

Study of the Parameters Affecting the Viscosity of Chitosan Solutions

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Summary: The temperature and storage time dependence of the viscosity of chitosan in a number of solvents (formic, acetic and propionic acids solutions) was determined. The temperature effect was studied over a temperature range of 20 °C to 50 °C while the storage time effect was examined at room temperature for a duration ranging between one to four days. The effect of chain length of the solvents on the viscosity of chitosan solutions was also investigated. Remarkable change in the viscosity of chitosan solutions was observed by varying the temperature, storage time and chain length of the solvents thus concluding that in the suitable design of experimental conditions these parameters play a vital role.

Introduction

Chitosan, a linear 1 → 4 linked 2-amino, 2-deoxy, β -D - glucan, is a fully N-deacetylated product of chitin [1, 2] which is the most abundant natural polymer on earth after cellulose [3]. Chitosan is a multifunctional polymer as it has more than one functional group in its chain such as the primary and secondary hydroxyl groups as well as the amino group. Due to the presence of the amino group, chitosan can be dissolved in some dilute organic acid solutions [4] for example formic acid and acetic acid. Due to its unique properties such as biodegradability and non-toxicity, chitosan has wide applications in many fields such as medicine [5-8], wastewater treatment [9, 10], agriculture [11] and tissue engineering [12, 13]

Viscosity of aqueous chitosan solutions has been the subject of research by many researchers [14, 15]; however, whether or how it is affected by the temperature is rarely mentioned elsewhere in the literature.

In this study, the influence of temperature, storage time and length of carbon chain of the solvent on the viscosity of chitosan solutions is reported.

Results and Discussion

Fig. 1 shows the variation of relative viscosity of chitosan solutions with temperature. As the temperature increases, the viscosity decreases or *vice versa*. This is true for all the three acids studied.

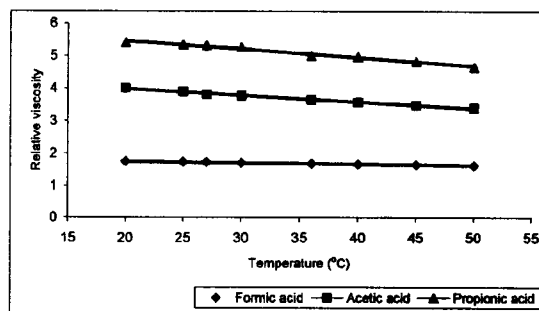


Fig. 1: Effect of temperature on Relative viscosity of chitosan-acid solutions.

However, chitosan in propionic acid is the most affected by the temperature while chitosan in formic acid is the least affected solution. These results were different from our hypothesis where we expect chitosan in propionic acid solution would be the least affected by temperature as it has highest viscosity among the three acids. This effect is more evident when the kinematic viscosity is plotted versus the temperature (Fig. 2).

The effect of storage time on chitosan in the three solvents was examined at room temperature. Storage time seems to play a crucial role in viscosity of acidic solutions of chitosan. This is clear from Fig. 4, where the viscosities of chitosan solutions drop to about 98 % for all the three organic acids within one day. Similar results were obtained, when the storage period was further prolonged.

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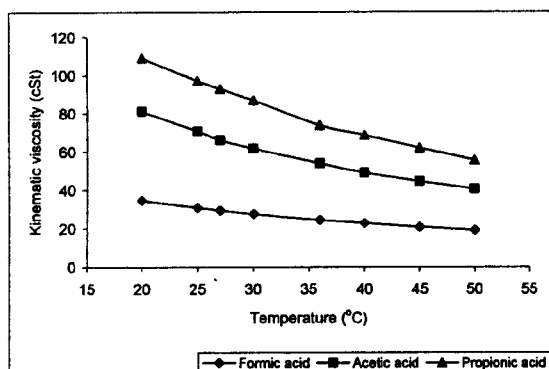


Fig. 2: Effect of temperature on Kinematic viscosity of chitosan-acid solutions.

The decrease in viscosity of chitosan solutions observed over the storage time may be due to degradation of chitosan by organic acid solutions [16]. Also, it has been reported that the degradation causes a reduction in the degree of structurization of

solutions and its viscosity, which in turn leads to the dilution of solution during storage [17].

However, chitosan in formic acid solution remained almost unchanged. The decrease in viscosity with increasing time is attributed to the hydrolysis process that occurs in acidic solutions. The hydrolysis of *O*-glycosidic and *N*-acetyl linkages of chitosan in acidic solutions has been studied and published [18]. Chemical equations related to this process, taken from the reference 18 are given in Fig. 3.

The effect of chain length of the organic acids on the viscosity of chitosan solutions is presented in Fig. 5. As the carbon number increases the viscosity also increases. This may be due to the chain entanglement between the macromolecular chains when chain length increases, therefore, the motion of the individual chains gets restricted with increasing number of entanglements.

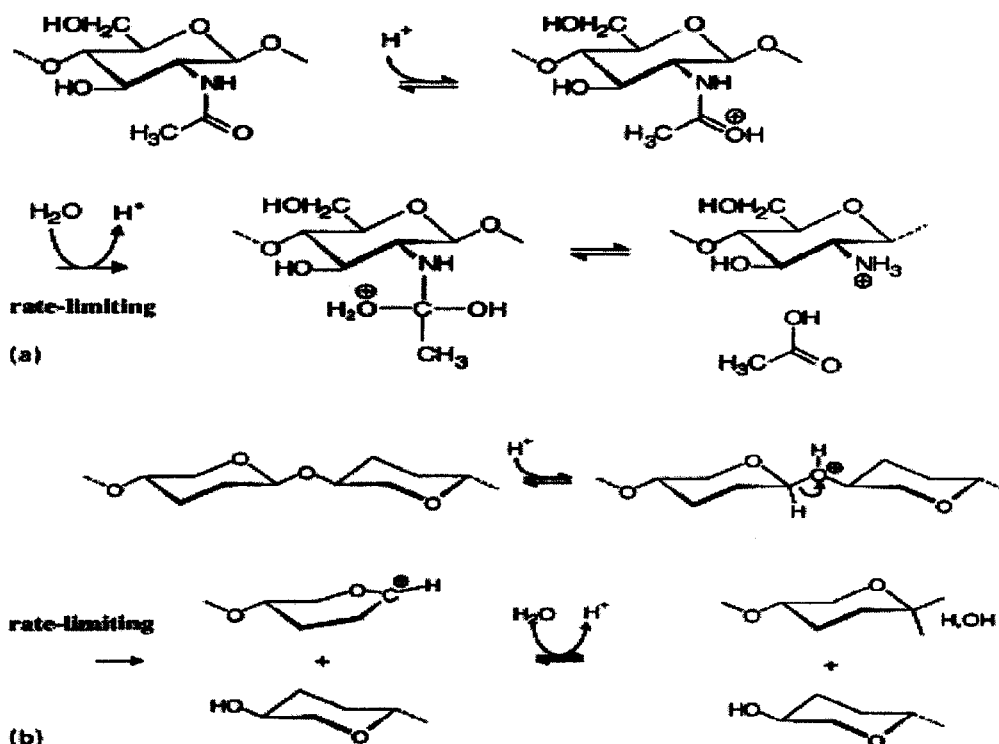


Fig. 3: Schematic illustration of the proposed reaction mechanisms for the acid-catalyzed hydrolysis of the *N*-acetyl linkage and the glycosidic linkage in chitosans. (a) Hydrolysis of the *N*-acetyl linkage (S_N2 reaction). (b) The most widely accepted mechanism for hydrolysis of the glycosidic linkage (S_N1 reaction) c.f [18].

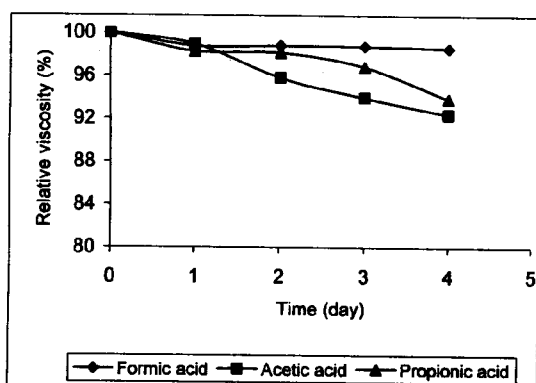


Fig. 4: Effect of storage time on the relative viscosity of chitosan-acid solutions.

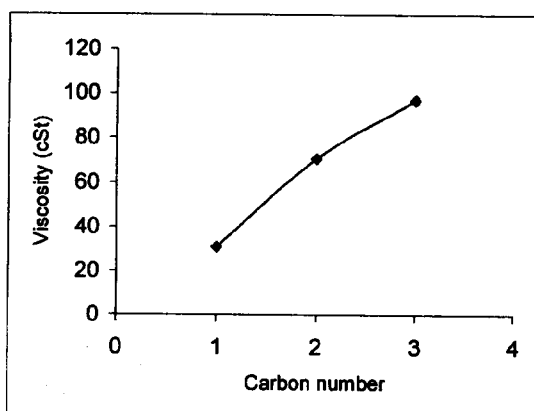


Fig. 5: Effect of carbon number in some organic acids on the Viscosity of chitosan solutions at 25 °C.

Experimental

Shrimp source chitosan (80-85 %) was provided by the chitin-chitosan laboratory of University Kebangsaan Malaysia (U K M). Acids used were 98-100 % formic acid, 99.5 % acetic acid and 98 % propionic acid. Distilled water was used to prepare all solutions and all samples were freshly prepared. The temperature of the water bath was measured to an accuracy of ± 0.1 °C.

A 0.4 g L⁻¹ solution of chitosan was prepared by dissolving 0.02 g chitosan in 50ml (0.1M) of each

organic acid solvent mentioned earlier. This was followed by continuous stirring and heating overnight.

The viscosity was measured with Ubbelohde type viscometer. The flow time was recorded automatically using a viscoclock (Schott ViscoClock). Every value was taken as an average of about 3 measurements.

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