

Salt tolerance (S) and Relative Stiffness Parameter (B) of *Acacia nilotica* var. *nilotica* Gum

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Abstract

Three samples of *Acacia nilotica* var. *nilotica* gum was subjected to comparison study of salt tolerance and stiffness parameter with chitosan nitrate and chitosan chlorhydrate. The results showed that two of samples have semi-stiff backbone with lower persistence length; the third sample has stiff backbone with higher persistence length.

Keywords: Salt tolerance, Intrinsic viscosity, *Acacia nilotica* var. *nilotica* gum, stiffness parameter

Introduction

Salt tolerance is a property that is related to the stiffness of polymer chains. The more flexible the chain, the higher the response, as observed from intrinsic viscosities, to changing ionic strengths (Anthonsen. M.W. et al 1993). Based on this fact, Smidsrød and Haug (1971) suggested an empirical parameter, B , that provides a relative measure of chain stiffness of polyelectrolytes. A necessary and useful feature of B is that it is independent of molecular weight, so that the comparison with polyelectrolytes of different chemical structure is possible. Also, B is estimated without molecular weight determinations. Smidsrød and Haug concluded that within a relatively broad range of stoichiometric charge densities, B was solely dependent upon chain stiffness. Smidsrød and Haug proposed that the salt tolerance parameter (S) can be determined from the slope of $[\eta]$ at various ionic strengths vs. the inverse square root of ionic strength ($I^{-0.5}$) plot according to the following equation:

$$[\eta] = [\eta]^\infty + S \cdot I^{-0.5} \quad (1)$$

Where $[\eta]^\infty$ is the intrinsic viscosity at infinite ionic strength. The relative stiffness parameter (B) was then obtained from the intercept of a double logarithmic plot of the salt tolerance vs. the intrinsic viscosity at an ionic strength of 0.1 M ($[\eta]_{0.1}$) according to the following equation:

$$S = B \cdot ([\eta]_{0.1})^\nu \quad (2)$$

Where ν was found to vary only in a narrow range (1.2–1.4) for most polyelectrolytes (Lapasin & Pricl, 1995). And an average value of 1.3 is widely used.

Low values of B are associated with stiff polymer backbones and vice versa.

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Another stiffness index that is commonly used is the persistence length q , which is a measure of the length over which the chain persists' in the direction of the first bond of the chain. The persistence length is related to the stiffness parameter B by the expression proposed by (Smidsrød and Christiansen 1991), (Mohammadifar, M.A. et al 2006).

$$q = 0.26/ B \quad (3)$$

Higher rigidity of the polyelectrolyte chain implies higher persistence length (Cristóbal., L. V. et al 2008).

This method is very simple and easy to use, and the chain stiffness parameter B can be estimated only from the intrinsic viscosity data. A number of studies showed that Smidsrød 'B-value' method is accepted widely, and even applicable to characterize biopolymers such as xanthan, hyaluronate, pectin, alginate, and cellulose derivatives. (Xiaojuan. X. et al 2009). From these examples, it can be seen that this 'B-value' method is not only applicable to homopolymers but also to heteropolymers.

Materials

Acacia nilotica var *nilotica* gum samples used in this study (A, B, D) were dried under shade and cleaned to remove any impurities such as bark and leave fragments and the cleanest nodules were selected and made into fine powder using mortar and pestle then kept in self-sealing polyethylene bags.

Gum samples were dissolved in different concentrations of sodium chloride.

Sodium chloride (99.9 > %) was obtained from Fisher Scientific UK. Distilled water (Bibby Merit W4000) was used for experiment.

Methods

Intrinsic viscosity was determined using Cannon- ubbelohde semi- micro dilution type viscometer (75 N 94). Gum sample was dissolved in 0.2M NaCl solution to give solution with concentration of 4%. The solution was filtered through whatman cellulose nitrate membrane filter paper 0.8 μ m into clean container. The viscometer was cleaned by washing with distilled water and dried in acetone. The viscometer was immersed in a water bath adjusted at 25°C \pm 1 and left to attain equilibrium. The efflux time of solvent and that of the test solution was measured by inserting exactly 2 ml in to the reservoir of the viscometer using glass pipette. The test solution in the viscometer was successively diluted by adding 0.3, 0.4, 0.5, 0.8, 1.2 and 1.8 ml of solvent and the efflux time of the diluted solution was measured. The readings were taken in duplicate using an accurate millisecond timer. The same method was repeated using 0.5M NaCl, 0.1M NaCl, 0.05M NaCl, 0.01M NaCl , 0.005M NaCl. The intrinsic viscosity is, therefore, obtained by extrapolating of reduced viscosity to the value at zero solute concentration by using a linear regression.

Salt tolerance parameter (S) was determined from the slope of $[\eta]$ at various ionic strengths vs. the inverse square root of ionic strength ($I^{-0.5}$) plot. The relative stiffness parameter (B) was then obtained from the intercept of a double logarithmic plot of the salt tolerance vs. the intrinsic viscosity at an ionic strength of 0.1 M ($[\eta]_{0.1}$).

Results and Discussion:

Figure 1 illustrates the plot of the intrinsic viscosities of *Acacia nilotica* var *nilotica* gum versus the inverse square root of ionic strength of NaCl. From the intercept, $[\eta]^\infty$ was determined.

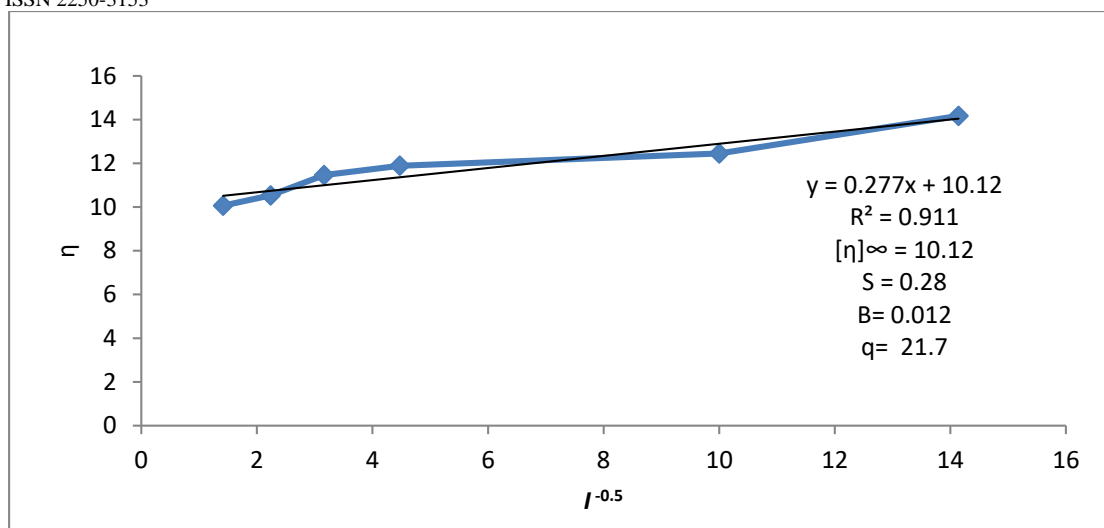


Figure 1: intrinsic viscosities of *Acacia nilotica var nilotica* gum as function of the inverse square root of ionic strength of NaCl.

Clearly, $[\eta]$ increased linearly with $I^{-0.5}$, suggesting that this ‘B-value’ method could be applicable to describe the chain conformation of *Acacia nilotica var nilotica* gum.

From the figure and data, shown in Table 1, the slope S was determined and the stiffness parameter B was then calculated based on the relationship defined by Eq. (2). The value of B for the three samples of gum was reported. The persistence length (q) was calculated using Eq. (3), it was calculated in the range of 21.7- 32.3 nm.

Table 1. Comparative values of salt tolerance, stiffness parameter, persistence length and intrinsic viscosity at infinite ionic strength estimate through Smidsrød’s approach for studied *Acacia nilotica var nilotica* gum samples

Sample	$S \text{ cm}^3 \text{M}^{1/2} \text{g}^{-1}$	B-value	q	$[\eta]^\infty \text{ cm}^3 \text{g}^{-1}$
A	0.28	0.012	21.7	10.12
B	0.25	0.010	26.0	11.45
D	0.18	0.008	32.5	10.84

The values were estimated for *Acacia nilotica var nilotica* gum were found to be different from Smidsrød’s approach that was employed to estimate the stiffness parameter of chitosan nitrate and chitosan chlorhydrate in acid free NaCl aqueous solution, The B -values for both salts were found 0.120 and 0.084 for chitosan nitrate and chitosan chlorhydrate, respectively (Cristóbal L. V. et al 2008). Table 2 shows the results that were obtained from viscosimetric studies of chitosan nitrate and chitosan chlorhydrate.

Table 2. Values of salt tolerance, stiffness parameter, and intrinsic viscosity at infinite ionic strength for chitosan nitrate and chitosan chlorhydrate

Chitosan salt	$S \text{ cm}^3 \text{M}^{1/2} \text{g}^{-1}$	B-value	$[\eta]^\infty \text{ cm}^3 \text{g}^{-1}$
chitosan nitrate	1.38	0.120	2.18
chitosan chlorhydrate	0.83	0.084	3.21

The resulting *B*-values of chitosans with different degrees of N-acetylation (Anthonson M.W 1993), also found to be different from the values of *Acacia nilotica* var *nilotica* gum. The higher N-acetyl content has 0.02 value of *B* and the lower N-acetyl content has 0.1 value of *B*, indicating that a higher N-acetyl content increases the stiffness of the chain.

Table 1, illustrate the *B*-values of A and B were in the range values of the tragacanthin (the water-soluble part of gum tragacanth), which was found to be 0.013, which is lower than that of several polysaccharides indicating the stiff backbone for tragacanthin. (Mohammadifar, M.A. et al 2006).

Also *B*-values of A and B were in the range values of the heteropolysaccharide *Erwinia* gum (EG) fractions (Xiaojuan.; X. et al. 2009). As shown in Table 3, (EG) fractions were found to be higher than those of xanthan, one double helical stiff polysaccharide (Tinland, B. et al 1989), but much lower than those of flexible carboxymethylamylose (Launay, B. et al 1986), and close to those of semi-stiff biopolymers, for example, carboxymethylcellulose (CMC) and alginate (Tobitani, A. et al 1997) indicating that EG also has semi-stiff backbone.

Table 3. *B*-values of (EG fractions) and different polymers with various conformations (Xiaojuan. X et al. 2009).

Sample	B-value	Conformation	Source
EGF-1	0.028	Semi-stiff	Ref. 10
EGF-2	0.036	Semi-stiff	Ref. 10
EGF-3	0.045	Semi-stiff	Ref. 10
EGF-4	0.033	Semi-stiff	Ref. 10
CMC	0.043	Semi-stiff	Ref. 9
Alginate	0.032	Semi-stiff	Ref. 9
Aeromonas gum	0.076	Semi-flexible	Ref. 11
Carboxymethylamylose	0.2	Flexible	Ref. 4
Xanthan	0.00525	Stiff	Ref. 8

This prediction indicating that A and B have semi-stiff backbone with lower persistence length. The *B*-value for the last sample D was found to be in the range of xanthan, indicating that this sample has stiff backbone with higher persistence length.

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