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Application of Chitosan in Textiles

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Abstract

Based on the origin, textiles are categorized into natural and synthetic materials. Chitosan is the deacetylated form of chitin. Chitosan is the second most abundant polysaccharide in nature after cellulose, and has been extensively used in agriculture, cosmetics, food and nutrition, environmental protection, and material sciences. This biomaterial is a promising topic of research for future studies concerning biomedical textiles. Chitosan has been studied for a number of useful properties such as biocompatibility, biodegradability, anti-inflammatory, wound healing, antitumor effects and antibacterial properties in most available biomaterials have been tested in different approaches by different groups. Fibers have extensive applications in wearable and decorative textiles. In the past decades, chitosan has been appraised for various textile usages.

Keywords: Chitin; Chitosan; Polymer; Textile

Introduction

Indeed, recent analyses evidently showed that the interest in chitosan in the life sciences and technology lead to enhance and to receive funding by research agencies worldwide. Definitely, life sciences and technologies is the territory where chitosan and chitosan derivatives have much attention as a biomedical material, due to its prominent biological functions. Here, the authors offer an overview of the state of the art of a wide range of chitosan and materials derived from them which can be utilized in various fields of life sciences and technologies.

Chitin: a natural polymer

Chitin, a natural occuring polymer (β-(1-4)-poly-N-acetyl-D-glucosamine) is the second most abundant polysaccharide in natural surroundings after cellulose. Chitin is embedded in a protein matrix of a crustacean shell or a squid pen. This biopolymer is found in the shells of crustaceans such as crabs, shrimps and lobster, in the exoskeleton of insects and molluscs and in the cell walls of definite fungi. It is reported that Braconnot in 1811 discovered and isolated chitin and called it fungine [1]. In 1832, this biopoymer was found in insects by Odier and it was called chitin [1]. Currently, chitin is commonly derived from crab and shrimp shells which are discarded as massive wastes by the marine industry. It is reported that the crustacean exoskeleton waste comprises 30-50% calcium carbonate, 30-40% protein and 20-30% chitin on a dry mass foundation [2] (Figure 1).

Chitosan: the main derivative of chitin

Chitosan is a polysaccharide made from alkaline N-deacetylation of chitin. Therefore, chitosan is a term which dedicated to a group of polymers that are made from deacetylation of chitin. Degree of deacetylation is the only difference between chitosan and chitin. For the first time, Professor Rouget in 1859 discovered chitosan by reaction of chitin with sodium hydroxide solution that leads to hydrolyze the N-acetyl linkages or deacetylation of chitin. Later, Rigby in 1934 achieved two patents, one for chitosan making from chitin and other for production of films and fibres from chitosan [3]. Chitosan is a cationic polysaccharide prepared from alkaline N-deacetylation of chitin. The structure of this polymer is depicted in (Figure 2).

In fact, Chitosan is a linear, semi-crystalline polysaccharide composed of β(1-4)-2-acetamido-2-deoxy-b-D-glucan (N-acetyl D-glucosamine) and (1-4)-2-amino-2-deoxy b-D-glucan (D-glucosamine) units [4]. The Deacetylation Degree (DD) of chitosan, indicates the number of amino groups along the chains, and is calculated as the ratio of D-glucosamine to the sum of D-glucosamine and N-acetyl D-glucosamine. To be named “chitosan”, the deacetylated chitin should contain at least 60% of D-glucosamine residues (which corresponds to a deacetylation degree of 60) [4]. The deacetylation of chitin is conducted by chemical hydrolysis under severe alkaline conditions or by enzymatic hydrolysis in the presence of certain enzymes, among of chitin deacetylase [4]. At industrial scales, the two main sources of chitosan are crustaceans and fungal

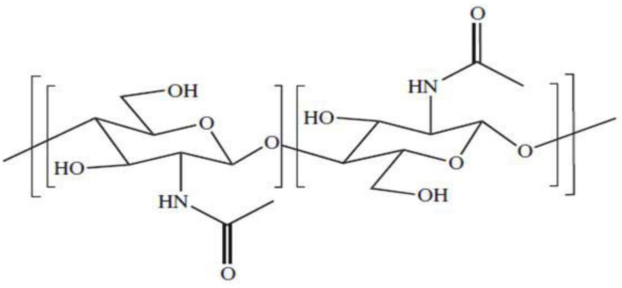

Figure 1: Chemical structure of chitin.

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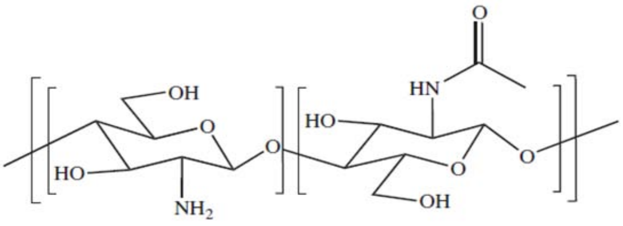

Figure 2: Chemical structure of chitosan.

mycelia; the animal source shows some disadvantages as seasonal, of limited supplies and with product variability which can lead to changeable physicochemical characteristics. The mushroom source suggested the advantage of a controlled production milieu all year round that assures a better reproducibility of the resulting chitosan, the physical properties of extracted chitosan being remarkably correlated to the growth substrate composition. Furthermore, the vegetable source is generally preferred to the crustacean one from an allergenic aspect. The produced chitosan derived from vegetable source is much safer for biomedical and healthcare applications [5]. Furthermore, chitosan has been widely used in agriculture, cosmetics, food and nutrition and environmental protection. In the aspect of biomedicine, it has such as anti-infection, anti-bacterial, antitumor, antiulcer, immunostimulatory, haemostatic, non-toxicity and wound-healing properties [6].

Chitosan and chitosan derivatives application in textiles

Bioengineering has the ability to lessen these complications. Biomaterials as one of the basic compartment of bioengineering can be engrafted alone, or attend as a scaffold or carrier for cells or growth factors to the site of injury [7].

Chitosan has the fibre-grade properties, coating ability, and good miscibility with other polymers, finds broad applications in different fields, such as medicine, agriculture, environmental protection, and food industry [7]. Also the chito-oligomers, i.e. the low-molecular chitosan fractions, which are degradation products of this polymer, have practical significance considering their high bioactivity [7]. Chitosan has a spongy property which can be used in localized drug delivery as a cell scaffold or carrier to control the release of growth factors to the site of injury [8]. In other word, chitin-based materials, together with their derivatives, have been shown to be useful as a wound dressing material, and can act as a suitable drug delivery carrier and also can be an essential candidate for tissue engineering [9]. It has also another roles such as DNA condensation, food microbiology, and crop protection [10]. The reason that chitosan and chitosan-based materials have been gained such a popularity is that they are unaffected by thermal disintegration [11]. In addition, they also exhibit the permeability and selectivity required for medical purposes [12]. It can provide better control of transport and inherent blood compatibility [13]. It is generally believed that modifying the structure of chitosan is a helpful method to improve the antimicrobial activity. The antimicrobial action was likely caused by the electrostatic interaction between amino groups of chitosan [14].

Definitely, fibres have very important functional roles in human being lives so that it is difficult today to delineate a field where a fibre doesn't involve. Use of chitosan in textile industries consists of fabrication of manufactured fibers, textile (cotton, silk, wool, polypropylene) dyeing, finishing including silk dyeing and wool dyeing, polypropylene dyeing, durable press finishing, wool finishing, antimicrobial finishing, antistatic finishing, de-odorizing finishing, sizing, textile printing, textile ink jet printing and medical textiles. In fact, fibres cover a wide range including living muscles, the bandages, automobile tyres, river guards, etc [15]. Remarkably, in the field of biomedical sciences researches involving the developments in the usage of textile fibres is concentrated [16].

Conclusion

Nowadays, chitin-based materials have been gained an increased attention towards eco-friendly, biocompatible and biodegradable polymers, as most of the widespread synthetic polymers lack these possessions. Hence, the benefits of chitosan as a textile fibre were appreciated.

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