American Journal of Applied Science and Technology

VOLUME Vol.05 Issue 06 2025
PAGE NO. 97-100
DOI 10.37547/ajast/Volume05Issue06-22

Physicochemical Properties of Carboxymethyl Chitosan and Its Application in The Chemical Industry

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Received: 25 April 2025; **Accepted:** 21 May 2025; **Published:** 23 June 2025

Abstract: This article discusses the synthesis of carboxymethyl chitosan from various molecules. The mass of chitosan, including low mass, has been determined in multivariate tests and averages 50–190 kDa, with a median size of 210–300 kDa and higher. Regarding antioxidant and moisturizing properties, carboxymethyl chitosan improved water solubility by 96%, 90%, and 89%, respectively. Natural chitosan resulted in the enhancement of the viscosity properties of carboxymethyl with higher molecular weight. As for the antioxidant properties, the radical scavenging activity values were 1.70 and 1.37 mg/mL, and thus the molecule had high antioxidant radical scavenging properties. Distilled water, propylene glycol, and pure Chitosan of three molecular weights have lower solubility and weaker antioxidant activity than carboxymethyl.

Keywords: Selectivity, hyaluronic acid, titrimetry, viscometry.

Introduction:

Chitosan is generally a compound with very low toxicity, high biodegradability, various wound healing, antibacterial, and gelling properties. Chitosan is an inexhaustible material with many applications not only in the chemical industry, but also in the cosmetic, pharmaceutical, and food industries. Now, it is even penetrating the biotechnology industry. The use of chitosan is limited due to its neutrality and insolubility in solutions. Therefore, increasing the solubility of chitosan is a priority, as it is convenient for many applications in both the chemical and agricultural industries and has a high level of suitability. Carboxymethyl chitosan is a chemical modification that improves water solubility, and its water solubility properties and applications are highly dependent on its structural properties and medium degree. The state of carboxymethylation (transition of amino acid or hydroxyl groups into each other) and the average number of hydroxyl groups substituted by carboxymethyl groups are 4 and 5, respectively, and these chitosans are obtained by alternately replacing –OH groups with –CH2COOH groups. Functional groups such as O-, N-, and N, O-carboxymethyl chitosan are formed by the reaction of chitosan with monohalogenated carboxylic acids. This substance, namely the carboxychitosan compound, is very convenient to use in combination with temperature, and the fact that it combines various properties, which makes it very convenient to use different reaction conditions to control the selectivity of the reaction.

The antioxidant activity of chitosan carboxyl is due to the exchange of active hydroxyl and amino groups. Amino acids in polymer chains can participate in the neutralization of free radicals. Based on various currently available data, it can be assumed that the carboxymethyl compound of chitosan is a better antioxidant than the native one, and its solubility in various solutions is higher. Chitosan, especially in terms of its ability to reduce acidity and superoxide oxidizing properties, can demonstrate the ability to chelate radicals as well as iron ions in solutions. On the other hand, natural chitosan compounds are associated with the ability of chitosan to absorb moisture and retain it. It has been found that moisture content increases with decreasing absorption capacity. Chitosan is known to improve moisturizing properties. Carboxymethyl chitosan has a high water-retaining capacity.

The ability of carboxymethylcellulose to retain water, combined with its positive electrical charge and high molecular weight, makes it widely used. When applied to the skin, it moisturizes it very effectively. Carboxymethyl chitosan solution is comparable in water-holding capacity to 20% propylene glycol. The compound, with a viscosity equivalent to hyaluronic acid, retains moisture perfectly. In addition, it can be seen that the ability of carboxymethyl chitosan to absorb and retain moisture is significantly improved by using highly active 3d metals with the presence of intermolecular hydrogen bonds within the molecular chains. The resulting gel was formed by adding carboxymethyl chitosan as a moisturizing agent. The cosmetic is also ideal for the skin, and the positive feedback from customers who use it has led to even wider use of this substance.

In cosmetics, humectants are used to increase the water content of the upper layers of the skin. The activity of carboxymethyl chitosan as a wetting polymer depends on the cationic charge, molecular weight, and hydrophobicity of the polymer. Positively charged ions help neutralize negatively charged ions in the skin. Carboxymethyl chitosan was effectively synthesized and characterized by FTIR spectroscopy. Changes in biological properties, including water solubility, antioxidant properties, and moisturizing efficiency, were evident. Carboxymethyl chitosan reduced antioxidant properties but provided more pronounced moisturizing properties. Carboxymethyl chitosan improved water solubility by about 89% compared to chitosan. Its height is also determined by various methods. The wetting effect was maximum, and the same effect was observed when 0.5% carboxymethylene was applied to pig skin, and it was found to be an effective water-soluble polymer. It is a high-viscosity stabilizer that can be successfully used as an emulsion in pharmaceuticals and cosmetics, and is currently classified as a thickener. It is advisable to further study this biopolymer for its effect on the skin, determine its composition, and then use it. Deacetylation of chitin yields chitosan, a widely studied polymer for pharmaceutical and non-pharmaceutical applications. According to these applications and information from various sources, the limiting factor in the use of this compound is the solubility of carboxymethyl chitosan. Carboxymethyl chitosan helps overcome this obstacle due to its good solubility in water. Although there are many studies related to carboxymethyl chitosan, it is worth taking a closer look at the data on this topic and addressing this limitation. Therefore, this article attempts to highlight the latest research results regarding the synthesis, characterization, and application of carboxymethyl chitosan, especially in the pharmaceutical field. Carboxymethyl chitosan was synthesized by methods such as direct alkylation, reductive alkylation, and Michael addition, and this material was thoroughly characterized down to the nanoparticle level using FTIR, NMR spectroscopy, DSC, titration, viscometry, gel permeation chromatography, X-ray diffraction, and capillary zone electrophoresis.

The carboxyl group may be present on the O or N atom or on both atoms of the chitosan molecule. Carboxymethyl chitosan has modulated physical and biological properties such as chelation, sorption, moisture retention, antioxidant activity in cells, antibacterial, and antiapoptotic properties etc. Carboxymethyl chitosan is used for delayed or controlled drug delivery, pH-dependent drug delivery, DNA delivery as a permeation enhancer, etc. Carboxymethyl chitosan can be modified by alkylation, grafting, and other methods. Carboxyalkylation of chitosan leads to the formation of carboxyethyl- and carboxybutylchitosan. These analogs of carboxymethylchitosan have proven useful in justifying the use of chitosan. To obtain carboxymethyl chitosan, Chitosan was reacted with monochloroacetic acid under alkaline conditions. Sodium hydroxide (NaOH) chitosan ratio, time, and molar ratio are used to evaluate the effect of monochloroacetic acid on the chitosan reaction yield and the properties of carboxymethyl chitosan in full-factorial core composite structures. An optimization strategy based on response surface methodology in combination with groups that perform the desired function is used to optimize this process. The presence of carboxymethylation was confirmed by FTIR and NMR spectroscopy. The optimal conditions for the carboxymethylation process were 12.4, 10.6 h, and 5 min for the molar ratio of sodium hydroxide (NaOH) to chitosan and monochloroacetic acid chitosan, respectively. Under these optimal conditions, carboxymethyl chitosan with DS^{-} 1.86 and solubility of 99.6% can be obtained. X-ray diffraction and thermogravimetric analysis showed that the crystallinity and thermal stability of the derivatives are lower than those of chitosan, which leads to a decrease in carboxylation with an increase in DS^{-}. Today, alcohols and oxidizers are widely used as antiviral agents for antiviral disinfection, i.e., specific gene products that create reliable protection against viral invasion.

However, these compounds are environmentally unfriendly, have a short lifespan, and may cause various health problems. Therefore, this study aims to develop metal-free and eco-friendly quaternary chitosans with excellent long-term virucidal activity. To evaluate this, mono- and dicarboxymethyl chitosans were prepared using the quaternary structures [2-acryloyloxyethyl] -trimethylammonium chloride and glycidyltrimethylammonium chloride. This study further examined the influence of quaternary functional group, charge density, and molecular weight on antiviral properties. It was suggested that high charge density, length of alkyl linkers, and hydrophobic interactions influence the complex membrane activity of carboxymethyl chitosan, which prevents viral entry into the cell. Data from various sources have shown that heterogeneously functionalized Chitosan exhibits excellent antioxidant activity against both the enveloped virus ph6 and the more complex viruses phX174 and MS2. These tetrahedral chitosan derivatives are used as effective antiviral agents, hand and surface disinfectants, and in other biomedical applications. Significant progress has been made in the development of chitosan production technologies in the chemical industry. Therefore, the use of carboxymethyl chitosan in the cultivation of insects and fungi (insect biotechnology), as well as in the fermentation processes of fungi, is one of the new achievements in this field. These new sources not only confirm the existence of a new source of chitosan, but also prove that chitosan has one of the excellent properties that can be easily and safely used in food, medicine, and pharmaceuticals.

These existing sources are used in the national economy to overcome the difficulties often encountered when using chitosan compounds obtained from marine organisms, and, at the same time, being a by-product of the food industry. The observation that different degrees of deacetylation and molecular weight of chitosan have a significant effect on its properties and hence on its function, especially in tissue engineering, expands the possibilities of its adaptation to specific applications, and the rapidly growing demand for chitosan in connection with the wound healing process, the expansion of its properties, synthesis methods and the increase in the number of synthesized compounds, methods of chemical modification and adaptation of its properties greatly expand the scope of chitosan. Although marine crustaceans are mainly used in the food industry, chitosan is obtained from fungi and insects. Carboxymethyl chitosan is becoming an increasingly important raw material due to its obvious availability, which will continue in the future. Chitosan will be an important strategic raw material of the future.

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