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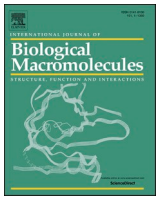

Review

Present status and application prospects of green chitin nanowhiskers: A comprehensive review

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ABSTRACT

Petrochemical resources are non-renewable, which has impeded the development of synthetic polymers. The poor degradability of synthetic polymers poses substantial environmental pressure. Additionally, the high cost of synthetic biopolymers with excellent degradation performance limits their widespread application. Thus, it is crucial to seek green, sustainable, low-cost polymers as alternatives to petrochemical-based synthetic polymers and synthetic biopolymers. Chitin is a natural and renewable biopolymer discovered in crustacean shells, insect exoskeletons, and fungal cell walls. Chitin chains consist of crystalline and amorphous regions. Note that various treatments can be employed to remove the amorphous region, enhancing the crystallinity of chitin. Chitin nanowhiskers are a high crystallinity nanoscale chitin product with a high aspect ratio, a large surface area, adjustable surface morphology, and biocompatibility. They discover widespread applications in biomedicine, environmental treatment, food packaging, and biomaterials. Various methods can be utilized for preparing chitin nanowhiskers, including chemical, ionic liquids, deacetylation, and mechanical methods. However, developing an environmentally friendly preparation process remains a big challenge for expanding their applications in different materials and large-scale production. This article comprehensively analyzes chitin nanowhiskers' preparation strategies and their drawbacks. It also highlights the extensive application in different materials and various fields, besides the potential for commercial application.

1. Introduction

Limited and non-renewable petrochemical resources [1] are the basis for preparing various synthetic polymers [2,3], including plastics [4,5] and synthetic rubber [6], which have been widely used in daily life and industrial production. With the rapid development of the global economy, the consumption of petrochemical resources has increased dramatically. However, excessive consumption of these resources depletes their supplies and releases harmful substances [7], especially carbon dioxide [8]. As we all know, carbon dioxide is the main gas responsible for the greenhouse effect [8]. The increasing concentration of carbon dioxide in the atmosphere will amplify the greenhouse effect and lead to global warming [9,10]. The 28th session of the United Nations Climate Change Conference reported that global temperatures have risen by 1.5 °C compared with pre-industrial levels, which alerted the world [11]. In this regard, many scientists are calling for the adoption of green technologies and eco-friendly materials to mitigate carbon footprints and curb greenhouse gas emissions [12–15]. Thus, to alleviate environmental pollution and climate change caused by the consumption of petrochemical resources and reduce dependence on them, many scientists attempt to use potentially green renewable resources to synthesize biopolymers [5,16,17]. However, the primary drawbacks restricting the development of synthetic biopolymers are the high cost of production and the absence of adequate extraction and purification techniques [17]. Therefore, seeking green, sustainable, and low-cost candidates to replace petrochemical-based synthetic polymers and synthetic biopolymers is significant.

Chitin, a natural and renewable biopolymer composed of β-(1 → 4)-linked *N*-acetyl-D-glucosamine, is widely discovered in the exoskeletons of crustaceans, insects, and the cell walls of some fungi [18–21]. The chitin molecule is semicrystalline, consisting of crystalline and amorphous regions [22–24]. Additionally, chitin nanowhiskers (ChWs) are a kind of nanoscale chitin product with high crystallinity. ChWs, known as chitin nanofibers or chitin nanocrystals, exhibit a rod-like appearance

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