Review Article

An Extensive Review on Chitosan as Versatile Material for Pharmaceutical and Biomedical Application

ABSTRACT

Chitosan is a polysaccharide and is derived from chitin. Chitosan every now and then referred to as a soluble chitin. chitosan is strongly basic polysaccharide. chitosan shows physiochemical and biological properties. This review presents the common source for chitosan manufacturing that is crabs and shrimp. According to researchers it is just a fat inhibitor. some of the application of chitosan in pharmaceutics/drug delivery and in biomedical field are also highlighted. Chitosan act as a diluent, as mucoadhesive excipient, as permeation enhancer, in vaccines delivery, as parenteral delivery, chitosan as food additive, cosmetics industry. chitosan also has a number of medicinal benefits. Chitosan is employed in a variety of applications because it is soluble in acidic aqueous conditions (food, cosmetics, biomedical and pharmaceutical applications). We give a quick overview of the chemical modifications of chitosan, a field in which a number of syntheses have been proposed but not yet realised on a large scale. This review focuses on current articles on these materials' high-value-added applications in medicine and cosmetics.

Keywords: chitosan, structure, application, biomaterials

INTRODUCTION

Chitosan is a polysaccharide that is made up of randomly dispersed-(1-4) linked D glucosamine and N-Acetyl-D-glucosamine. It is created by processing the shells of shrimp and other crustaceans with the alkali, sodium hydroxide (1). It is also found in certain microbes and fungi, such as yeast. The word chitosan refers to a group of chitosan polymers with varying molecular weights (50KDa-2000KDa), viscosities (2000MPaS), and degrees of deacetylation (48 percent -98 percent). Chitosan is sometimes referred to as soluble chitin. Chitin is made up of unbranched chains of -(1-4)-2-acetamido-2-acetamido-2-acetamido-2-deoxy-D-glucose. It is identical to cellulose except that the hydroxyl group is substituted with an acetamido residue. Depending on the origin of the product, chitin is basically insoluble in water, dilute acid, and alcohol. Chitosan reacts with inorganic and organic acids such as glutamic acid, lactic acid, hydrochloric acid, and acetic acid to produce salt (2). The structures of chitin and chitosan are shown in figure 1.

Comment [u1]: Please, check for plagiarism

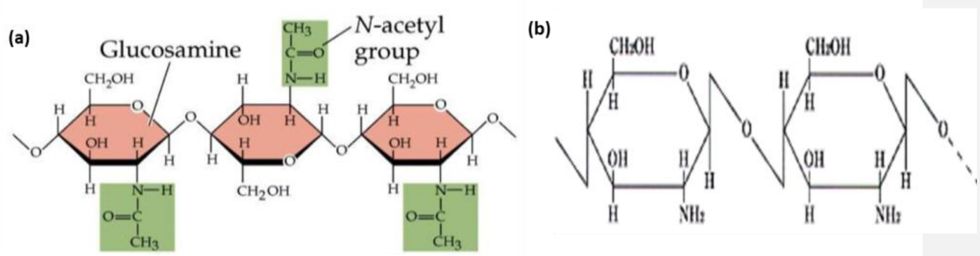

Figure 1: Chemical structure of (a) chitin, (b) chitosan

PROPERTIES

Natural polymers such as fiber, dextrin, pectin, alginic acid, and agar are acidic in nature, but chitosan is a strongly basic polysaccharide. Chitosan characteristics include solubility, viscosity, and the ability of polyelectrolytes to form films.

Physico-Chemical properties:

Comment [u2]: Please, check for plagiarism

Chitosan's physicochemical characteristics are as follows:

• Chitosan is a colourless, off white, rigid, inelastic, nitrogenous polysaccharide with a molecular weight ranging from 1.03×106 to 2.5×105 Daltons on average. However, the

Chitosan formed through Deacetylation is reduced to 1×105 to 5×105Daltons.

• Chitin is simply converted into gels, powders, membranes, fibres, colloids films, and beads.

• Chitosan is a polymer that is linear.

• The presence of chitosan They are easily replaced by reactive amino groups and hydroxyl groups.

• It chelates with numerous transitional metal ions since it is a polysaccharide (3)

Biological properties

• Biocompatible- since they lack antigenic properties, they are compatible with animal and plant tissue.

• Biodegradable at room temperature

• Non-toxic and safe

• Associated with mammalian and microbial cells

• The ability to regenerate connective gum tissue

• It has hemostatic, hypocholesterolemic, radical scavenging, and anticoagulant property (4).

THE COMMON SOURCES FOR CHITOSAN PRODUCTION

Shrimp and crabs are the most commonly cited causes in the literature as raw materials for chitosan preparation, there are other family like lobster, cryfishand oyster are also used for chitosan preparation (5-8). Different creatures have different chitin content (wt percent): crustacean shell waste on average contains 30 percent - 50 percent by weight of calcium carbonate and 20 percent - 30 percent by weight of chitin, whereas in some genera of lobsters, such as Nephrops sp. and Homarus sp., the shell contains 60 percent - 75 percent by weight of chitin content, which is the highest among all chitin containing species (9,10).

Current research on the synthesis of chitin or chitosan from crustacean by-products containing 20% (wt%) or higher chitin has yielded encouraging findings as industrial feedstocks for chitosan manufacture. For example, Procambarus clarkii (crayfish) by-products (which included the entire animal body, thorax, and claws) were originate to comprise almost 20% - 23% (by weight) of chitin, which now permits its usage as an economically worthwhile cause for chitin manufacture on an industrial scale due to its complete convenience and little cost (10-12). Current literature has also suggested the commercial and eco-friendly benefits of such crustacean causes for chitosan preparation, because 40 percent - 50 percent by weight of the total mass of the crustacean for social eating ends up as left-over, and the majority of such leftover is discarded into the sea and becomes important toxins in sea zones (9,13). As a result, crustacean leftovers such as lobster cephalothorax can be recognised as a viable source for chitosan production on a large scale.

HISTORY

Chitosan (pronounced Kite-O-San) has long been thought to be a "fat magnet." According to researchers, it is just a obese inhibitor that seems to perform wonders for people looking for a safe approach to decrease body fat. About 20 ages later, there was a gentleman who authored an article on creatures in which he noted that alike material was existing in the structure of creatures as well as the structure of plants. He subsequently dubbed this incredible chemical "chitin." The term chitin is taken from Greek and means "tunic" or "envelope." Lassaigne proved the existence of nitrogen in chitin in 1843, expanding on the notion (3). Rouget addressed the deacetylation method of chitosan, and numerous studies have emphasised the want to understand and examine the material, from improved manufacturing, purifying techniques, to changes of the fundamental structure and its uses. Chitosan is a possible cause of bioactive material, but it has numerous restrictions for use in biological systems, including poor solubility under physiological conditions. To overcome these limitations, scientists focused on the Derivatisation of chitosan through chemical alterations. These changes result in enhanced solubility in liquid as well as biological diluents (14).

Chitosan, primarily for increasing the plant resistance, are created on how this amine containing polymer impact on the bio-chemical and molecular biology of the plant cell. Chitosan is typically used as a natural seed treatment and shrub development enhancers and as eco welcoming bio pesticides substances that increases the inhere capability of plant to protect themselves against further infections (15).

PROCESSING OF CHITOSAN

Chitin may be extracted chemically from crustacean shells. It entails the following processing steps (figure 2):

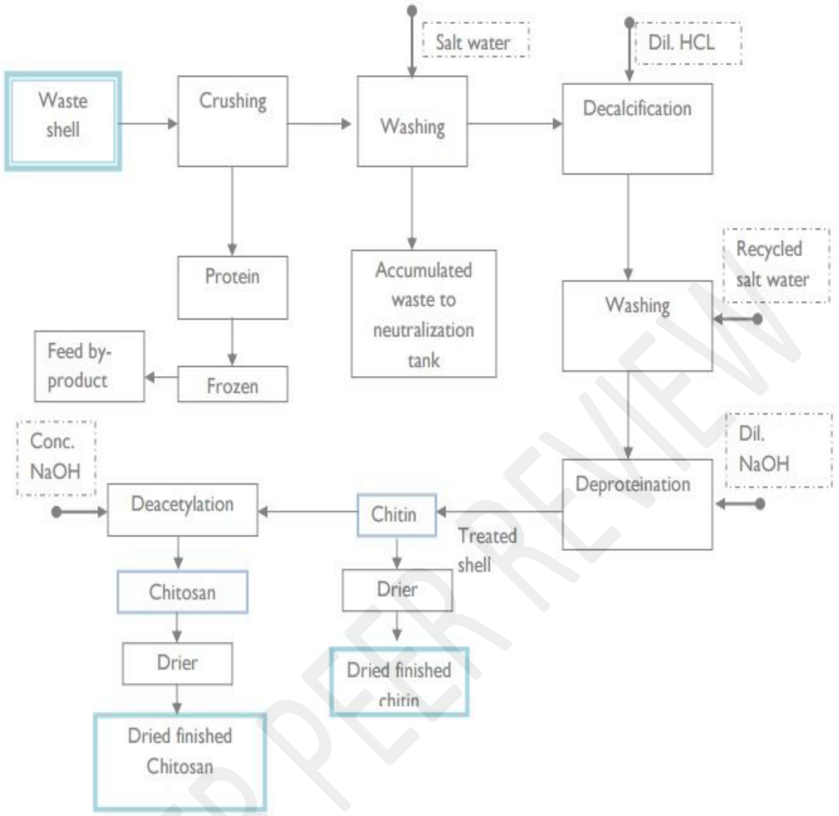

Figure 2: Manufacturing process of chitosan

a) Demineralization entails acid treatment (HCl) to remove inorganic particles, primarily calcium carbonate (16).

b) Deproteinization: this requires extracting protein matter in an alkaline medium (NaOH).

c) Decoloration: bleaching the product with organic substances to accomplish a colourless product (17).

APPLICATION OF CHITOSAN IN PHARMACEUTICS/DRUG DELIVERY

Chitosan has a number of medicinal benefits (figure 3).

• Polymers, micelles, liposomes, and nanoparticles have recently gained considerable interest as medicinal carriers (18-20).

• These systems have several benefits, the most notable of which is improved medication effectiveness and safety.

• Depending on the type of the carrier, these schemes can contain both hydrophobic and hydrophilic dynamic chemicals.

• They can also provide greater therapeutic stability against chemical and enzymatic degradation, prolonged drug impact in the target tissue, higher bioavailability, and drug targeting by including particular ligands (21).

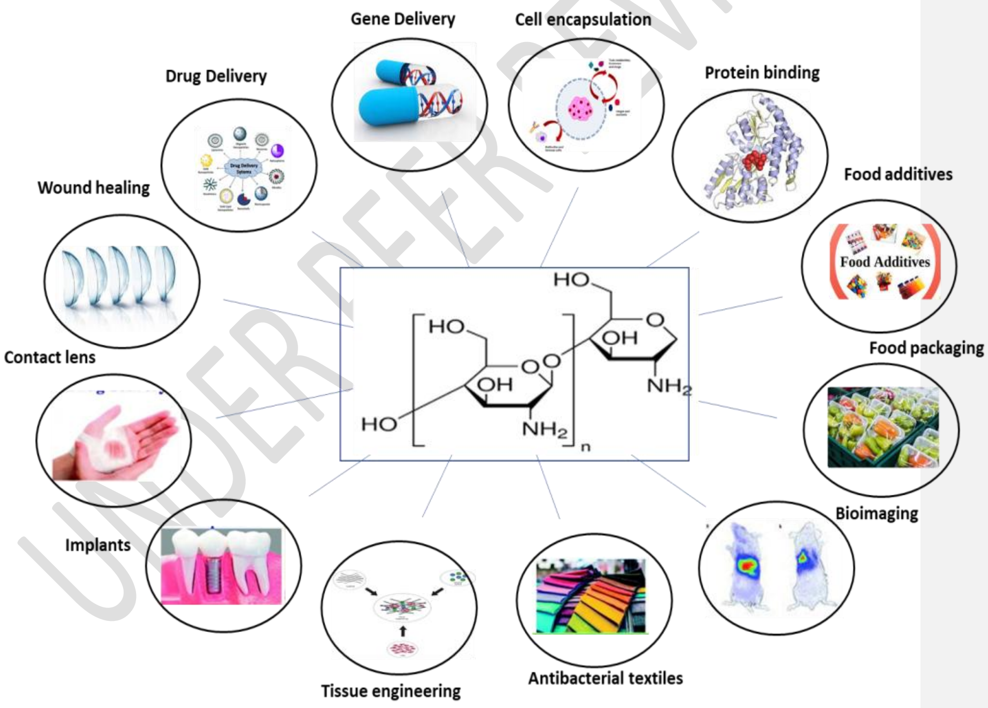

Figure 3: A schematic indicating pharmaceutical applications of chitosan in various areas.

APPLICATION OF CHITOSAN IN BIOMEDICAL FIELD

Comment [u3]: Please, check for plagiarism

As diluents

Because of the interactions that occur between their reactive hydroxyl and amino groups, chitosan and 2-hydroxyethyl starch are miscible mixes, and by utilising these combinations, we can obtain various controlled release formulations. It is due to the combination of matrix tablet diffusion and disintegration (22,23).

Adnan A. Badwan, et al. Chitin and chitosan, as well as their derivatives, can be used as useful excipients in pharmaceutical applications that can be associated for DC dispensation. The variety of physicochemical features of semi-crystalline nature, DDA, and MW improves its usefulness as a standalone and as a coprocessed excipient in medicinal formulations. Furthermore, their large surface area, porous structure, and plastic distorting nature improve particle connection and tablet ability in the DC mode with negligeable vulnerability to lubrication. When chitin and chitosan are co-processed with other excipients, they can be used optimally as a only multifunctional excipient (24).

As mucoadhesive excipient

Bioadehesion is a sort of controlled drug delivery system that is primarily aimed at the GI tract. When chitosan is compared to other polymers, the cationic polymer has a greater bioadhesion ability than other natural polymers[10]. Because of the presence of OH and the amine group, chitosan has a mucoadhesive characteristic. Because to the presence of mucoadhesion, the drug's residence duration is prolonged. As a result, absorption and bioavailability in the gastrointestinal tract are increased (11,24,25).

As controlled drug delivery system

Chitosan is a cationic polymer that is utilised in medication delivery. Polyion complexes are formed as a outcome of its interactions with anionic polymers. Poly ion complexes and their fundamental characteristics have been employed in medicinal applications (26).

As permeation enhancer

Chitosan's cationic nature allows it to open tight junctions in cell membranes. This characteristic has prompted a number of research into the use of chitosan as a permeation enhancer for hydrophilic medicines with low oral bioavailability, such as peptides. Yu-jie

Zhang et al used the permeation coefficient of fluorescein isothiocyanate recombinant hirudin-2 across the stimulated rabbit nasal epithelium in vitro to assess the permeation boosting impact of different chitosan formulations. It was determined that Chitosan, with or without certain enhancers, may effectively recover nasal absorption of recombinant hirudin while without producing important mucosal ciliotoxicity. A chitosan preparation method would be an effective method for nasal administration of recombinant hirudin (27).

In vaccines delivery

The latent use of chitosan as a transfer method for disabled virus vaccinations administered intravenously has been investigated. According to research, low molecular weight chitosan in the form of nano particles has the potential to be a novel long-term nasal vaccination delivery vehicle (15). Chitosan microparticles are able to interrelate with significant quantities of ovalbumin (model vaccination for diphtheria toxoid). In an acidic environment, chitosan microparticles do not dissolve and preserve the antigen from deprivation by tricking it inside their permeable structure. The related ovalbumin is transported into the peyer's patch by the chitosan microparticles. Since the acceptance of antigen by Peyer's coverings is an important step in oral injection, these porous chitosan microparticles are a very auspicious injection transfer system (28,29).

As parenteral delivery

Because extremely cleansed chitosan fractions were found to be neither toxic nor hemolytic, they have the capability to complex DNA and nuclease deprivation, and low molecular weight chitosan can be directed IV deprived of liver accumulation, there is potential to further observe low molecular mass chitosan as components of a synthetic gene therapy system (30).

Chitosan in fuel cell

Fuel cells are electrochemical devices that change mechanical energy into electrical energy. Fuel cells have gotten a lot of attention because they have the potential to be a viable alternative to traditional power sources. Recently, the effective and globally friendly biopolymer chitosan has been expansively examined as a novel material for use in fuel cells.

This biopolymer can be used as a membrane electrolyte as well as an electrode in a variety of fuel cells, including alkaline polymer electrolyte fuel cells, direct methanol fuel cells, and bio fuel cells (31).

Chitosan as a food additive

Chitosan has the ability to form films and act as a barrier, making it a potential raw material for edible films or coating. Chitosan's antibacterial or antifungal properties, as well as its antifilm forming property, make it ideal for use as a biodegradable antimicrobial packaging material that can be used to improve the storage of destructible foods. Several studies show that chitosan can be used as an effective film forming or preservative to improve the excellence and shelf life of several diets. Chitosan was approved as a food additive by the US FDA (32).

Cosmetic industry

Cosmetic compositions for hair or skin treatment are disclosed, with the formula containing new quaternary chitosan derivatives. Chitosan byproducts have a good substantively, predominantly to hair keratin, and show hair strengthening and air conditioning properties. Chitosan is used in oxidation hair-coloring compositions, hair setting lotions, gel form, and skin creams (33).

Colon specific drug delivery

Because chitosan is removed in the colon, enteric coating resources are used for colon definite drug transference. Anti-inflammatory drugs, such as sodium diclofenac, are tricked inside the main of the chitosan microspheres. These microspheres are then shielded with enteric coating, which is then used for drug transference. In colon, sodium diclofenac is start to be released over the period of time of nearly 12 hours (33).

CONCLUSION

Chitosan is a natural polymer with colourless, rigid, inelastic polysaccharide characteristics. It is a linear polymer that is biodegradable, harmless, and non-toxic. Chitin, which is derived from shrimp and other crustacean shells, is the primary core material used in the production of chitosan. Chitosan has several applications in the pharmaceutical industry, including diluents in tablet production, mucoadhesive excipients, permeation enhancers, and wound healing properties. Chitosan has recently been utilised in vaccine delivery procedures. Aside from the pharmaceutical industry, chitosan is employed as a fuel agent and as an anti-dot in metal detection. This Examination delivers whole data on the physical characteristics and uses of chitosan.

Comment [u4]: Please, check for plagiarism

REFERNCES

1. Ilium L. Chitosan and its use as a pharmaceutical excipient. Pharm Res. 2004;15:1326-31.
2. A brief review on chitosan and application in biomedical field. Available from: https://www.researchgate.net/publication/314117499_A_Brief_Review_on_Chitosan_and_Application_in_Biomedical_Field.
3. Sun K, Li ZH. Preparations, properties and applications of chitosan based nanofibers fabricated by electrospinning. Express Polym Lett. 2011;5(4):342-61. doi: 10.3144/expresspolymlett.2011.34.
4. Dewangan HK. A review: chitosan as natural versatile material for biomedical and diseases treatment. IJISET. 2020;7(11):107-20.
5. Muzzarelli RAA. Chitins and chitosans as immunoadjuvants and non-allergenic drug carriers. Mar Drugs. 2010;8(2):292-312. doi: 10.3390/md8020292, PMID 20390107.
6. Kim SK. Chitin, chitosan, oligosaccharides and their derivatives: biological activities and applications. Vol. 643; 2011.
7. M R. Chitosan as promising materials for biomedical application: Review [review]. RDMS;2(4). doi: 10.31031/RDMS.2017.02.000543.
8. Chitosan-BASED hydrogels: functions and applications; 2017.
9. Arbia W, Arbia L, Adour L, Amrane A. Chitin extraction from crustacean shells using biological methods – a review. Food Technol Biotechnol. 2013;51:12-25.

10. Synowiecki J, Al-Khateeb NA. Production, properties, and some new applications of chitin and its derivatives. Crit Rev Food Sci Nutr. 2003;43(2):145-71. doi: 10.1080/10408690390826473, PMID 12705640.

11. Kumari S, Rath PK. Extraction and Characterization of Chitin and chitosan from (Labeo Rohit) Fish Scales. Procedia Mater Sci. 2014;6:482-9. doi: 10.1016/j.mspro.2014.07.062.

12. Meyers SP. Preparation and characterization of chitin and chitosan- a review. J Aquat Food Prod Technol. 1995;4(2):27-52. doi: 10.1300/J030v04n02_03.

13. Vaingankar PN, Juvekar AR, Vaingankar PN, Juvekar AR. Fermentative production of mycelial chitosan from Zygomycetes: media optimization and physico-chemical characterization. Adv Biosci Biotechnol. 2014;5:940-56.

14. Pokhrel S, Yadav PN, Adhikari R. Applications of chitin and chitosan in industry and medical science: a review. Nepal J Sci Technol. 2016;16(1):99-104. doi: 10.3126/njst.v16i1.14363.

15. Applications of chitin and chitosan in industry and medical science: a review. Available from: https://www.researchgate.net/publication/291174564_Applications_of_Chitin_and_Chitosan_in_Industry_and_Medical_Science_A_Review.

16. Recent advances in application of chitosan in fuel cells. Available from: https://www.researchgate.net/publication/268811074_Recent_Advances_in_Application_of_Chitosan_in_Fuel_Cells.

17. Ravi Kumar MNV. A review of chitin and chitosan applications. React Funct Polym. 2000;46(1):1-27. doi: 10.1016/S1381-5148(00)00038-9.

18. Vatanparast M, Shariatinia Z. AlN and AlP doped graphene quantum dots as novel drug delivery systems for 5-fluorouracil drug: theoretical studies. J Fluor Chem. 2018;211:81-93. doi: 10.1016/j.jfluchem.2018.04.003.

19. Shariatinia Z, Shahidi S. A DFT study on the physical adsorption of cyclophosphamide derivatives on the surface of fullerene C60 nanocage. J Mol Graph Model. 2014;52:71-81. doi: 10.1016/j.jmgm.2014.06.001, PMID 25005535.

20. Nikfar Z, Shariatinia Z. DFT computational study on the phosphate functionalized SWCNTs as efficient drug delivery systems for anti-osteoporosis zolendronate and risedronate drugs. Phys E Low Dimensional Syst Nanostruct. 2017;91:41-59. doi: 10.1016/j.physe.2017.04.011.

21. Nikfar Z, Shariatinia Z. Phosphate functionalized (4,4)-armchair CNTs as novel drug delivery systems for alendronate and etidronate anti-osteoporosis drugs. J Mol Graph Model. 2017;76:86-105. doi: 10.1016/j.jmgm.2017.06.021, PMID 28719844.

22. A brief review on chitosan and application in biomedical field. Available from: https://www.researchgate.net/publication/314117499_A_Brief_Review_on_Chitosan_and_Application_in_Biomedical_Field.

23. Dewangan HK, Sharma A, Mishra A, Singour P. Mucoadhesive microspheres of atorvastatin calcium: rational design, evaluation and enhancement of bioavailability. Indian J Pharm Educ Res. 2021;55(3):1-9.

24. Rinaudo M. Chitin and chitosan: properties and applications. Prog Polym Sci. 2006;31:603-32.

25. Hosseini F, Sadighian S, Hosseini-Monfared H, Mahmoodi NM. Dye removal and kinetics of adsorption by magnetic chitosan nanoparticles. Desalin Water Treat. 2016;57(51):24378-86. doi: 10.1080/19443994.2016.1143879.

26. Kumar Dutta P, Dutta J, Tripathi VS. Chitin and chitosan: chemistry, properties and applications. J Sci Ind Res. 2004;63:20-31.

27. Chitosan nanoparticles - properties and applications. Available from: https://www.azonano.com/article.aspx?ArticleID=3232.

28. Dewangan HK. Rational application of nanoadjuvant for mucosal vaccine delivery system. J Immunol Methods. 2020;481-482:1-11.

29. Dewangan HK, Pandey T, Singh S, Singh S. Rational design and evaluation of HBsAg polymeric nanoparticles as antigen delivery Carriers. Int J Biol Macromol. 2018;111:804-12. (IF:5.16). doi: 10.1016/j.ijbiomac.2018.01.073, PMID 29343454.

30. Priya VSV, Roy HK, jyothi N, Prasanthi NL. Polymers in drug delivery technology, types of polymers and applications. Sch. Acad. J Pharmacol. 2016;5:305-8.

31. Zhang Y, Liu LB, Wang LJ, Deng YH, Zhou SY, Feng JW. Preparation, Structure and Properties of Acid Aqueous Solution Plasticized Thermoplastic Chitosan. Polymers. 2019;11:818- 26.

32. Karteek P. Chitosan: a BIOCOMPATIBLE POLYMER FOR PHARMACEUTICAL APPLICATIONS IN VARIOUS DOSAGE FORMS Chemical structure of chitosan: introduction. Int J Pharmtechnol IJPT. 2010;2:186-205.

33. Vaghari H, Jafarizadeh-Malmiri H, Berenjian A, Anarjan N. Recent advances in application of chitosan in fuel cells. sustain chem process. 2013;1(1). doi: 10.1186/2043-7129-1-16.

34. Altaf F, Batool R, Gill R, Shabir MA, Drexler M, Alamgir F, Abbas G, Sabir A, Jacob KI. Novel N-p-carboxy benzyl chitosan/poly (vinyl alcohol/functionalized zeolite mixed matrix membranes for DMFC applications. Carbohydr Polym:116111. doi: 10.1016/j.carbpol.2020.116111 (Altaf F, Batool R, Gill R, Shabir MA, Drexler M, Alamgir F, Abbas G, Sabir A, Jacob KI. Novel N-p-carboxy benzyl chitosan/poly (Vinyl alcohol/functionalized zeolite mixed matrix membranes for DMFC applications. Carbohydr Polym. 2020;237:116111. doi: 10.1016/j.carbpol.2020.116111).