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Review paper on chitosan and its applications

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ABSTRACT

Chitosan is a hydrophilic biopolymer, which is obtained industrially by hydrolyzing the amino-acetyl group of chitin. It is a natural, non-toxic, biodegradable polysaccharide available as solution, flake, fine powder, bead, and fiber.

Keywords: *Chitosan, Chitin, Deacetylation, Biopolymer, Polysaccharide*

1. INTRODUCTION

Chitosan is a hydrophilic biopolymer, which is obtained industrially by hydrolyzing the amino-acetyl group of chitin. It is a natural, non-toxic, biodegradable polysaccharide available as solution, flake, fine powder, bead and fiber. Chitosan is a derivative of chitin, the second most abundant in nature, which is a supporting material of crustacean, insects, and fungal mycelia. Synonyms- Kaitosaen, Poliglusam, De- acetylchitin, Poly-(D)-glucosamine

History-

Chitosan was first discovered in 1811 by Henri Braconnot, director of the botanical garden in Nancy, France. Bracannot observed that a certain substance (chitin) found in mushrooms did not dissolve in sulfuric acid. Over the last 200 years, the exploration of chitosan has taken on many different forms. Several other researchers continue to build on the original finding of Bracannot, discovering new uses for chitin as they find different forms of it in nature.

Source-

Chitosan also obtained from fungi, production is associated with fermentation processes from *Aspergillus niger*, *Mucor rouxii*, *Saccharomyces cerevisae,* and *streptomyces species.* Crustacean chitosan – commercially chitosan is derived from the shells of shrimp and other sea crustaceans including *Pandalus borealis.* Squid pen chitosan- squid pen chitin is obtain from the Loligo species and *Ommastrephes bastrame* squid pens (a waste byproduct of New Zealand squid processing) are the novel, renewable source of chitin and chitosan.

Fig-1

2. STRUCTURE AND SYNTHESIS

Chitosan is a linear polysaccharide composed of randomly distributed β-(1-4) linked D-glucosamine (deacetylated unit) N-acetyl-D-glucosamine and glucosamine (acetylated unit). It is produced commercially by Deacetylation of chitin. It has a Pka value of approximately 6.5 which leads to protonation in acidic to neutral solution.

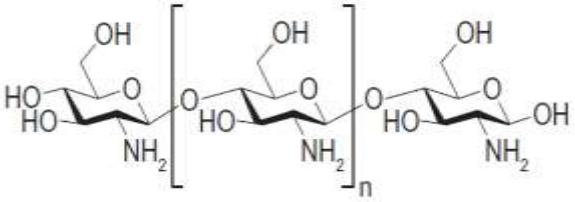

Fig-2

Synthesis of chitosan from chitin

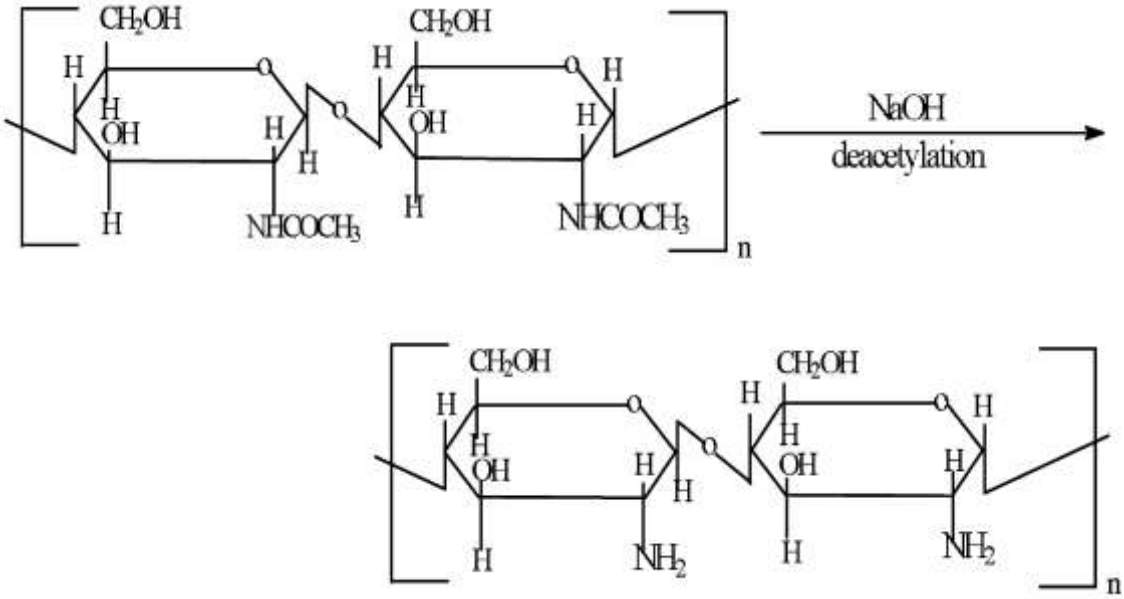

Fig-3

Properties of chitosan

Physical properties-

1. Form-solution, powder, flake, fibre and film.
2. Solubility (acetic acid, water and most ordinary solvents)
3. Bulk Density- range of 0.20- 0.38 g/ml
4. Assay >=75%

Chemical properties-

Chitosan is a poly-cationic biopolymer with wide biological applications due to its unique chemical nature, positive charge, presence of reactive hydroxyl, and amino group.

1. Hydrophilic, cationic molecule
2. Linear polyamine, Reactive amino groups

Biological properties-

1. Biodegradable, nontoxic
2. Biocompatible
3. Fungicidal
4. Spermicidal

Grades -

Technical general purpose-

1. Low viscosity (50-250cps)
2. Medium viscosity (250-700cps)
3. High viscosity (700-2100cps)

Cosmetic grade-

(Viscosity10-100cps)

Degree of deacetylation 85-92%

Dietary grade-
1. Standard density (<=0.30-0.50 g/cc)
2. High density (<=0.50-0.60g/cc)

3. METHOD OF PREPARATION

There are seven methods of preparation of chitosan micro/nanoparticle system as-

A) Emulsion cross linking method –following cross-linking agents are used
Ex-Cross-linking agents:-glutaraldehyde, sulfuric acid, Formaldehyde.
Ex-stabilizing agents:-Dioctyl sulfosuccinate.

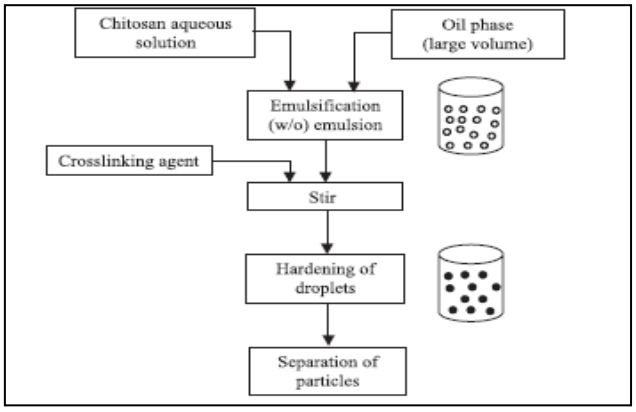

Fig-4

B) Coacervation/precipitation- It utilizes the Physicochemical Properties of chitosan. Two types as- a. Simple coacervation, b. Complex coacervation.

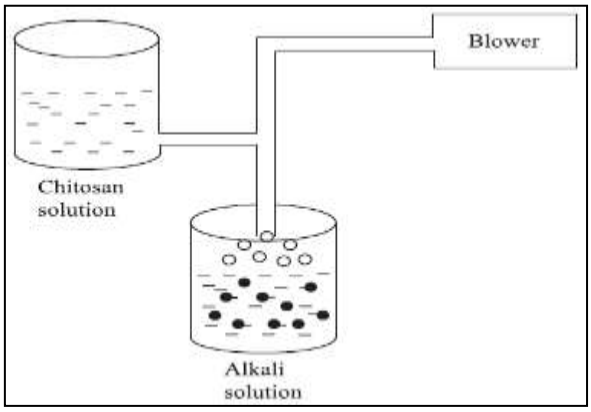

Fig-5

C) Spray-drying method- It is based upon drying of atomized droplets in a Stream of hot air.

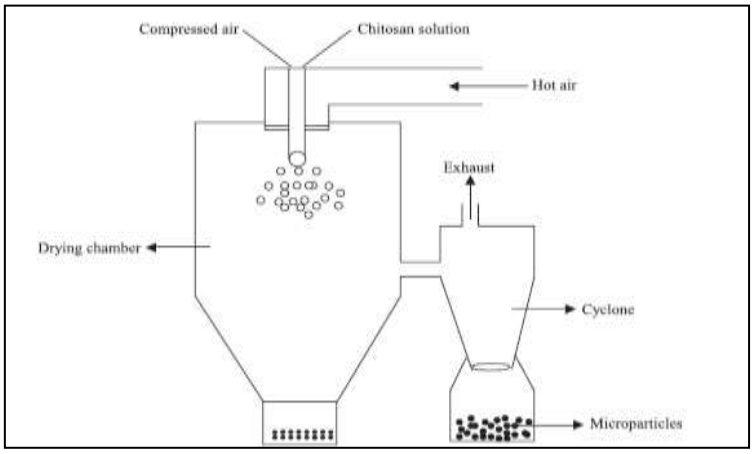

Fig-6

D) Emulsion-droplet coalescence method-
This method utilizes the principle of both emulsion-cross linking and precipitation. However, in this method, instead of cross-linking the stable droplets and precipitation is induced by allowing coalescence of chitosan droplets with sodium hydroxide droplets.

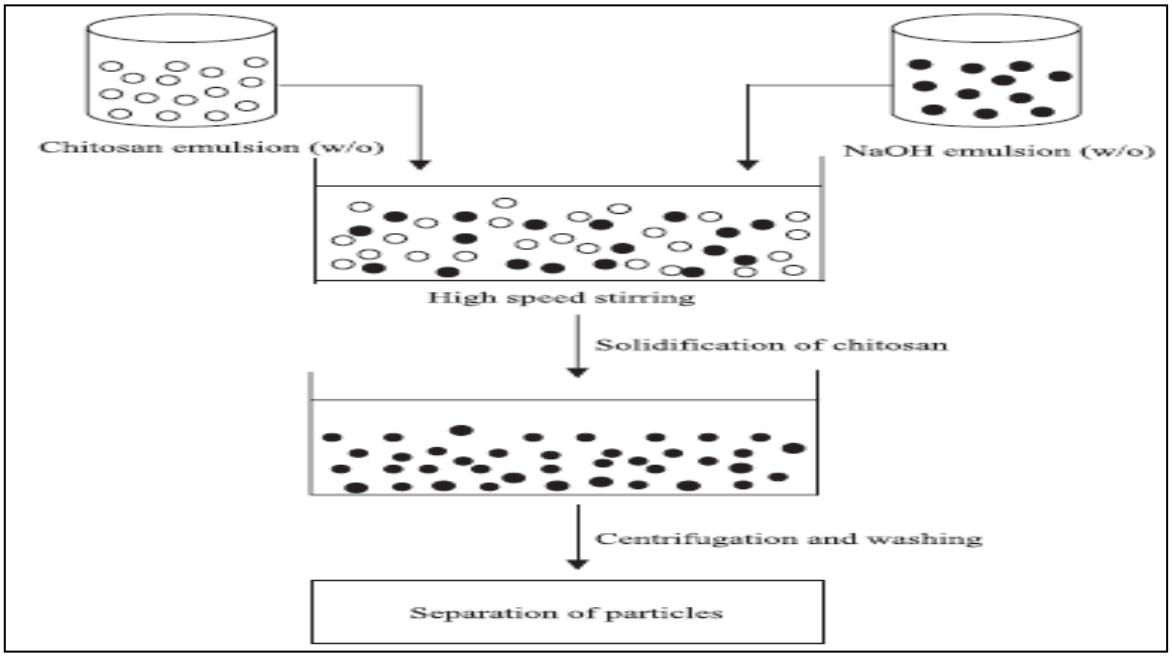

Fig-7

E) Ionic gelation-

The use of complexation between oppositely charged macromolecules to prepare chitosan microspheres has attracted much attention because the process is very simple and mild.

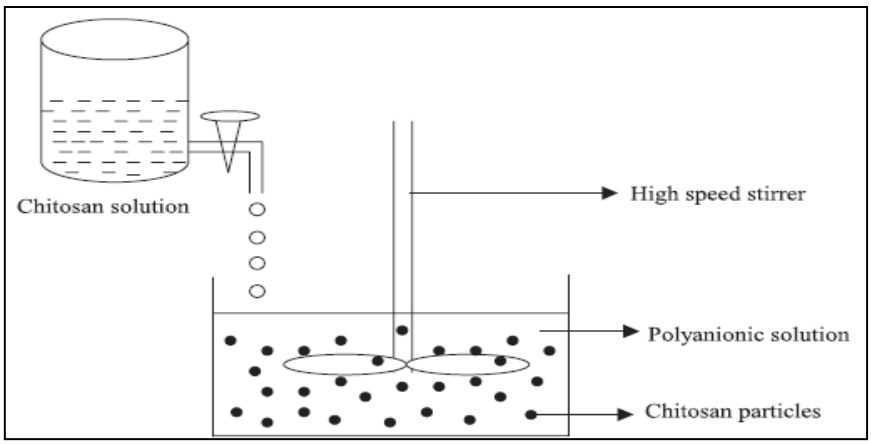

Fig-8

F) Sieving method-

It is novel method to produce chitosan-microparticles. Advantage of this method is that it is devoid of tedious procedures and can be scaled-up easily. Disadvantage of this microparticles obtained is irregular.

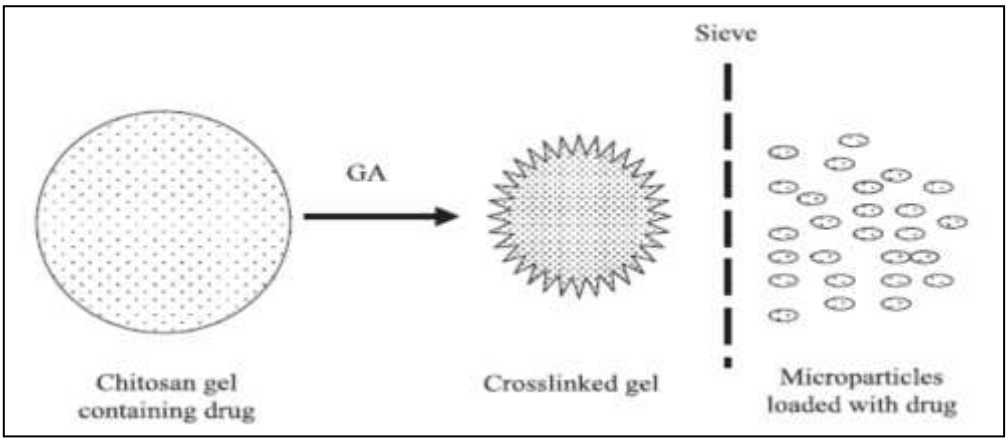

Fig-9

G) Reverse micellar method-

Reverse micelles are thermodynamically stable mixtures of water, oil and surfactant.

Advantage of this method is aspect of reverse micelle hosted system is their dynamic behavior.

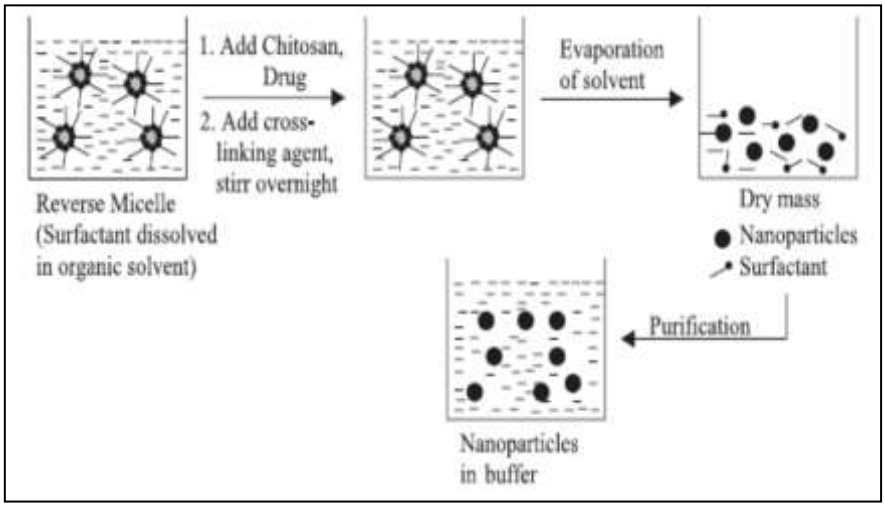

Fig-10

Purification-

Purification of chitosan is done by following purifiying agents.

- Deproteinization/protein complexing agent- example- sodium codicil sulfate (SDS), sodium tetradecyl sulfate, and sodium lauryl sulfate (SLS)
- Demetalization/metal complexing agents example- ethylenediaminetetraacetic acid (EDTA), diethylenetriaminepentaaceticacid(DTPA)
- Reducing agents- example-dithiothreitol (DTT), dithioerythritol (DTE)

Release kinetic of chitosan micro/nanoparticles-

The release of drug from chitosan particulate systems involves three different mechanisms-

⦿ Release from the surface of particles,
⦿ Diffusion through the swollen rubbery matrix,
⦿ Release due to polymer erosion.

Diffusion- drug release by diffusion involves three steps-

❑ Water penetrates into particulate system, which causes swelling of the matrix.
❑ The conversion of glassy polymer into rubbery matrix.
❑ In this step diffusion of drug from the swollen rubbery matrix, so release is slow initially and later it becomes faster.

Drug loading in chitosan micro/nanoparticles-

⦿ The drug loading in micro/nanoparticle is done by two methods i.e.
❑ During the preparation of particles / (incorporation):-
❑ After the formation of particles/(incubation):-
⦿ The maximum drug loading can be achieved by incorporating method i.e. during formation of the particles, but it may get affected by the process parameters as: method of preparation, presence of additives.

FDA approval for chitosan use-

It has been certified as a wound dressing by the US Food and Drug Administration. This invention was made for methods of purification of chitosan for food and commercial grade chitosan with United States Government support under grant number DAMD17-98-1-8654 from the United States Army.

Chitosan applications for plants and crops are regulated by the EPA, and the USDA National Organic Programmes regulates its use on organic certified farms and crops.

Side effects of chitosan-

⦿ Constipation
⦿ Gas
⦿ Upset stomach
⦿ Anyone allergic to any form of shellfish will have an adverse reaction to chitosan
⦿ Occasionally chitosan can hinder the absorption of useful minerals and chemicals by the body as well
⦿ Problems in breathing
⦿ Swelling up of the wrists and the heels
⦿ Rashes on skin

Application-

⦿ Industrial applications-Pharmaceutical applications- Drug delivery system

Cosmetic application-Chelating agent in shampoo

⦿ Water engineearing-
⦿ Paper industry-
⦿ Textile industry-
⦿ Food processing-
⦿ Agriculture-
⦿ Biomedical application-Tissue engineering-
⦿ Ophthalmology-

- Artificial skin-
- Photography-
- Chromatographic separation-
- Solid state batteries- Chitosan gel for LED application
- Marketed formulations containing chitosan-
- Tablets- Diclofenac –Na, propranolol-HCl
- Microspheres- Theophylline, pentazocine, Prednisolone,interleukin-2, Cimetidine, vit D-2, felodipine

4. CONCLUSION

At present the state of the art of several drug delivery systems based on chitosan, which has proven to be a suitable excipient for the pharmaceutical industry. Nevertheless, the number of papers published on this subject is very large, and focus only on four of the techniques of major importance, Which lead to the production of microparticles. Although there are many other methods for preparing controlled release forms based on chitosan, these techniques have wider application in the pharmaceutical industry nowadays and have been tested for drugs of different solubility. These dosage forms are promising for the treatment of different diseases.

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