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Preparation and Applications of Chitosan Nanoparticles: A Brief Review

Divya Lanka[1]*, Vijay Kumar Mittapally[2]

[1]Department of Pharmaceutics, Gland Institute of Pharmaceutical Sciences, Medak, Telangana
[2]Department of Biotechnology, Periyar University, Salem, Tamilnadu

Review Article

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***For Correspondence**

Divya Lanka, Department of Pharmaceutics, Gland Institute of Pharmaceutical Sciences, Medak, Telangana.

E-Mail: ramanujandivya@gmail.com

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ABSTRACT

Chitosan is a natural polysaccharide well-known for its significant biological and chemical properties such as biodegradability, biocompatibility, bioactivity, and polycationicity. It is widely used in the nanomedicine, biomedical engineering and development of new therapeutic drug delivery systems with enhanced bioavailability, specificity and reduced pharmacological toxicity. Chitosan is a natural polymer obtained by deacetylation of chitin. After cellulose chitin is the second most abundant polysaccharide in nature. Different methods of synthesis of chitosan nanoparticles and their applications in nanomedicine, biomedical engineering, industrial and pharmaceutical fields were discussed in this review.

INTRODUCTION

Chitosan nanoparticles are biocompatible, biodegradable, cationic and relatively non-toxic in nature. Hence, they are widely used in drug delivery systems. Chitosan is a natural polysaccharide prepared by the N-deacetylation of chitin, which is a natural carbohydrate polymer found in the skeleton of crustaceans, such as crab, shrimp and lobsters **(Figure 1)** [1-5].

Figure 1: Different types of Crustaceans

METHODS

Chitin is prepared from crustacean shells through various chemical processes involving demineralization and deacetylation [6-8].

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The crustacean shells are rinsed several times with water. Followed by drying in a hot air oven for about 24 hrs at 55°C, the sample obtained was soaked in boiling 4% sodium hydroxide using 1000 ml beaker for 1 hr. The sample is then allowed to cool at room temperature for half an hour [9-11].

Demineralization

The sample obtained in the first step is demineralized using 1% hydrogen chloride in a ratio of 1:4 and soaked for 24 hrs. Then the samples are treated with 50 ml of 2% sodium hydroxide for 1 hr [12,13]. The sample remains are washed with deionized water after 24 hrs and then drained off [14-16].

Deacetylation

50% sodium hydroxide is added to the demineralized sample and boiled for 2 hours at 100°C. The sample is allowed to cool and washed continuously with 50% sodium hydroxide. The sample obtained is filtered and dried in hot air oven for 6 hrs at 110°C [17-20].

Purification

The purification process was performed by removal of insoluble material by filtration. The sample is further re-precipitated with 1 N sodium hydroxide and demetallized [21-25].

PREPARATION OF CHITOSAN NANOPARTICLES

Nanoparticles are defined as colloidal structures with a varying size range of 1–1000 nm. Chitosan nanoparticles can be prepared by various methods including:

1. Ionotropic gelation method
2. Microemulsion method
3. Emulsification solvent diffusion method
4. Emulsion droplet coalescence method
5. Reverse micellisation
6. Desolvation

Ionotropic gelation method

Ionotropic gelation method involves the formation of chitosan nanoparticles based on the electrostatic interaction between the amine group of chitosan and negatively charged group of polyanions [26,27]. Chitosan is dissolved in acetic acid solution utilizing a stabilizing agent, such as poloxamer. Polyanion polymers are then added at room temperature under mechanical stirring which results in the formation of nanoparticles [28-30].

Microemulsion method

In this method, N-hexane is dissolved with a surfactant. Then, chitosan dissolved in acetic solution and glutaraldehyde is added dropwise to surfactant/hexane mixture under continuous stirring at room temperature. Nanoparticles are formed in the presence of surfactant [31-34]. The mixture is allowed to stir overnight to complete the crosslinking process. This enhances conjugation of the free amine group of chitosan with glutaraldehyde. The acetic acid solution is removed by evaporation [35-38].

APPLICATIONS OF CHITOSAN NANOPARTICLES

1. Chitosan nanoparticles are used as anti-thrombogenic materials for: controlled release and drugs encapsulation [39,40].
2. Chitosan nanoparticles-based films are used in the food industry for the control of microorganisms in food thereby enhancing the shelf life of the food products.
3. Also used for the delivery of anti-infectives such as antibacterial, antiviral, antifungal drugs [41,42].
4. Chitosan exhibits anti-fungal property against *Aspergillus niger, Rhizopus stolonifer, Rhizopus oryzae* etc., in its free polymer form.
5. Chitosan nanoparticles can be a major source for the delivery of various drugs like heparin, chondroitin sulphate through oral route [43-45].
6. Chitosan nanoparticles, being extremely low toxic are used as efficient vectors for gene delivery.

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7. Used as a potential adjuvant for vaccines against influenza, hepatitis [46,47].
8. Chitosan NP is also used in the dentistry to eliminate caries [48].
9. Used as an additive in antimicrobial textile industry for producing clothes for health care professionals.
10. The nanoparticles have also been proven to show skin regenerative properties, hence they can be used in anti-aging skin care products [49,50].

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