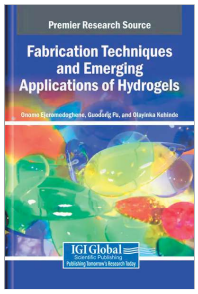

Fabrication Techniques and Emerging Applications of Hydrogels

Onome Ejeromedoghene (Soochow University, China), Guodong Fu (Southeast University, China), and Olayinka Kehinde (Lead City University, Nigeria)

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Description & Coverage

Description:

Hydrogels have gained attention in recent years due to their physical properties and biocompatibility. Advancements in fabrication techniques have expanded the potential of hydrogels in various scientific and industrial domains. These innovations improve the structural and functional versatility of hydrogels while catalyzing their integration into emerging applications, including medical engineering, drug delivery systems, robotics, and wearable technology. Further exploration of the latest developments in hydrogel fabrication technologies may reveal their growing role in the future of biomedical and engineering solutions.

Fabrication Techniques and Emerging Applications of Hydrogels explores the field of functional materials and materials chemistry. It examines emerging opportunities available in the application of hydrogels and soft materials. This book covers topics such as electrochemistry, mechanical engineering, and sensor devices, and is a useful resource for engineers, chemists, manufacturers, academicians, researchers, and environmental scientists.

Coverage:

The many academic areas covered in this publication include, but are not limited to:

- 3D/4D Printing
- Additive Manufacturing
- Bioelectronics
- Biomedicine
- Chemical Engineering
- Electrochemistry
- Environmental Science
- Fabrication Techniques
- Hydrogels
- Machine Learning
- Materials Science
- Mechanical Engineering
- Sensor Devices

Table of Contents

Please note that this book is currently in development and this table of contents is tentative. Chapter authors can make adjustments to their individual submissions in the eEditorial Discovery® system if they notice any discrepancies.

Irum Fatima, Humaira Razzaq, Shazia Naheed, Zobiya Asghar

To overcome the hindrance in the rate of swelling and mechanical strength of hydrogels for different targeted applications that require rapid fluid uptake. Superporous hydrogels have emerged as a new class of materials to hinder these challenges. This chapter will explore the fabrication of SPHs, and various synthetic techniques such as porosigen, phase separation, cross-linking, and gas-blowing methods. The main features of SPHs are high porosity, rapid rate of swelling, higher adsorption capacity, stimuli-responsive behavior to the external environment, biocompatibility, high surface area, and enhanced mass transfer. The SPHs are categorized into three generations: conventional SPHs, SPH composites, and SPH hybrids, with improved mechanical properties and functionalities across various generations. Various applications of SPHs in biotechnology and biomedical engineering are discussed. SPHs have a lot of potential to revolutionize different fields due to their unique properties and tailored functionalities.

Chapter 8

Stimuli-Responsive Intelligent Hydrogels

Muzammal Hussain, Aneela Tabasum, Tahira Amir, Khurram Shehzad

Recent progress in materials science has led to the emergence of stimuli-responsive intelligent hydrogels, which have gained significant interest due to their unique properties and wide-ranging applications. These hydrogels undergo reversible changes in physical or chemical properties when exposed to external stimuli like temperature, pH, light, electric fields, and biomolecules. Their potential spans biomedical engineering, drug delivery, soft robotics, and environmental sensing. This paper explores their synthesis, properties, and applications. Various stimuli can trigger hydrogel responsiveness, with the choice depending on the application. We discuss methods for incorporating stimuli-responsive elements, including physical entrapment, covalent attachment, and self-assembly. Fabrication techniques such as physical and chemical crosslinking are examined, along with the importance of structure-property relationships in designing precise, responsive hydrogels.

Chapter 9

INNOVATIVE TECHNIQUES IN HYDROGEL BASED SUNSCREEN FABRICATION AND ITS APPLICATION IN HEALTHCARE: Hydrogel, Sunscreen, Fabrication techniques

BRINDHA DEVI PARTHIBAN, Gokul V, Ivo Romauld S, Sudha R, Manjunathan J

The biocompatibility, high water retention, and controlled-release characteristics of hydrogels three-dimensional networks of hydrophilic polymers have made attractive carriers for sunscreen compositions.The Physical, chemical, radiation-induced, enzyme-assisted, electrospinning, and cryogelation are some of the manufacturing methods for hydrogel-based sunscreens that are examined in this review. Incorporating the hydrogels into sunscreen formulations improves skin hydration, increases the effectiveness of UV protection, and prolongs the stability of active components, such as chemical (oxybenzone, avobenzone) and physical (ZnO, TiO_2, Iron oxide) UV filters. Moreover, hydrogels contains organic antioxidants like betalains and anthocyanins, which prevents from photoaging and oxidative stress. Hybrid formulations maximizes these bioactive chemicals' bioavailability and photostability including hydrogel sunscreens loaded with nanoliposomes.

Chapter 10

Synthesis and application of hydrogels of insect origin

Victor Enwemiwe, Eric Esiwo, Chioma Ojianwuna

Insect hydrogels like other hydrogels are versatile, three-dimensional polymeric networks with significant water-retention capacity, making them valuable in biomedical, agricultural, and environmental applications. This book review explores the techniques for synthesis, and multifaceted applications of insect-derived hydrogels, emphasizing their sustainability, biocompatibility, and functionality. Insects such as darkling beetles/super worm (Zophobas morio), black soldier fly (Hermetia illucens), yellow mealworm (Tenebrio molitor), large brown cicada (Graptopsaltria nigrofuscata), wingless flightless cockroach (Eupolyphaga sinensis), silk worm (Antheraea assama), silk worm (Bombyx mori), and many others serve as point source for hydrogel production. Chitosan, silk fibroin, and hemolymph proteins extracted are transformed into hydrogels via physical, ionic, enzymatic, and chemical crosslinking into valid hydrogels for diverse applications in novel food and feed, drivers for drug delivery, pesticide delivery, drinkers for insects, tissue, skin, bone and organ regeneration and more.

Chapter 11

Biomedical Prospects of Hydrogels: Chapter 06

Muzammal Hussain, Aqib Mehmood, Zaheer Ahmad, Munir Hussain, Muhammad Ajmal

Hydrogels have revolutionized biomedical applications, evolving from simple water-absorbing materials to multifunctional drug delivery systems. This section highlights their role in drug delivery, wound care, and therapeutic interventions. Their 3D network enables localized and sustained drug release, enhancing efficacy while reducing side effects. pH-sensitive hydrogels facilitate targeted gastrointestinal delivery, while thermosensitive types are effective for nasal and transdermal administration. In ophthalmology, hydrogels improve drug retention, and their ability to bypass the blood-brain barrier makes them a key research focus. Incorporating nanoparticles like silver, zinc oxide, or copper oxide enhances antimicrobial properties. Despite their potential, challenges such as scalability, stability, and precise drug release hinder clinical adaptation. However, advancements in nanoscale hydrogels, smart materials, and innovative fabrication techniques like 3D printing and microfluidics can improve drug loading and controlled release, driving future biomedical breakthroughs.

Chapter 12

Super-absorbent hydrogels for environmental remediation

Peter Oladoye, Elizabeth Omotola, Ivan Oyege, Mayowa Oladipo, Wycliffe Wanyonyi

The removal of water and wastewater contaminants by adsorptive means has been shown to be very promising. Amongst different adsorbent materials, hydrogels have been found to be a good tool for eliminating both inorganic and organic toxic chemical substances from water and wastewater, because of swelling characteristics, bio-compatibility, non-toxicity, re-usability and high functionalities. From previous studies, it has been shown that hydrogels can be re-used and regenerated for up to 5 times, with only about 10-15% adsorption capacity loss. This chapter focuses on the viability of hydrogels and its modified forms for the treatment of water and wastewater that contains micro-pollutants like pharmaceuticals, pesticides, dyes and heavy metals. Specifically, the mechanisms of interaction/uptake, adsorption isotherm modelling, adsorption capacities and regeneration potentials of (modified) hydrogels for these selected water contaminants shall be discussed.

Chapter 13

Catalytic Hydrogels and Hydrogel-Based Composites: Applications and Innovations

Irum Fatima, Abbas Faheem, Sana Javaid, Gul E Nayyab

Catalytic hydrogels represent a groundbreaking class of materials that integrate the unique properties of hydrogels with catalytic functionality, offering transformative solutions across environmental remediation, biotechnology, and industrial processes. This chapter highlights the synthesis and utilization of hydrogel-nanoparticle composites, demonstrating their efficacy in pollutant degradation, energy conversion, and chemical synthesis. Photocatalytic hydrogels,