

## Cellulose-based hydrogels: Designing concepts, properties, and perspectives for biomedical and environmental applications

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Development of new products and materials, especially those which are based on renewable organic resources using innovative sustainable processes, represents an increasing interest in both academic and industrial research. Cellulose and its derivatives have demonstrated to be versatile materials with unique chemical structure which provides a good platform for the construction of hydrogel networks with distinctive properties as respects of swelling ability and sensibility to external stimuli. Indeed, the high density of free hydroxyl groups in the cellulose structure makes them become a solid substrate that can undergo functionalization, allowing the production of new materials for novel advanced applications. Moreover, the smart behaviour of these materials, in response to specific environmental stimuli, namely temperature, pH, ionic strength, determines the obtained hydrogels especially attractive for *in vivo* applications. Consequently, cellulose-based hydrogels are promising materials, biodegradable, biocompatible, and the low cost, which exhibit properties that make them attractive in many applications, particularly in biomedical and environmental applications.

**Keywords:** cellulose-based hydrogels; biocompatibility; biomedical and environmental applications

### 1. General remarks

Hydrogels are material that exhibit three-dimensional network of hydrophilic polymers, capable to swell and retain a large amount of water within its structure [1]. The chemical crosslinking [2], physical entanglement [3], hydrogen bonds [4], and ionic bonds [5] are responsible to achieve the network of hydrogels. They can be obtained from the synthetic and natural polymers [6], and depend on various parameters, including the preparation method, charge, as well as mechanical and structural characteristics. Due to their excellent hydrophilicity, permeability, compatibility, and low friction coefficient, polymer-based hydrogels have been used extensively as drug delivery, food, cosmetics, high water-absorbing resin, contact lenses, corneal, implant, substitutes for skin, tendons, ligaments, cartilage, and bone [7,8]. Furthermore, an exclusive class of hydrogels - superporous hydrogels - can potentially be used for both short- and long term applications, as superdisintegrant, controlled release platform, and a gastroretentive drug delivery system. Also, superporous hydrogels have been successfully used as soil improvers [9], slow release fertilizers [10,11], pesticide release devices [12].

Recently, hydrogels have captured progressively the interest of researchers, due to the intrinsic properties corresponding of the medical applications. They can serve as scaffolds that provide structural integrity to tissue constructs, control drug, and protein delivery to tissues and cultures, and serve as adhesives or barriers between tissue and material surfaces. The advantages provided by hydrogels for drug delivery applications include the possibility of sustained release, leading to the maintenance of a high local concentration of an active pharmaceutical ingredient over an extended period of time [13]. Their biocompatibility, ability to release water-soluble compounds from the polymeric matrix, and versatility in modeling the physico-chemical properties, permit the generation of new biomaterials with applications in controlled drug release. Among them, polymers of natural origin are one of the most attractive options, mainly due to their similarities with the extracellular matrix (ECM), chemical versatility, as well as typically good biological performance.

It is worth noting that natural polymers have better biocompatibility and less latent toxic effect than most synthetic polymer hydrogels [14], so pure natural polymer hydrogels would be more suitable for biomaterials [15]. Indeed, polysaccharide-based hydrogels behave as smart materials and offer a variety of properties that can be exploited in several applications. Moreover, polysaccharides are gaining a particular attention as components of stimuli-responsive drug delivery systems, especially since they can be obtained in a well characterized and reproducible manner from natural sources [16]. In this context, they can be promising for application in the biomaterial domain, due to their unique benefits, like non-toxicity, abundance, biodegradability, biocompatibility, and biological functions [17]. The most important properties of polysaccharides are derived from natural sources, and their difficulty imposed new synthetic chemical modification methods, the aim being to promote new biological activities and to modify their final properties for specific goals. Furthermore, polysaccharide-based materials have opened new roads in the biomedical domain, namely in the tissue engineering of controlled drug delivery systems and cell immobilization. According those above-mentioned, cellulose represents the most abundant renewable and biodegradable polymeric material, being considered as the main constituent of plants and natural fibers. Also, cellulose is an environmentally friendly alternative to conventional materials and exhibit properties that make them very attractive in many applications [18]. Nowadays, cellulose derivatives-based hydrogel have gained a great popularity in agriculture and pharmaceutical industry, and

# Cellulose Based Hydrogels Designing Concepts Properties

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Mustansar Hussain**

## **Cellulose Based Hydrogels Designing Concepts Properties:**

**Plant and Algal Hydrogels for Drug Delivery and Regenerative Medicine** Tapan Kumar Giri, Bijaya

Ghosh, 2021-06-12 Plant and Algal Hydrogels for Drug Delivery and Regenerative Medicine offers a materials focused and systematic overview of biopolymeric hydrogels utilized for biomedical applications. The book details the synthesis and characterization of plant and algal based hydrogels with each chapter addressing a separate polysaccharide hydrogel type. Specific applications in drug delivery and regenerative medicine are also discussed, highlighting the efficacy, biocompatibility, benefits, and challenges for each polysaccharide hydrogel subtype. There is increasing demand for biomaterials which reduce prevent the host response, inflammation, and rejection, hence this book provides a timely resource. Biopolymeric hydrogels have skyrocketed because of their necessity in in vivo applications. They create an environment similar to living tissue which is both biocompatible and biodegradable. Plant and algal polysaccharides in particular are well equipped with functional groups that are easily modified for beneficial results. Systematically covers each plant and algal polysaccharide hydrogel subtype from starch based hydrogels to pectin and alginate based hydrogels. Provides an end to end description of the synthesis, characterization, and application of biopolymeric hydrogels for drug delivery and regenerative medicine. Appeals to a diverse readership including those in biomedicine, pharmacy, polymer chemistry, biochemistry, materials science, biomedical engineering, and other biotechnology related disciplines. 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. Sustainability of Biomass through Bio-based Chemistry Valentin Popa, 2021-03-21 The process of photosynthesis

is a potential source of energy and bioproducts Renewable sources of polymeric materials offer an answer to maintaining sustainable development of economically and ecologically attractive technology The innovations in the development of materials from biopolymers preservation of fossil based raw materials complete biological degradability reduction in the volume of garbage and compostability in the natural cycle climate protection through reduction of carbon dioxide released and the application possibilities of agricultural resources for the production of bio green materials are some of the reasons why such materials are attracting public interest

**FEATURES** Discusses waste from urban areas forestry and agricultural processes specifically grown crops such as trees starch crops sugar crops hydrocarbon plants and oils and finally aquatic plants such as water seaweeds and algae which can be used as raw materials for sustainable development Presents recent advances in the development of some specifically chemical components of biomasses for a sustainable future Focuses on lignocellulose as a source of bio based products Draws upon expertise from various countries Describes how upgraded and integrated biomass processing may reduce the risks associated with the COVID 19 pandemic

Valentin I Popa is professor emeritus of Wood Chemistry and Biotechnology at Gheorghe Asachi Technical University of Iasi Romania

**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

**Extracellular Sugar-Based Biopolymers Matrices** Ephraim Cohen, Hans Merzendorfer, 2019-07-02 The extracellular matrix ECM is an acellular three dimensional network composed of proteins glycoproteins proteoglycans and exopolysaccharides It primarily serves as a structural component in the tissues and organs of plants and animals or forms biofilms in which bacterial cells are embedded

ECMs are highly dynamic structures that undergo continuous remodeling and disruptions are frequently the result of pathological processes associated with severe diseases such as arteriosclerosis neurodegenerative illness or cancer In turn bacterial biofilms are a source of concern for human health as they are associated with resistance to antibiotics Although exopolysaccharides are crucial for ECM formation and function they have received considerably little attention to date The respective chapters of this book comprehensively address such issues and provide reviews on the structural biochemical molecular and biophysical properties of exopolysaccharides These components are abundantly produced by virtually all taxa including bacteria algae plants fungi invertebrates and vertebrates They include long unbranched homopolymers cellulose chitin chitosan linear copolymers alginate agarose peptoglycans such as murein heteropolymers like a variety of glycosaminoglycans hyaluronan dermatan keratin heparin Pel and branched heteropolymers such as pectin and hemicellulose A separate chapter is dedicated to modern industrial and biomedical applications of exopolysaccharides and polysaccharide based biocomposites Their unique chemical physical and mechanical properties have attracted considerable interest inspired basic and applied research and have already been harnessed to form structural biocomposite hybrids for tailor made applications in regenerative medicine bioengineering and biosensor design Given its scope this book provides a substantial source of basic and applied information for a wide range of scientists as well as valuable textbook for graduate and advanced undergraduate students

Cellulose-Based Hydrogels and Aerogels Gang Wei, Jianming Zhang, 2025-09-26

This book explores the rapidly advancing field of cellulose based hydrogels and aerogels highlighting their immense potential for sustainable applications in materials science nanotechnology biomedicine tissue engineering energy and environmental science With their highly porous structure eco friendly nature excellent biocompatibility and biodegradability these materials offer remarkable versatility for next generation sustainable technologies This book presents cutting edge research on the design synthesis and functionalization of cellulose based hydrogels and aerogels It demonstrates how their properties can be fine tuned through integration with organic and inorganic materials and examines their wide ranging applications in sustainable technologies Despite their promise challenges remain in achieving large scale production with enhanced mechanical properties controllable modifications and functionalization for diverse applications To address these issues researchers have developed innovative strategies to refine synthesis methods improve functionality and expand potential uses A valuable resource for researchers postdoctoral scholars PhD students and engineers this book serves as a comprehensive guide to the latest advancements and future directions in this growing field

*Cellulose Based Hydrogels* Kalim Deshmukh, Shaswat Barua, Swagata Baruah, Chaudhery Mustansar Hussain, 2025-01-28

Cellulose Based Hydrogels Production Properties and Applications provides detailed information on the properties characterization techniques preparation methodologies applications and commercial viability of cellulose based hydrogels The book starts with an in depth overview of the structure of cellulosic materials and their chemical modification approaches covering various forms of

cellulose such as nanocrystalline and nanofibrillar cellulose The following chapters focus on characterization methods of such materials including advanced techniques followed by a through discussion of the strategies for preparation of cellulose based hydrogels Finally applications of cellulosic structures in different fields such as biomedicine environmental science and energy are presented This is a valuable resource for researchers and advanced students across polymer science nanomaterials and materials science as well as scientists engineers and R D professionals with an interest in sustainable materials and their composites nanocomposites for advanced applications Describes structural features preparation methods characterization techniques properties and applications of cellulose based hydrogels Reviews the biodegradability and biocompatibility of cellulosic hydrogels Offers critical analysis on current and potential applications of cellulose based hydrogels including a discussion on their commercial viability

*Green Approaches in Medicinal Chemistry for Sustainable Drug Design* Bimal Banik, 2024-05-31 Extensive experimentation and high failure rates are a well recognized downside to the drug discovery process with the resultant high levels of inefficiency and waste producing a negative environmental impact Sustainable and Green Approaches in Medicinal Chemistry 2e reveals how medicinal chemistry can play a direct role in addressing this issue After providing essential context to the growth of green chemistry in relation to drug discovery the book goes on to identify a broad range of practical techniques and useful insights revealing how medicinal chemistry techniques can be used to improve efficiency mitigate failure and increase the environmental benignity of the entire drug discovery process Drawing on the knowledge of a global team of experts Sustainable and Green Approaches in Medicinal Chemistry Second Edition encourages the growth of green medicinal chemistry and supports medicinal chemists drug discovery researchers pharmacologists and all those in related fields across both academia and industry in integrating these approaches into their own work This second volume of the second edition includes the development of nanoparticles and nanocomposites as well as the application of ultrasound and microwave induced methods studies solventless synthesis defines the role of steroids studies reactions in aqueous solution identifies enzyme mediated reactions investigates ionic liquids and deep eutectic solvents explores natural products investigates solid supports realizes the effects of salts focuses on combinatorial chemistry develops one pot methods analyzes multi component reactions investigates dipole moment values and examines computer assisted methods Highlights the need for adoption of sustainable and green chemistry pathways in drug development Reveals risk factors associated with the drug development process and the ways sustainable approaches can help address these Identifies novel and cost effective green medicinal chemistry approaches for improved efficiency and sustainability

**Advances in Cellulose-Based Hydrogels** Christian Demitri, Lorenzo Bonetti, Laura Riva, 2023-03-23 This volume collects the recent progress in cellulose based hydrogels including gels prepared from natural cellulose and its derivatives cellulose graft co polymers and composite gels based on cellulose covering key aspects of cellulose based hydrogels including design characterization as well as application focused research

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,2006 **Abstract Bulletin of the Institute of Paper Chemistry** ,1988-06 Macromolecular Solutions Raymond Benedict Seymour,G. Allan Stahl,American Chemical Society,1982 **Faculties, Publications, and Doctoral Theses in Chemistry and Chemical Engineering at United States Universities** American Chemical Society. Committee on Professional Training,1981 **Macromolecular Engineering, Volume 1** Krzysztof Matyjaszewski,Yves Gnanou,Ludwik Leibler,2007-04-09 The book provides a state of the art description of the synthetic tools to precisely control various aspects of macromolecular structure including chain composition microstructure functionality and topology as well as modern characterization techniques at molecular and macroscopic level for various properties of well defined co polymers in solution bulk and at surfaces The book addresses also the correlation of molecular structure with macroscopic properties additionally affected by processing Finally some emerging applications for the co polymers are highlighted *Comprehensive Biotechnology: The principles of biotechnology* Murray Moo-Young,1985 V 1 The principles of biotechnology Scientific fundamentals v 2 The principles of biotechnology Engineering considerations v 3 The practice of biotechnology Current commodity products v 4 The practice of biotechnology Speciality products and service activities *2000 International Chemical Congress of Pacific Basin Societies* ,2000 **Anticancer Research** ,1981 **Contact Lenses** Anthony John Phillips,Janet Stone,1989 Cellulose-Based Superabsorbent Hydrogels Md. Ibrahim H. Mondal,2019-02-22 With the prospect of revolutionizing specific technologies this book highlights the most exciting and impactful current research in the fields of cellulose based superabsorbent hydrogels with their smart applications The book assembles the newest synthetic routes characterization methods and applications in the emergent area Leading experts in the field have contributed chapters representative of their most recent research results shedding light on the enormous potential of this field and thoroughly presenting cellulose based hydrogel functioning materials The book is intended for the polymer chemists academic and industrial scientists and engineers pharmaceutical and biomedical scientists and agricultural engineers engaged in research and development on absorbency absorbent products and superabsorbent hydrogels It can also be supportive for undergraduate and graduate students **Chemical Abstracts** ,2002

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