renewable energy alternative fuels and biosynthetic materials for sustainable applications Advances in these technologies are evolving to meet growing demand and industries are adapting to green technologies such as solar panels bioethanol hydroponics and more With the aid of sophisticated technology and integration strategies these industries are moving toward being more environmentally friendly and sustainable This book serves as a guide to the newest technologies that will enable the implementation of microbial technologies in fostering an eco friendly industrial and environmental landscape which will have widely positive impacts for generations to come Provides recent insights on diverse technologies involved in green technologies Explains the application of microbes via fungi to remediate pollutants and examines the latest treatment technologies in bioleaching and electronic waste treatment Provides updated information on bioenergy and flexible fungal materials as alternatives to plastics Discusses the application of IOT and communication electronics in the development of green technologies

Natural Polymers Jissy Jacob, Fernando Gomes, Józef T. Haponiuk, Nandakumar Kalarikkal, Sabu Thomas, 2022-03-24 This new volume Natural Polymers Perspectives and Applications for a Green Approach covers the synthesis characterizations and properties of natural polymeric systems including their morphology structure and dynamics It also introduces the most recent innovations and applications of natural polymers and their composites in the food construction electronics biomedical pharmaceutical and engineering industries

Natural polymers provide a striking substitute for various applications as compared to synthetic polymers obtained from petrochemicals because they are biocompatible biodegradable easily available and fall within the budget of many industries The applications of natural polymers in pharmaceutical industries are large in comparison to synthetic polymers and are also wide in scope in the food and cosmetic industries This new volume provides the information needed to design new applications for natural polymers This book is a valuable reference for researchers academicians chemists pharmacists researchers scientists industrialists dealing with applications of natural polymers and people working in field of natural polymers **Natural Polymer Drug Delivery Systems** Saurabh Bhatia,2016-09-23 This book describes 200 bio polymers including the most recent and advanced nanotechnology applications The applications of various bio medical and other future potential uses are covered and examined in depth Systematic discussion of current leading natural polymers is also included

Polymer Engineering Bartosz Tylkowski,Karolina Wieszczycka,Renata Jastrzab,2017-09-25 Polymer Engineering focuses on the preparation and application of polymers in several hot topics such as artificial photosynthesis water purification by membrane technologies and biodiesel production from wastewater plants The authors not only describe the latest developments in polymer science but also support these experimental results by computational chemistry and modelling studies

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