ChemXpress
ISSN: 2320-1975

ChemXpress

Editorial | Vol 13 Iss 2

Recent Developments in Nanocellulose Preparation, Characterization, and Applications

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Received date: May 12, 2021; **Accepted date:** May 15, 2021; **Published date:** May 22, 202

Abstract

With growing environmental and ecological concerns as a result of the use of petroleum-based chemicals and products, the development of novel materials that combine high efficiency, low cost, and minimal environmental impact is critical. In this situation, nanocellulose seems to be a remarkable substitute due to its remarkable properties such as renewability, biocompatibility, high specific surface area, low density, high elastic modulus, dimensional stability, low thermal expansion coefficient, outstanding reinforcing potential, hydrogen-bonding capacity, and eco-friendliness. The development of effective materials for novel and emerging applications from nanocellulose derived from renewable and abundant lignocellulosic materials has drawn the interest of researchers.

Keywords:* *Nanocellulose; Petroleum-based chemicals; Lignocellulose; Fibrillation

Introduction

Lignocellulosic materials can be thought of as a valuable alternative, a source of biofuels and chemicals, and an excellent substitute for petroleum. It has been proven that nanocellulose can be used to create a variety of high-value products with minimal environmental and societal impact. As evidenced by the growing number of scientific contributions and industrial investments in a variety of fields, nanocellulose has piqued the interest of many people.

The three-dimensional hierarchical structures that comprise these cellulose nanofibers at different scales, as well as the combo of cellulose's physicochemical properties and potential benefits of nanomaterial (e.g., a high specific surface area, aspect ratio), open up new possibilities in a variety of fields ranging from electronics to medical applications. Nanocellulose has been one of the most dynamic research fields for more than two decades, with remarkable results and exciting issues to be dealt. Effective use of nanocellulose provides environmental benefits, exceptional physicochemical properties, and high efficiency. To fully exploit the intrinsic properties of starting nanoscale materials, however, continuous development of robust and versatile isolation, synthesis, surface functionalization, and processing procedures to well control assembly over a wide range of length scales is required.

The current state and future prospects of nanocellulose-based flexible energy and hybrid electronic components and devices have been thoroughly researched and it has been discovered that functionalized nanocellulose can be used as a substitute for conventional petroleum-based electronics. The main challenge that must be resolve in the future to fully harness the advantages of nanocellulose and integrate it into materials in society and commerce is the fusion of characteristics such as flexibility, conductivity, luminescence, low environmental impact, and acceptable cost. Recently, a thorough review of nanocellulose-reinforced Thermoplastic Starch (TPS), Polylactic Acid (PLA), and Polybutylene Succinate (PBS) for food packaging applications

Citation: Clare Anderson. Recent Developments in Nanocellulose Preparation, Characterization, and Applications. 2021; 13(2): 141

was published. The addition of nanocellulose to PBS and PLA improved their mechanical properties as well as their oxygen barrier, whereas Nano composites containing TPS and nanocellulose had a low water barrier and tensile strength. Compatibilizers, on the other hand, can help to promote and increase dispersion by generating strong interfacial interaction between nanocellulose and polymeric matrices, resulting in improved barrier and mechanical properties as well as biodegradable properties, which are important in food packaging.

Wakabayashi did another interesting study on customizing nanocellulose film properties by controlling the degree of fibrillation of 2,2,6,6-Tetramethylpiperidine-1-Oxyl (TEMPO)-Oxidized Cellulose (TOC) dispersed in water and dissolved with a magnetic stirrer under varying conditions. It was discovered that using fibrillated TOC/water dispersions with a configurable degree of fibrillation, TEMPO-oxidized cellulose nano network sheets with a variety of optical, porous, and mechanical properties, as well as low oxygen permeability, could be obtained. Despite the widespread use of Polyvinyl Alcohol (PVA) hydrogels in a variety of applications and their commercial availability, research into PVA aerogels augmented with Cellulose Nanocrystals (CNC) generated by the freeze-thrawing method is still ongoing. PVA and CNC have different effects on the properties of composite hydrogels made using the freeze-traw process. It was demonstrated that using 10% CNC resulted in a more dense structure with superior mechanical performance and a high water content, both of which are important characteristics in medical applications such as artificial tissue engineering.

The current section improves not only our understanding of nanocellulose's developing and essential role in different sectors, but also the obstacles and future research paths that must be addressed in order to utilize its intriguing characteristics in constructive ways.