Journal of Macromolecular Science, Part A
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713597274

Studies on Albizia zygia Gum. I. Chemical Properties and Viscosity of Its Aqueous Solution

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To cite this Article Kumsah, C. A. and Oghene, S.(1981) 'Studies on Albizia zygia Gum. I. Chemical Properties and Viscosity of Its Aqueous Solution', Journal of Macromolecular Science, Part A, 15: 2, 231 — 239
To link to this Article: DOI: 10.1080/00222338108066443
URL: http://dx.doi.org/10.1080/00222338108066443

J. MACROMOL. SCI.–CHEM., A15(2), pp. 231-239 (1981)

Studies on Albizia zygia Gum. I. Chemical Properties and Viscosity of Its Aqueous Solution

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ABSTRACT

The sparse literature on Albizia zygia (D.C.) Macbride is briefly reviewed. The nature of the gum particles when in aqueous suspension is discussed. The viscosity of the solutions increases with concentration, but at concentrations greater than 2% the solution gelled. At low concentration (i.e., below 1%) the solutions exhibit ideal Newtonian behavior but above this concentration the solutions exhibit non-Newtonian behavior. The gum behaves like gum ghatti and sodium alginate in its interaction with sodium chloride and magnesium chloride, the viscosity decreasing with increasing concentration of these electrolytes. For Albizia zygia Grade I variety, the viscosity increases with increasing magnesium chloride concentration, reaching a maximum and then falling off at higher magnesium chloride concentrations. The acid gum shows reserve acidity in its interaction with acids.

INTRODUCTION

Albizia zygia is one of the many gum exudates obtained from trees which are widely available in West Africa. The genus Albizia (family Leguminosae, subfamily Mimosoidaea) contains 100 to 150 species [1]. The exudate used in the present investigation was obtained from Albizia zygia (D.C.) Macbride, also known as Albizia brownei (Walp.) Olive or West African Walnut. Chemical analysis of the gum by Drummond and Percival [2] reveals the presence of L-arabinose, D-galactose, D-glucuronic acid, D-mannose, 4-O-methyl-D-glucuronic acid, and L-rhamnose in the approximate ratio 6:4:2:1:5:1:trace. A partial structure has been proposed consisting of a main chain of 1→3 D-galactose units, with also some 1→6 linked D-galactose units. L-Arabinose, linked through the C_3 position, is also known to be a major structural component, but its position and the positions of the other sugar residues have not been determined. However, contrary to the data of Drummond and Percival, Ashton [3] found no 4-O-methyl-D-glucuronic acid.

The object of the present investigation was to examine the behavior of the gum when dissolved in water and how the aqueous solution of this gum changes with progressive dilution of the system. The scope of this study extends to the examination of the variation of viscosity and pH at different dilutions, and the effect of electrolytes on the solution of this gum.

EXPERIMENTAL

Preparation of the Gum Solutions

The gum samples used in this investigation were procured directly from plants and therefore contained impurities in the form of bark and leaves of the plant, dust, etc. When powdered gum was mixed with water, there was a tendency for clumps with gelatinous membranes to form which prevented the water from coming into contact with the interior. The gum was therefore dissolved by keeping it in contact with water for about 6 to 10 hr. As decantation was not possible, the impurities were removed by filtering through a single-fold linen. Alcohol precipitation of the gum rendered the resultant product insoluble in water. The filtered gum solution was used as such for the experiments. For sodium alginate, solutions were prepared by dissolving a weighed amount in a known volume of water since the gum was readily soluble in water. For gum ghatti, large particles of the tree were seen in the solution and it was necessary to filter the solution through a single-fold linen.

Methods of Measurement

The concentrations of Albizia zygia and gum ghatti were obtained by indirect means. This was done by drying a known volume of the gum solution in a beaker to a constant weight in an oven kept at 120°C. The weight of the gum in a known volume of the solution was projected to obtain the weight of the gum in 100 mL of the solution. Measurements were carried out at room temperature (28°C). All chemicals used were of BDH Analar quality. The viscosity of the gum solutions were obtained by the use of a Ferranti Portable Viscometer, Model VL. The pH values of the solutions were obtained by using a direct pH meter (Model 23A).

RESULTS AND DISCUSSION

Analyses of samples of powdered Albizia zygia show a moisture content of 9.60 to 12.31% and an ash content of 5.28 to 5.72%. The aqueous solutions have an acid reaction (pH 4.6). Albizia zygia gives a blue-black color with iodine solution, similar to tragacanth but different from karaya gum [4]. Millon's reagent gives a deep red coloration when added to a solution of the gum, a reaction which distinguishes it from karaya [4] which gives a white curdy precipitate. Other gums give precipitates of different appearances. A purple ring was obtained at the interface between α-naphtol solution and the gum solution. When a solution of the gum was boiled in dilute phosphoric acid under a reflux condenser, an orange solution with a yellow gelatinous precipitate was obtained.

Viscosity

The results of relative viscosity measurements are represented graphically in Fig. 1. The curve for Albizia shows that the relationship is not linear. At higher concentrations the curve runs convex toward the concentration axis, which signifies that the viscosity increases much more rapidly than the concentration. The mode of increase of relative viscosity at higher concentrations, as observed here, has been regarded by Kruyt and Tendeloo [5] as a characteristic feature of all lyophilic colloids.

The change of viscosity with shear rate (Figs. 2a and 2b) indicates shear-thinning behavior above concentrations of 1.0%. The variation of viscosity with concentration at a constant shear rate is shown in Fig. 3. Corresponding results for gum ghatti and sodium alginate are shown for comparison. The viscosity of Albizia zygia (Grades I and II) solutions is appreciably greater than the viscosity of gum ghatti solutions, and shows resemblance to the viscosity of sodium alginate.

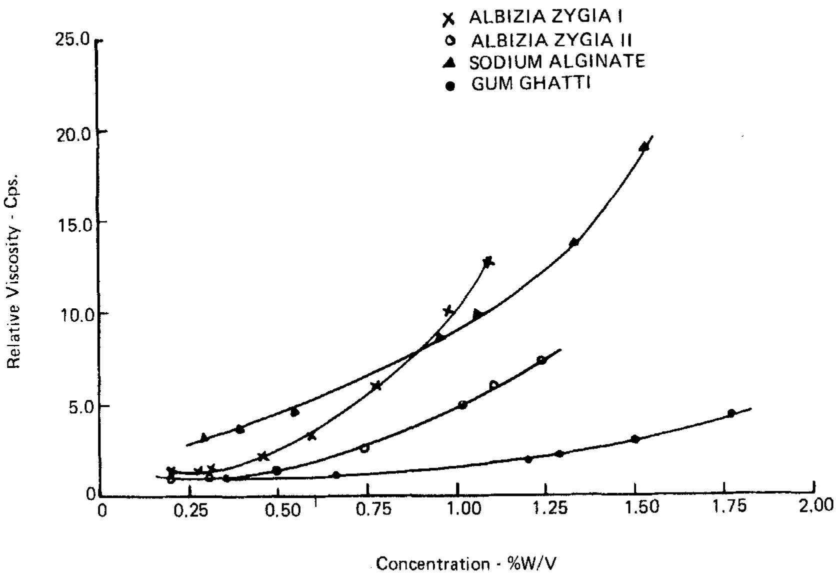

FIG. 1. Relationship between relative viscosity and concentration.

The effect of electrolytes $MgCl_2$ and NaCl on the viscosity of Albizia zygia is shown in Figs. 4 and 5. The results for sodium alginate and gum ghatti are also shown. The results show that neither NaCl or $MgCl_2$ has any appreciable effect on sodium alginate. For lower concentration of $MgCl_2$ solutions (0.3 M), the viscosity of Albizia zygia Grade I increases; above this concentration the viscosity decreases. NaCl of all concentrations decreases the viscosity of Albizia zygia moderately. Both NaCl and $MgCl_2$ decrease the viscosity of gum ghatti, but the effect is more marked with $MgCl_2$.

Buffering Properties

pH values of six different concentrations of Albizia zygia are shown in Fig. 6. The pH appears not to change very much although the concentration change was as much as 400%. This is very suggestive of the fact that the gum probably has an inherent buffering property. This point was further examined by the addition of increasing quantities of the gum to a fixed quantity of HCl solution and noting the changes in pH produced. For this reason 10 mL of HCl solution (~M/50) was taken and increasing volumes of the gum solution were added to it. The final volume of the mixture was made up to 20 mL with water. A control experiment was performed by mixing 10 mL

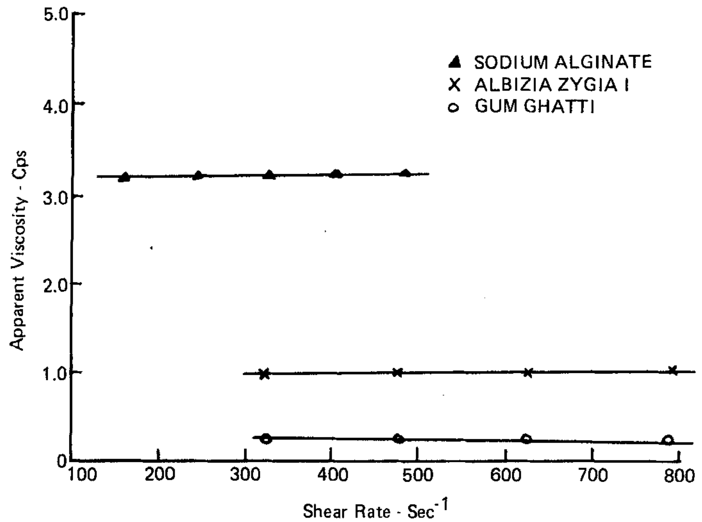

FIG. 2a. Relationship between apparent viscosity and shear rate for Albizia zygia I (0.09%), sodium alginate (0.33%), and gum ghatti (0.07%).

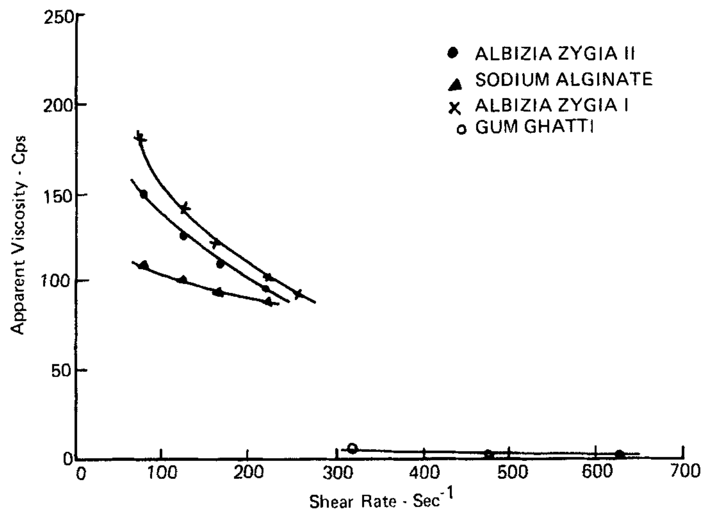

FIG. 2b. Relationship between apparent viscosity and shear rate for Albizia zygia I (2.16%), Albizia zygia II (3.95%), sodium alginate (3.66%), and gum ghatti (2.29%).

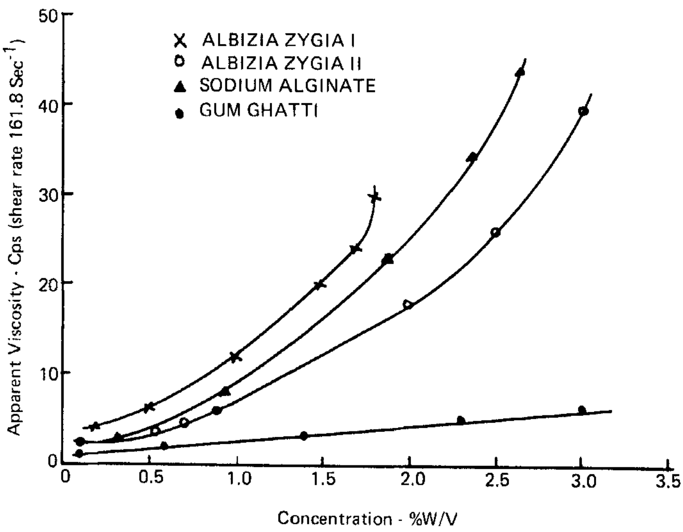

FIG. 3. Relationship between apparent viscosity and concentration.

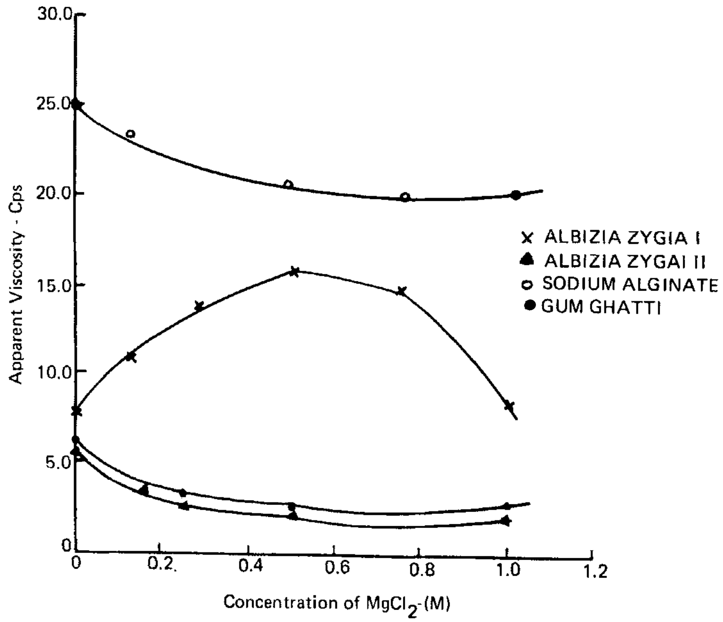

FIG. 4. Effect of Mg^{2+} ions on the apparent viscosity.

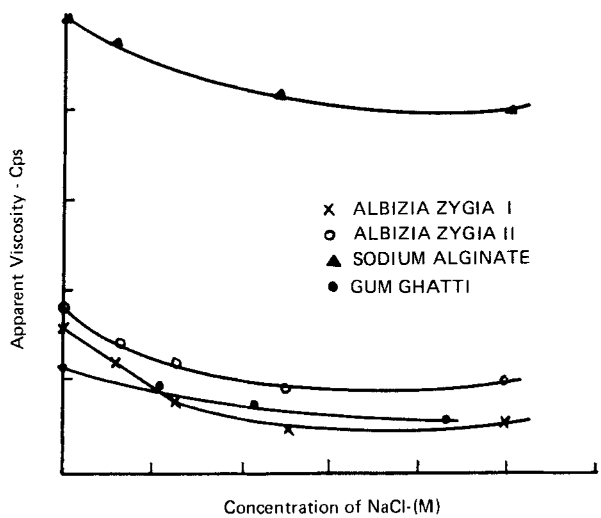

FIG. 5. Effect of Na^+ ions on the apparent viscosity.

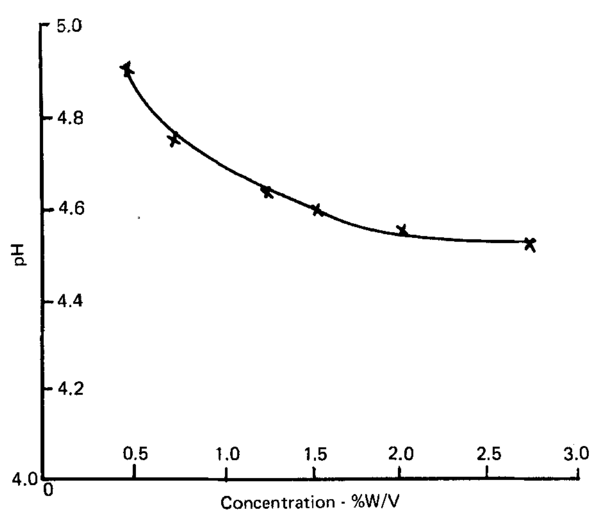

FIG. 6. Variation of pH with concentration for Albizia zygia II.

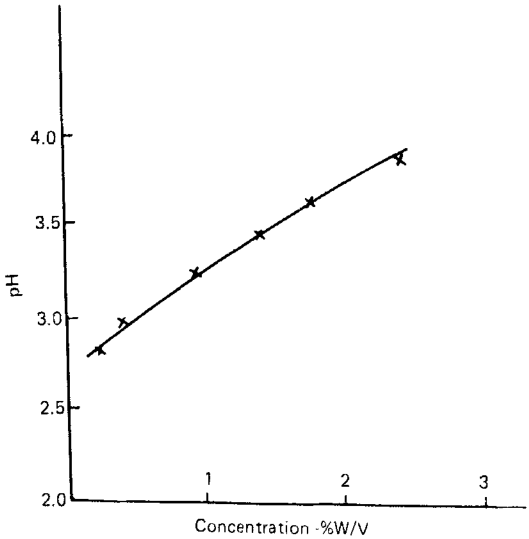

FIG. 7. Variation of pH with concentration for Albizia zygia II.

of HCl solution with 10 mL of water. The control was observed to have a pH of 2.70. The results of this series of experiments are graphically represented in Fig. 7 from which it is evident that the pH of the HCl solution gradually increases with the addition of increasing quantities of the gum.

Such large changes in the activity of H ions cannot be wholly attributed to changes in the ionic strength of the solution brought about by increasing the concentration of the gum as envisaged by the Debye-Huckel interionic attraction theory. The buffering properties of the gum can therefore be understood in the light of the H-ion reserve which is set up as the concentration increases. Regarding the mechanisms as to how and where these hydrogen ions are retained by the gum molecules, the problem appears to await further experimentation.

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Accepted by editor October 19, 1979
Received for publication November 13, 1979