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Chitosan Synthesis and Applications: A Review

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Abstract

Chitosan, one of the largest environmentally friendly polymers available in nature. It is a biopolymer that comes from chitin, and this polymer has a high concentration due to its unique properties, such as non-toxicity, biodegradability, and biocompatibility. This review includes methods for manufacturing chitosan, various chemical modifications, and the possibility of its application in multiple fields such as agriculture, medicine, environmental protection, and food processing.

Keywords: *Chitosan, Applications, Synthesis, Biodegradable, Biopolymer.*

1. Introduction

Chitosan (Cs) is a natural biopolymer which is mainly obtained from crustacean shells. It is achieved by deacetylation of chitin [1,2]. The manufacturing process of chitosan can vary depending on the preparation method, the source of chitin, and the degree of deacetylation. There are wide applications of chitosan due to its promising properties e.g. antimicrobial and antibacterial activity, ability to form films and gels, and biodegradability [3-6].

2. Synthesis of Chitosan

From chitin, chitosan can be manufactured. It is a polysaccharide arranged from N-acetyl glucose amine units. Synthesis involves a two-step process:

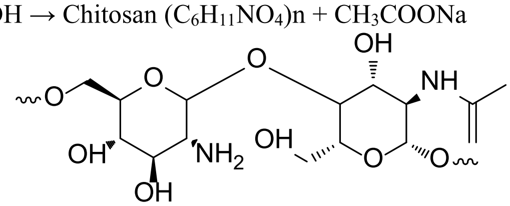
2.1 Chitin Extraction

Chitin is usually extracted from crab or shrimp shells. The extraction process involves several steps, including removing the metals using an acid (e.g., dilute hydrochloric acid (HCl)) after which the protein is removed (deproteinization) using an alkaline solution of a certain concentration (e.g., sodium hydroxide (NaOH)) [7].

2.2 Deacetylation of Chitin to Form Chitosan

The key step in synthesizing chitosan is deacetylation process, this can be applied by Chitin treatment with sodium hydroxide (NaOH), as a strong alkali solution. The properties of the resulting chitosan depending on deacetylation degree , which is the extent to which the N-acetyl groups are removed from the chitin[8]. The deacetylation process is usually controlled at temperatures between 50°C - 100°C for some hours.

Reaction: Chitin $(C_8H_{13}NO_5)_n$ + NaOH → Chitosan $(C_6H_{11}NO_4)n$ + CH_3COONa



Cs   C

Figure 1. Chitin (C) and Chitosan (Cs) Structural units.

2.3 Factors Affecting Chitosan Synthesis

- **Alkali Concentration:** The higher deacetylation degrees succeeded by Higher concentrations of sodium hydroxide [NaOH] [9].

- **Temperature and Time:** The higher degree of deacetylation achieved by raise temperatures and extended the treatment times [10].

3. Chitosan Chemical Modification

To improve chitosan performance in various applications the properties of its can be modified. The chemical modifications of chitosan include:

3.1 Carboxy-methylation

The carboxy methyl chitosan is synthesized by introducing carboxy methyl groups (-CH_2COOH) into the chitosan structure [11]. By this modification, the solubility in water is improves, also increases chitosan use in drug delivery systems and tissue engineering [12].

3.2 Crosslinking

To get more stable networks and enhance mechanical properties of chitosan, chitosan crosslinking by using agents such as glutar-aldehyde. To develop hydrogels and for various applications chitosan-based films, this method is usually applied [13,14].

3.3 Grafting with Polymers

Chitosan can be grafted with other synthetic polymers, to improve its functionality. For example, chitosan-grafted poly(vinyl alcohol) (PVA) combines the antimicrobial possessions of chitosan with the flexibility of PVA [15,16].

4. Applications of Chitosan

Chitosan has wide-ranging applications in various industries, such as medicine, food processing, agriculture, and environmental protection [17].

4.1 Pharmaceutical and Medical Applications

The biocompatibility and biodegradability of chitosan make it a adaptable material in drug delivery systems. To reduce cholesterol levels, chitosan can be used to encapsulate drugs for even work as a controlled release and wound-healing agent [18]. The chitosan derivatives are also employed as biomaterial for tissue engineering and scaffolds [19].

4.2 Chitosan Agricultural Applications

Chitosan can be used as a natural pesticide, fungicide and improves resistance to pathogens and plant growth. It has also been found to enhance the shelf life of fruits and vegetables by forming an edible layer that prevents the growth of microbes [20].

4.3 Food Industry

Chitosan is used to enhance the texture of foods and increase their nutritional value. Also, because of its ability to bind cholesterol and fats, it is used in the food industry as a fat substitute, as a food preservative, and as a nutritional supplement [21,22].

4.4 Chitosan Environmental Applications

Due to the high adsorption capacity of chitosan, it has been used in wastewater treatment, dyes, heavy metal removal, oils and environmental remediation, where chitosan-based sorbents have proven effective [23,24].

5. Conclusion

Chitosan is an adaptable biopolymer that has wide applications in many fields, including environmental protection, healthcare, agriculture and food fields. Its properties can be changed through chemical modifications to meet special requirements. As research continues to explore new methods of synthesis and modification, chitosan's role in sustainable solutions is expected to grow significantly.

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