polymers

MDPI

Review

Applications and Advantages of Cellulose–Chitosan Biocomposites: Sustainable Alternatives for Reducing Plastic Dependency

Akmaral Darmenbayeva [1,*], Gaziza Zhussipnazarova [1,*], Reshmy Rajasekharan [2], Bakytgul Massalimova [3], Roza Zharlykapova [1], Aisha Nurlybayeva [1], Zhazira Mukazhanova [4], Gulsim Aubakirova [3], Bahyt Begenova [3], Saltanat Manapova [5], Kamila Bulekbayeva [1] and Assem Shinibekova [1]

[1] Department of Chemistry and Chemical Technology, M.Kh. Dulaty Taraz University, Taraz 080000, Kazakhstan; ros61_2010@mail.ru (R.Z.); rustem_ergali@mail.ru (A.N.); nurhat2000@mail.ru (K.B.); aa.shinibekova@dulaty.kz (A.S.)
[2] Department of Science and Humanities, Providence College of Engineering, Ala 689122, Kerala, India; reshmypkumar@gmail.com
[3] Department of Chemistry and Chemical Engineering, M. Kozybayev North Kazakhstan University, Petropavlovsk 150000, Kazakhstan; bkmasalimova@ku.edu.kz (B.M.); gbaubakirova@ku.edu.kz (G.A.); bebegenova@ku.edu.kz (B.B.)
[4] Higher School of IT and Natural Sciences, S. Amanzholov East Kazakhstan University, Ust-Kamenogorsk 070010, Kazakhstan; mukazhanovazhb@mail.ru
[5] Department of Chemistry, S. Amanzholov East Kazakhstan University, Ust-Kamenogorsk 070010, Kazakhstan; salta_kz_18@mail.ru
* Correspondence: maral88.ad@gmail.com (A.D.); jgm.092016@gmail.com (G.Z.); Tel.: +7-701-787-53-89 (A.D.); +7-707-969-87-25 (G.Z.)

Abstract: This review presents a comprehensive review of cellulose–chitosan-based biocomposites that have high potential as sustainable alternatives to synthetic polymers. These biocomposites, due to biocompatibility, biodegradability, and antimicrobial properties, attract attention for wide application in various industries. This review includes modern methods for producing cellulose–chitosan composites aimed at improving their mechanical and chemical properties, such as strength, flexibility, and water resistance. Particular attention is paid to the use of composites in packaging materials, where they provide protection and durability of products, and help reduce the environmental footprint. In medicine, such composites are used for drug delivery and tissue engineering, providing controlled release of active substances and tissue regeneration. In addition, their advantages in wastewater treatment are discussed, where the composites effectively remove heavy metal ions and organic pollutants due to their high sorption capacity. This study focuses on the wide potential of cellulose–chitosan biocomposites and their role in solving environmental problems.

Keywords: cellulose–chitosan biocomposites; biodegradable materials; eco-friendly packaging; drug delivery; wastewater treatment; sustainable materials

Academic Editor: Sergiu Coseri

Received: 14 November 2024
Revised: 19 December 2024
Accepted: 24 December 2024
Published: 26 December 2024

Citation: Darmenbayeva, A.; Zhussipnazarova, G.; Rajasekharan, R.; Massalimova, B.; Zharlykapova, R.; Nurlybayeva, A.; Mukazhanova, Z.; Aubakirova, G.; Begenova, B.; Manapova, S.; et al. Applications and Advantages of Cellulose–Chitosan Biocomposites: Sustainable Alternatives for Reducing Plastic Dependency. *Polymers* **2025**, *17*, 23. https://doi.org/10.3390/polym17010023

1. Introduction

Nowadays, the excessive use of plastics, coupled with insufficient recycling efforts, has caused significant environmental damage [1]. One potential biomaterial for replacing plastics is cellulose, which is the most abundant natural biomaterial [2]. Cellulose possesses a range of favorable properties, such as widespread availability, cost-effectiveness, biocompatibility, low toxicity, lightweight, effective oxygen gas barrier properties, excellent