Biotechnology Reports xxx (2018) xxx xxx

Contents lists available at ScienceDirect

Biotechnology Reports

journal homepage: www.elsevier.com/locate/btre

Review

Commercial application of cellulose nano-composites – A review

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ARTICLE INFO

Article history:
Received 16 January 2019
Received in revised form 12 February 2019
Accepted 13 February 2019

Keywords:
Cellulose nano crystal (CNC)
Cellulose nano fiber (CNF)
Nanocomposites
Nanocellulose
Commercial applications

ABSTRACT

Cellulose is the biosynthetic product from plants, animals and bacteria. Cellulose is the most abundant polymer having long linear chain like structure composed of (1,4) linked β-D glucopyranosyl units assembled into hierarchical structures of microfibrils with excellent strength and stiffness. And 'nanocellulose' refers to the cellulosic materials with defined nano-scale structural dimensions. They may be cellulose nanocrystal (CNC or NCC), cellulose nanofibers (CNF) or bacterial nanocellulose. Nanocellulose is non-toxic, biodegradable and biocompatible with no adverse effects on health and environment. Due to its low thermal expansion coefficient, high aspect ratio, better tensile strength, good mechanical and optical properties, they find many applications in thermo-reversible and tenable hydrogels, paper making, coating additives, food packaging, flexible screens, optically transparent films and light weight materials for ballistic protection, automobile windows. It also find potential in biopharmaceutical applications such as in drug delivery and for fabricating temporary implants with PHB like sutures, stents etc.

1. Introduction

Polymer composites have endless usage from low cost household products to high value industrial production entities. Cellulose being the natural and most abundant biopolymer, cellulose-fiber-reinforced polymer composites has gained much potential in research for past few years. It has some relevant properties to be utilized for various polymer composite preparation like their low density, non-abrasiveness, combustibility, non-toxicity, biodegradability and of course less expensive than other synthetic polymers. However, it has some major drawbacks like poor interfacial adhesion, high water absorption and due to these reasons, cellulose-fiber-reinforced composites has been less attractive for industrial production processes. Although the issues can be solved to some extent by chemical modification of the cellulose fibers, but recent researchers are now focused to extract nanocellulose material from cellulosic fibers for fabrication of nanocellulose reinforced biocomposites to be utilized for high throughput applications [1].

The extraction and production of nanoscale cellulose materials have been reviewed extensively in the last decade, but their application as reinforcing agents to prepare composite materials for novel applications is relatively a new research field and has gained increasing attention among nanotechnology researchers. This is because, with compared to cellulose, nanocellulose materials are lighter in weight with high surface area to volume ratio and higher strength and stiffness [2]. Hence it can act as a superb reinforcing agent for developing green bio-nanocomposites for various industrial applications [3].

In this review paper, we have described various procedures for extraction of nanocellulose and various surface modification approaches to modify native cellulose and nanocellulose biopolymers as reinforcing material for the development of polymers composites with enhanced properties and application of these composites in various fields and the insights of scaling up nanocellulose production technology were also discussed.

2. Cellulose and its different sources

Majority of cell walls in plants consists of cellulose, hemicelluloses and lignin (see Fig. 1), where lignin presents at about 10–25% by dry weight and acts as a binder between cellulose and hemicelluloses components. It is the lignin, which confers the stiffness and strength with its binding function and gives protection to the cell wall. Another two major components of plant cell wall i.e. cellulose and hemicelluloses represents about 35–50% and 20–35% of dry weight of lignocellulosic biomass respectively.

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https://doi.org/10.1016/j.btre.2019.e00316