

Rheological Modeling of Interaction Existing between Synergistic Combination of Gum Arabic and *Khaya senegalensis*

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Authors' contributions

This work was carried out in collaboration between all authors. Authors DEA, EON designed the study and wrote the protocol. Authors CEG, DEA and AIS performed the statistical analysis, managed the literature search and wrote the first draft of the manuscript with assistance from authors LM and AA. Both authors DEA and EON read and approved the final manuscript.

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ABSTRACT

An Ubbelohde viscometer was used to study the miscibility properties of *Khaya senegalensis* (KS gum) and *Acacia senegal* (AS gum) blends in dilute solution when the blends were subjected to temperature rise, increase in concentration and as well as on effect of some inorganic salts. The intrinsic viscosity and the elasticity of the gums were evaluated. Molecular conformation of the blend AS-KS was also assessed by the power law and 20% AS–80% KS blend was found to exhibit the strongest attraction between Khaya gum and gum Arabic molecules since the blend had the highest value of intrinsic viscosity value determined, while 60% AS–40% KS blend had the least

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attraction as evidenced by the polymer miscibility coefficient a , the elastic component and a positive Huggins coefficient K_m found to be less than one, which indicates absence of aggregation in the blend. The power-law model was successfully employed in the predicting the molecular conformation of AS and KS in dilute solution as they were found to have random coil conformation. Their hydrodynamic interaction value bm_1 indicates that the blends become more soluble in water when more concentration of gum Arabic is added to the blends. The power-law coefficient b was found to have an indirect relationship with a rising addition of the KS fraction in the blends, suggesting a more flexible AS-KS complex dependent on KS. FTIR and other analysis were carried out, these includes rheological study on the gum with corresponding effects from increased temperature and effects of salts.

Keywords: Gums; blends; rheology; intrinsic viscosity; polymer interaction.

1. INTRODUCTION

Gums are exudate products of plants formed by a breakdown of cell walls to give exudates of complex carbohydrate derivatives of a polysaccharide nature following injury to the plant or as a result of unfavorable conditions, such as drought [1]. They are principally soluble in water as in the case of gum *Arabic*, while some others form mucilages by the absorption of large amounts of water (gum tragacanth). There are mostly used in foodstuffs because of their ability to impart desired qualities to foods and soft drinks by altering their viscosity, body and texture. They also used in pharmaceutical as demulcents, adhesives in pill manufacture and its industrial applications in corrosion inhibitors, paints, inks and as emulsifying agents. The use of gum exudates and gums extracted from plants have been in high demand in the international market, due to the wide lucrative possibilities for industrialization, example being *Gum Arabic* which in Current production potential is around 30,000 to 40,000 tonnes per annum, of which bulk (80%) originates in Sudan.

Khaya gum are found in nature as a long glass-like translucent fragments protruding from injured parts of a tree. The gum is brownish in colour and has been reported to contain highly branched polysaccharides consisting of D galactose, D-galacturonic acid, L-rhamnose, and 4-O-methyl-D-glucuronic acid [2]. Studies on the physicochemical and rheological properties of some gum exudates have been carried out. Gum exudates from *Khaya senegalensis* (Family Meliaceae) plants grown in northern Nigeria have been well researched upon, the physicochemical properties such as its pH, swelling capacity and viscosities at varying temperatures were documented by [3]. It was found that *Khaya* gum has a reddish brown translucent tears and has pH of 4.2 at 28°C when 5% w/v mucilage was

tested. The gum is slightly soluble in water but insoluble in organic solvents indicating the polarity nature of the gum to be high. The results indicated that the swelling ability of *Khaya senegalensis* gum may provide potentials for its use as a disintegrant in tablet formulation.

The objective of this work was to study the rheological behaviour of the blend prepared from two natural gum exudates in dilute solution with variation in temperature, salt, concentration etc. Different intrinsic-viscosity models for the blends were used to establish any conformational change occurring within the gums using an ubbelohde viscometer.

The results in this study would reveal the relationship of temperature rise or the presence of salts added to the gum blends significantly affects the blends elastic component. These results gotten would be modeled and intrinsic viscosity established.

The gum solutions prepared were found to be Newtonian in nature and hence the results gotten was used in show casing the critical role played by the elastic component of the gums in the blend. This role may be affected by the addition of large amounts of salt, thereby affecting molecular conformational change which may coincide with an increase or a decrease in the elastic component, due to removal or addition of salts, respectively.

2. MATERIALS AND METHODS

2.1 Sample Collection

Crude *Khaya senegalensis*, (chewstick tree) gum were obtained as dried exudates from their parent trees grown at Kanya babba village in Bubura local Government Area of Jigawa State. The plant was identified, authenticated and a

voucher number 872 assigned to it in the herbarium Department of Biological Sciences of Ahmadu Bello University Zaria. The crude *Acacia senegal* gum was obtained from Falgore forest in Doguwa LGA of Kano State. The Gums along with its plant were identified at the herbarium, department of biological sciences ABU zaria.

2.1.1 Tapping of gums

The gums were collected from the plant species by tapping (Smith and Montgomery, 1959) around mid-December during the day time. A small axe was used to break the outer bark. Tapping was carried out by driving an axe underneath the bark which was pulled back until the bark broke horizontally to give two broken ends. The cut was made about 4.0 cm wide. The bark was then carefully peeled both along the length of the wounded trunk.

Gum droplets formed were 3.0 – 5.5 cm in diameter. They had dried and hardened on exposure to atmosphere.

2.1.2 Purification of the gum

The procedure used in the purification of the gums in Fig. 1, was done using the method

described by [4]. The gums were oven dried at 40°C for 2 hrs and size reduced with the use of an electronic blender. It was then hydrated in double strength chloroform water for five days within intermittent stirring to ensure complete dissolution of the gum before then filtered through a 75 µm sieve to obtain a particulate free slurry which was allowed to sediment. Thereafter, the gum was precipitated using absolute ethanol, after which it was filtered and defatted with dried flakes. The precipitate was dried in the oven at 40°C for 48 hours, before the dried flakes were pulverized using a blender and stored in an air tight container.

The study of the gums interaction within the blends were carried out by the following treatments: *Khaya senegalensis* (KS) 100%, *Acacia Senegal* (AS) 100%, KS 80%-AS 20%, KS 60%-AS 40%, KS 50%-AS 50%, KS 40%-AS 60%, KS 20%-AS 80%. Stock solutions of 1.0 % (m/v) for all the blends were stirred at room temperature after dialysis. The varying concentration of the gums need for the analysis were prepared via serial dilution. To study the effect of salt on interaction between gums, appropriate amounts of KBr, KCl and AlCl₃ were added and completely dissolved to make 0.2, 0.4, 0.6, 0.8 and 1.0-mM solutions.



Fig. 1. A photograph of dried and processed of purified plant gum exudates used

2.1.3 FTIR analysis

FTIR analyses was carried out on the gums using the Scimadzu FTIR-8400S Fourier transform infrared spectrophotometer. The sample was prepared using KBr before the analysis was done by scanning the sample through a wave number range of 400 to 4000 cm⁻¹.

2.1.4 Rheological properties

Rheological measurements were carried out at room temperature with the aid of an ubbelohde viscometer and a well calibrated thermo-stated water bath. Microsoft Excel 2013 software was used to plot the viscosities against the rising concentrations, as well as to obtain linear regression lines with their corresponding equations and correlation coefficients (R^2) needed in the assessments of the best model.

2.1.5 Determination of intrinsic viscosity

The intrinsic viscosity $[\eta]$ can be defined as a measure of the hydrodynamic volume occupied by a macromolecule, which is closely related to the size and conformation of the macromolecular chains in a particular solvent [5]. The intrinsic viscosity $[\eta]$ was calculated by measuring the viscosity of the gums at a sufficiently diluted concentration. Given that solution and solvent viscosity are represented as η_{solution} and η_{solvent} respectively.

$[\eta]$ can be determined through the following relationships:

$$\text{Relative viscosity: } \eta_{rel} = \frac{\eta_{\text{solution}}}{\eta_{\text{solvent}}} \quad (1)$$

$$\text{Specific viscosity: } \eta_{sp} = \eta_{rel} - 1 \quad (2)$$

$$\text{Intrinsic viscosity: } [\eta] = \lim_{C \rightarrow 0} \frac{\eta_{sp}}{C} \quad (3)$$

[6], reported that intrinsic viscosity can be obtained by measuring specific viscosities at different concentrations at the same shear-rate, and extrapolating the plot of specific viscosity at infinite dilution. Therefore the intrinsic viscosity $[\eta]$ was obtained by extrapolating the specific viscosities of the gums to zero concentration with the aid of a linear regression model.

[7] also reported the use of reduced viscosity ($\frac{\eta_{sp}}{C}$) in determining intrinsic viscosity, which was

later modeled in the form of a Huggins equation [8].

$$\frac{\eta_{sp}}{C} = [\eta] + K^l [\eta]^2 C \quad (4)$$

Where k^l is the Huggins constant. The determination of the intrinsic viscosity is therefore, the extrapolation of reduced viscosity to the value at infinite dilution. In addition, [7] also reported that the intrinsic viscosity could be obtained from the Kraemer equation [9] by extrapolation to very dilute concentration (C)

$$\frac{\ln \eta_{rel}}{C} = [\eta] + k^{ll} [\eta]^2 C \quad (5)$$

where k^{ll} is the Kraemer constant. For very dilute solutions, however, Eq. (5) can be reduced by retaining only the first-order term, and $[\eta]$ determined from the slope of a plot of C against $\ln \eta_{rel}$ [10]. McMillan showed that methods of determination of the intrinsic viscosity that were based on slopes of plots had higher correlation coefficients and lower standard errors, compared with those based on intercepts of plots.

[11] used the following equations to obtain the intrinsic viscosity of tomato serum:

$$\eta_{rel} = 1 + [\eta]C \quad (6)$$

The intrinsic viscosity $[\eta]$ was obtained from the slope by plotting

$$\eta_{rel} \text{ vs. } C$$

The intrinsic viscosity of the gum samples was determined when the gums were diluted in significant amount of distilled water. The gum solutions were prepared by dispersing 1 g of each of the gum sample separately in 100 ml of the distilled water at room temperature and then it was properly mixed until a uniform solution was gotten. 2 ml of solution was then transferred into a viscometer which was immersed in a precision water bath to maintain the temperature at 25.0±0.1°C and after equilibration for 10 minutes, the flow time was determined. Serial dilution was performed in situ and triplicate readings were taken for each dilution and averaged, before the relative viscosity (η_{rel}) was calculated using the equation

$$\eta_{rel} = \frac{\eta - \eta_0}{\eta_0} = \frac{C\rho t - C\rho_0 t_0}{C\rho_0 t_0} \quad (7)$$

where C and ρ in equation (7) indicate the calibration constant (viscometer) and density respectively. Subscript o stands for solvent. For a very dilute solution, the density of solution is very close to that of solvent. In that case, the relative viscosity is approximately given below as equation (8):

$$\eta_{rel} \cong \frac{t - t_0}{t_0} \quad (8)$$

Where t is the flow time of the blend solution in seconds, while t_0 is the flow time of solvent (water) in seconds.

2.1.6 Determination of the molecular conformation and polymer interaction

The power-law equation

$$\eta_{sp} = aC^b \quad (9)$$

was used to determine the exponent b from the slope of a double logarithmic plot of η_{sp} against concentration, and provide an indication of the conformation of polysaccharides [12] and based on the classical Huggins equation which expresses the specific viscosity (η_{sp}) of a polymer as a function of polymer concentration C , the equation was then expressed as

$$\frac{\eta_{sp}}{C} = [\eta] + bC \quad (10)$$

and

$$b = K[\eta]^2 \quad (11)$$

Where $[\eta]$ is the intrinsic viscosity, while b and K are Huggins parameters. [13] That for a dilute solutions, the term bC from Eq. (10) is negligible, and the plot of the specific viscosity against the concentration gives a straight line. The term b was extrapolated from the intercept of the plot of specific viscosity against concentration [14].

According to this theory, the following equation applies to a ternary polymer–polymer–solvent dilute solution, in which there is no aggregation between molecules

$$\alpha = b_m - (\sqrt{b_1}W_1 + \sqrt{b_2}W_2)^2 \quad (12)$$

Where b_m , b_1 , and b_2 are the Huggins coefficients for blend, gum 1, and gum 2, respectively. W_i is the weight fraction of polymer i in the blend ($i = 1$ or 2). The equation was used to provide a qualitative information on the gum–

gum interaction in the blends [15], that when the polymers in a blend are attractive in solution then $\alpha \geq 0$, whereas they are repulsive when $\alpha < 0$.

[16] Reported that three types of interaction contribute to the value of b_m for a ternary polymer–polymer solvent interaction, they are given below as

1. Long-range hydrodynamic interaction of pairs of single molecules:

$$b_{m1} = b_1W_1^2 + b_2W_2^2 + 2\sqrt{b_1b_2}W_1W_2 \\ = (\sqrt{b_1}W_1 + \sqrt{b_2}W_2)^2 \quad (13)$$

Where b_i is given as the Huggins parameter b for component i ($i = 1$ or 2) and W_i represents the weight fraction of polymer i in the blend.

2. The formation of double molecules or attraction between blend components can be given as:

$$b_{m2} = k'([\eta]_1 - [\eta]_2) \quad (14)$$

Where $[\eta]_1$ and $[\eta]_2$ are the intrinsic viscosities of the individual gum component in the blend and k' is a constant. This term is neglected in the absence of aggregation between molecules at very low concentrations.

3. Intermolecular attraction or repulsion is given as:

$$b_{m3} = \alpha \quad (15)$$

Where $\alpha \geq 0$ means attraction, whereas $\alpha < 0$ means repulsion.

Therefore,

$$b_m = b_{m1} + b_{m2} + b_{m3} \approx b_{m1} + b_{m3} \quad (16)$$

$$b_m = (\sqrt{b_1}W_1 + \sqrt{b_2}W_2)^2 + \alpha \quad (17)$$

By measuring b_m from the Huggins equation for polymer blend solvent solution, α was calculated and the interaction was characterized.

2.2 Statistical Analysis

For each gum blend the effects of the salts (KCl, KBr and $AlCl_3$) at the concentration (10 g/dm³ or 1 g/dl), effect of temperature and as well as the rise in solute concentration on the viscosity of the

blends were subjected to statistical analysis for the determination of intrinsic viscosity, the elastic component, the molecular conformation coefficient **b**, the miscibility coefficient **a** and the Huggins coefficient **K**. In each instance, the intrinsic viscosities were calculated by the general linear regression models procedure, using a Statistical Package for social science (version 16.0). Comparisons among treatments were analyzed by using Tukey significant test, with a significance level at $P < 0.05$.

3. RESULTS AND DISCUSSION

3.1 Effect of Concentration on Relative Viscosity of Blends

In general, AS:KS blends increase in relative viscosity as their concentration in aqueous medium increases, but a more pronounced or sharp increase in relative viscosity was noticed for concentration 0.6 g/dl for the 60:40 blend, this is seen in Fig. 2.

3.2 Effect of Temperature on the Specific Viscosity of the Blends

Thermodynamic and transport properties of gum mixture or blends, help in understanding the nature of molecular interaction taking place in solutions, this further helps in improving on the

quality grade of gums used in both food and pharmaceutical industries.

Fig. 3 shows plot for the variation of specific viscosity of the blends AS:KS gums with temperature. It was observed from the Figure that a decrease in viscosity as the temperature of the gums solution was increased. In order to calculate the activation energy of flow for the studied gums, the Arrhenius-Frenkel-Eyring equation (equation 18) was used [17].

where A denotes the pre-exponential factor, E_F is given as the activation energy of flow, R is the universal gas constant and T is the absolute temperature in Kelvin. In the AS:KS blend the 60:40 and 50:50 blend dropped lower than the rest and the latter having the least viscosity at 70°C but they all slightly increased further as we approach 90°C.

$$\eta = A \exp\left(\frac{E_F}{RT}\right) \quad (18)$$

3.3 Effect of Added Salt on Specific Viscosity of the Gums

The study of the specific viscosity and its effect in the presence of inorganic salt is achieved by using a uniform concentration of the gum maintained at (1.0 g/dl) while that of the salts were varied from (0.20-1.00 g/dl).

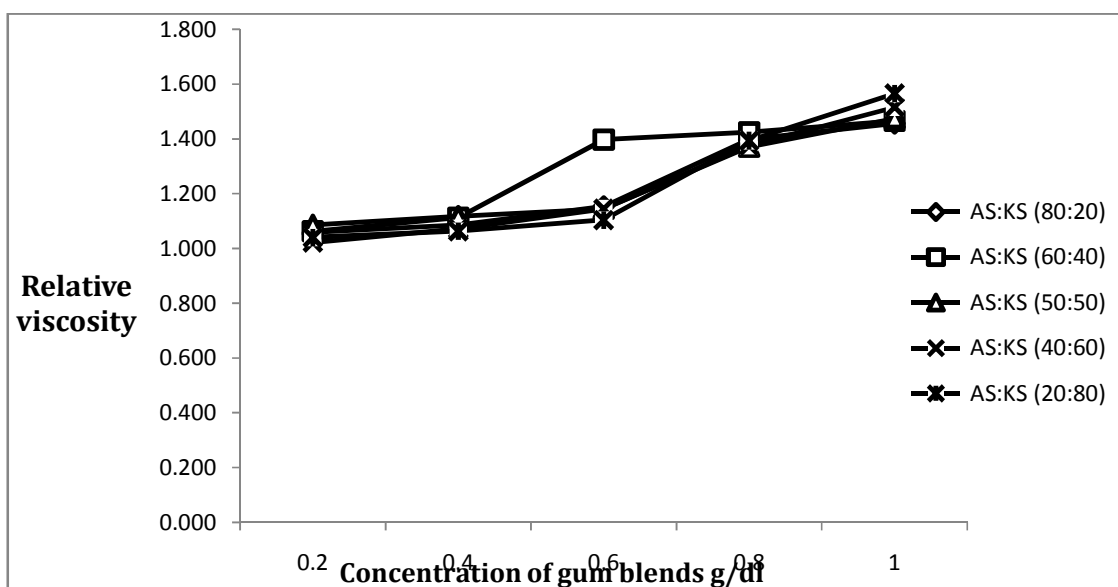


Fig. 2. Variation of relative viscosity of the blend As:Ks with concentration of the blends at room temperature

For AS–KS blends, a decrease in specific viscosity was observed as the concentration of KBr increased, (Fig. 5). An increase intrinsic viscosity was observed when KCl and AlCl₃ were added. (Figs. 4 & 6)

Table 2 shows that the hydrodynamic behavior of AS:KS gum blends was strongly affected by type and concentrations of the cations. In each of the gum blend, the trivalent ions from AlCl₃ showed a more pronounced effect on the specific viscosity when compared with monovalent ions from KCl and KBr respectively. The increase in ionic strength of the three salts from 0.2 to 1 g/dl positively affected the specific viscosity of all the gum. The specific viscosity was increased by more than 30% of the value obtained in the pure gums and their blends when only 1 g/dl salt was

added to the gum blends. Similar results were found in some other reported findings by [5 & 15].

When salt is added, the cations affects the side chains by selectively reacting with excess acidic components and as a result collapsing the backbone of the polymer giving the Acacia-Khaya gum molecule a rod-like conformation and thereby reducing their hydrodynamic volume [18]. The pronounced effect of the trivalent ions (aluminium) on the specific viscosities of the blends when compared with that of monovalent ions (potassium), could be as a result of molecular interaction between the gums and the aluminium ions, which led to the promotion molecular contraction in the blends [5].

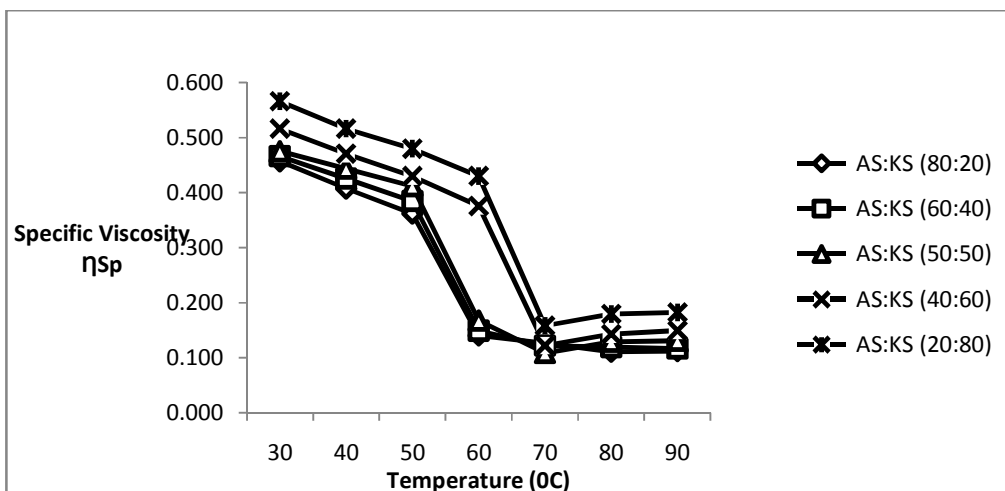


Fig. 3. Variation of specific viscosity of the blend As:Ks at different temperatures of the blends

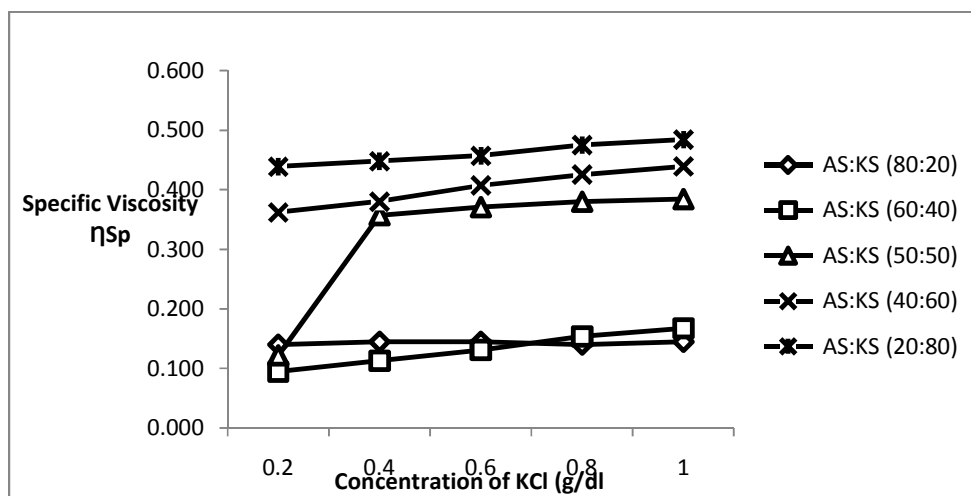


Fig. 4. Graphical relationship of specific viscosity of As:Ks blends with concentration of KCl

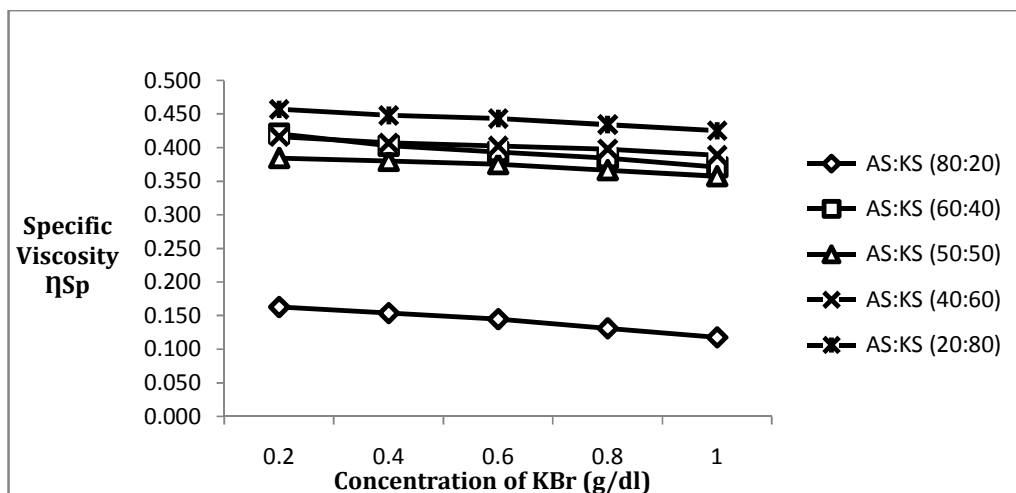


Fig. 5. Plots of specific viscosity of the blends AS:KS with increasing concentration of KBr

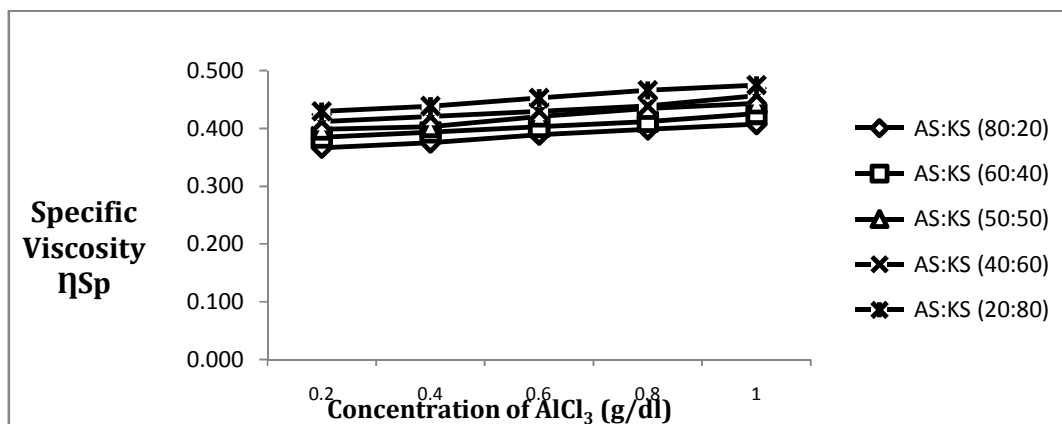


Fig. 6. Variation of specific viscosity of the blend AS:KS with concentrations of AlCl₃

3.4 Intrinsic Viscosity

Intrinsic viscosity calculated for all the pure gums and their blends were found to have a direct relationship with their concentrations (Table 1), similar trend was reported by [19], although a more pronounced increase in their relative viscosity was seen for concentrations higher than 0.4 g/dl. The failure of the GDEP to generate the intrinsic viscosity for the gums and their blends is attributed to the fact that the datas generated could not give a good linear regression model. The Huggins and Kraemer plots did not provided a good fit and so Tanglertpaibul and Rao plot was used, since it was found to have the best fit when compared to the other two models [12 & 10]. McMillan in 1974 reported that the use of slopes of plots in intrinsic viscosity determination is better than the alternative extrapolated from the intercepts of the plots, since they have been

found to have a characteristic large correlation coefficients as associated with their smaller standard errors than the latter. larger intrinsic-viscosity values from this study may be due to the concentration of the gums in deionized water, since the presence of counter ions for the gums would be lacking, thus facilitating molecular expansion.

3.5 Intrinsic Viscosity: Tanglertpaibul and Rao plot

3.5.1 Thermodynamic parameters

Acevedo and Katz [20] reported that the thermodynamic parameters of matter flow can be theoretically determined using the Frenkel-Eyring equation written below,

$$\ln \eta = \left(\ln A - \frac{\Delta S_V}{R} \right) + \frac{\Delta H_V}{RT} \quad (19)$$

The activation energy and enthalpy change of gum flow were accounted for using the frenkel-eyring and Arrhenius-frenkel model respectively [21].

Table 1. The intrinsic viscosity extrapolated from the slope of Tanglertpaibul and Rao [11] plot for the blends are given below as

Gum blends	Intrinsic viscosity (dl/g)
KS	59.02±0.02
AS	68.08±0.03
AS:KS (20:80)	69.07±0.06
AS:KS (60:40)	55.81±0.02
AS:KS (50:50)	51.51±0.02
AS:KS (40:60)	64.46±0.05
AS:KS (80:20)	55.44±0.05

Results are written in the form mean ± SD for triplicate evaluation, The individual mean for each blend were found to be significantly different when $p < 0.05$

3.5.2 Molecular conformation and polymer interaction

The power-law equation was primarily used in the extrapolation of the exponent b from the slope, If $b > 1$ it suggest that the gum has a random coil conformation, this was reported by [22] and when $b < 1$ it indicates that a rod-like conformation is inherent in the blend [5]

Table 2. Enthalpy change (ΔH) and Energy of Gum Flow (E_f) for the gums and their blends

Gum blends	ΔH (KJ/mol)	E_f (KJ/mol)
AS	11.482	4.9868
KS	23.16	10.0581
AS:KS (20:80)	17.406	7.5595
AS:KS (80:20)	17.295	7.5111
AS:KS (60:40)	17.604	7.6454
AS:KS (50:50)	17.776	7.7200
AS:KS (40:60)	17.359	7.5390

Table 3. shows the values for the conformation parameter in the gums

Gum blends	b_{law}	Gum conformation
AS	1.392	random coil
KS	1.715	random coil
AS:KS (20:80)	1.673	random coil
AS:KS (40:60)	1.979	random coil
AS:KS (50:50)	1.072	random coil
AS:KS (60:40)	1.376	random coil
AS:KS (80:20)	1.356	random coil

From the Huggins equation the specific viscosity of the blends were determined, which is given as

$$\frac{\eta_{sp}}{C} = [\eta] + bC$$

Based on the Huggins equation a plot of specific viscosity against concentration, the intercept approximated at very low concentration give s the value of b, from which the Huggins parameter K can be calculated [14] Hence $b = K[\eta]^2$

3.5.3 Polymer interaction parameter

Table 4. shows the value of K, which is the huggins parameter, used to check for the possibility of aggregation of polymer molecules in polymer solution

- When K value > 1 indicates aggregates, whereas K values < 1 indicates no aggregation [23].
- From the results in this research as shown in (Table 4), where the K values were all less than 1, indicating the absence of aggregation of the gums in the solution.

3.6 FTIR Analysis

Infrared spectroscopy is an important tool used for proper characterization of polymer blends it is imperative in identifying chemical changes in their structure as a result of new functional group found [24]. The IR spectra gives a very strong bands which was found at $2854-3008 \text{ cm}^{-1}$ in the gums, the signal peaks can be attributed to CH stretch and CH_2 - asymmetric stretch in aliphatic groups. The C-O stretch vibration due to carboxylic acid or alcohol was noticed at 1054.13 cm^{-1} confirming the presence of a carbonyl group.

Table 4. Polymer Interaction type with varying Blend concentration

Blends	Huggins parameter (K)	Interaction type
AS	0.0016	no aggregation
KS	0.0001	no aggregation
AS:KS (50:50)	0.0027	no aggregation
AS:KS (20:80)	0.0038	no aggregation
AS:KS (40:60)	0.0039	no aggregation
AS:KS (60:40)	0.0014	no aggregation
AS:KS (80:20)	0.0033	no aggregation

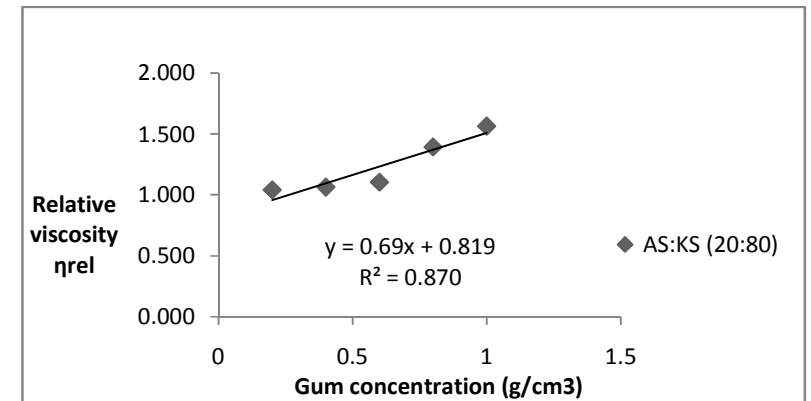
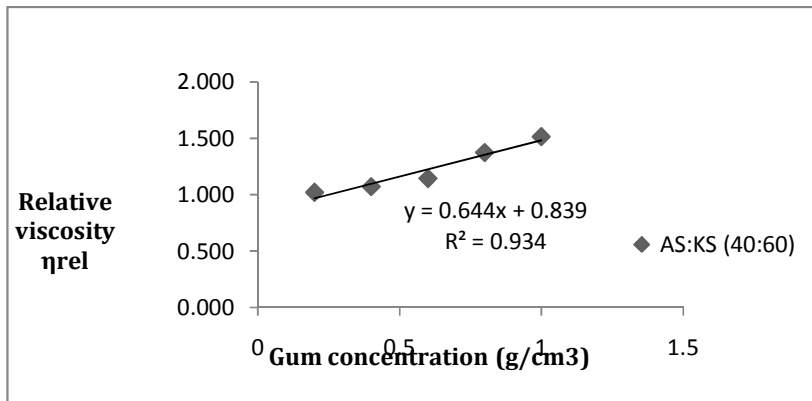
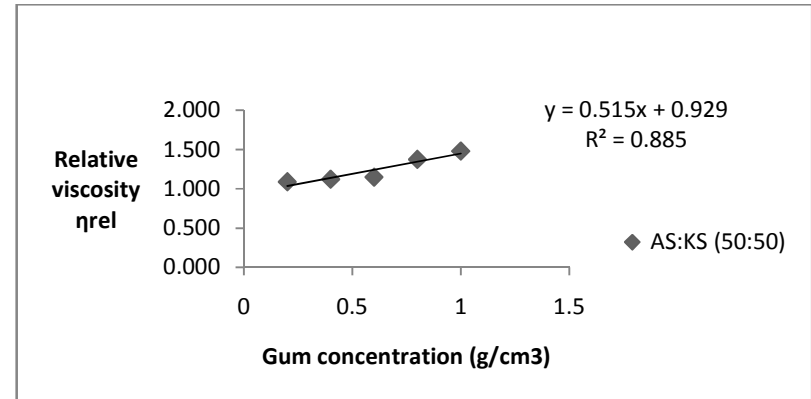
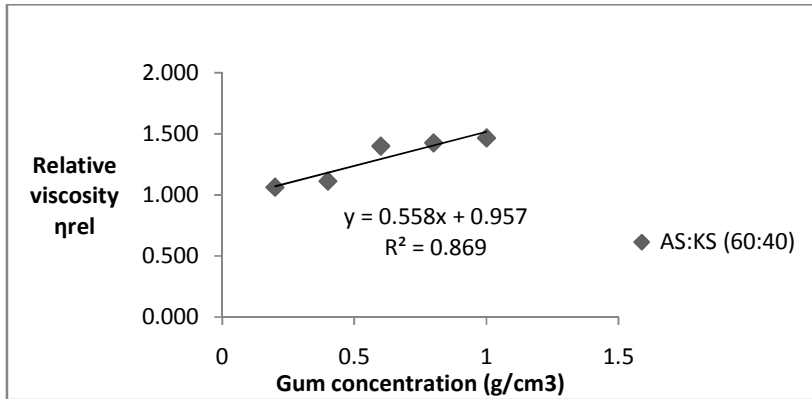


Fig. 7. Plot Tanglertpaibul and Rao model for the blends of AS:KS with concentration
These results suggest an intermolecular synergism between AS and KS gums, which was greater at 20% AS and 40% KS blend

Fig. 10 shows the IR spectra of different blend composition for AS:KS. from the results obtained it is evident that positive shift of absorption band of O-H stretch from 3397.72 cm^{-1} to 3400.62 cm^{-1} , for the 80:20 and 20:80 composition, could be attributed to the increase composition of the AS gum, although the shift in absorption band for C-H aliphatic stretch is opposite to that of O-H stretching, there is a superposition of the absorption band for 40:60 with that of 50:50, i.e. 2936.72 and 2933.83 cm^{-1} respectively. It was noticed that the percentage transmittance of IR in the blends became more intense for C-H aliphatic stretch and C-O stretch.

The stability or sorption properties were found in Fig. 8, which reveals that the blend hydrodynamic interaction decreases with increase in KS composition, while in Fig. 9 the interaction parameter between the blend increases with an increase in KS composition, hence there is a relationship between the interaction parameter and that of the hydrodynamic behavior of the blends. Fig. 7 and 11 shows that the Tanglerpaibul and rao model is the best model for defining the intrinsic viscosities of the blends, this is evident form the value of its coefficient of regression.

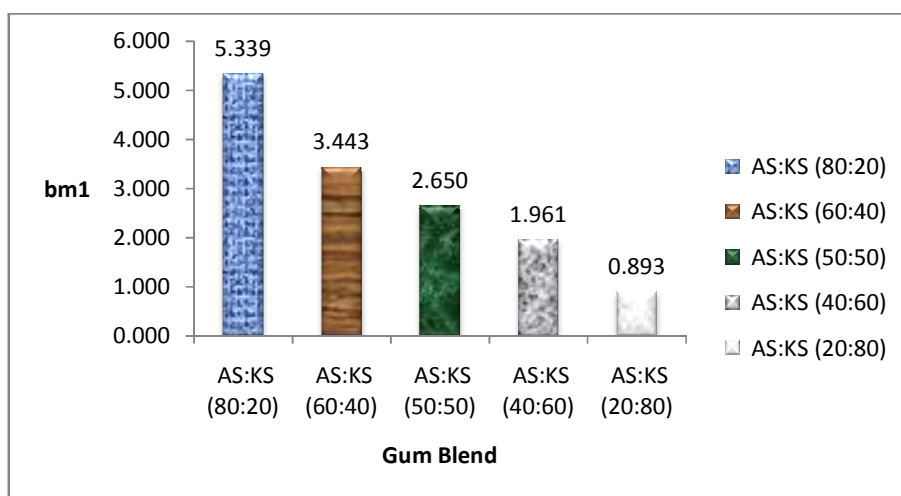


Fig. 8. Variation of long range hydrodynamic interaction with the gum blends

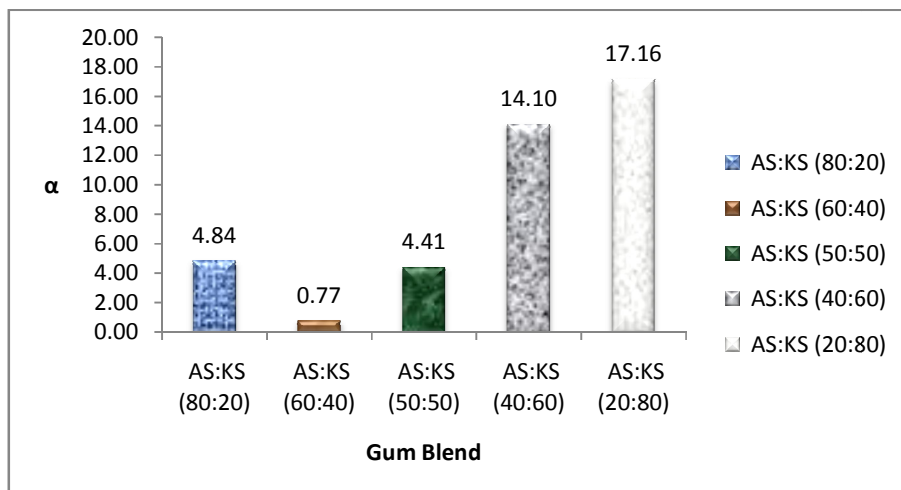


Fig. 9. Gum blends composition relationship with interaction parameter α

The values of α in this research were obtained as shown by [25 and 14]. Where $\alpha \geq 0$ means attraction, whereas $\alpha < 0$ means repulsion

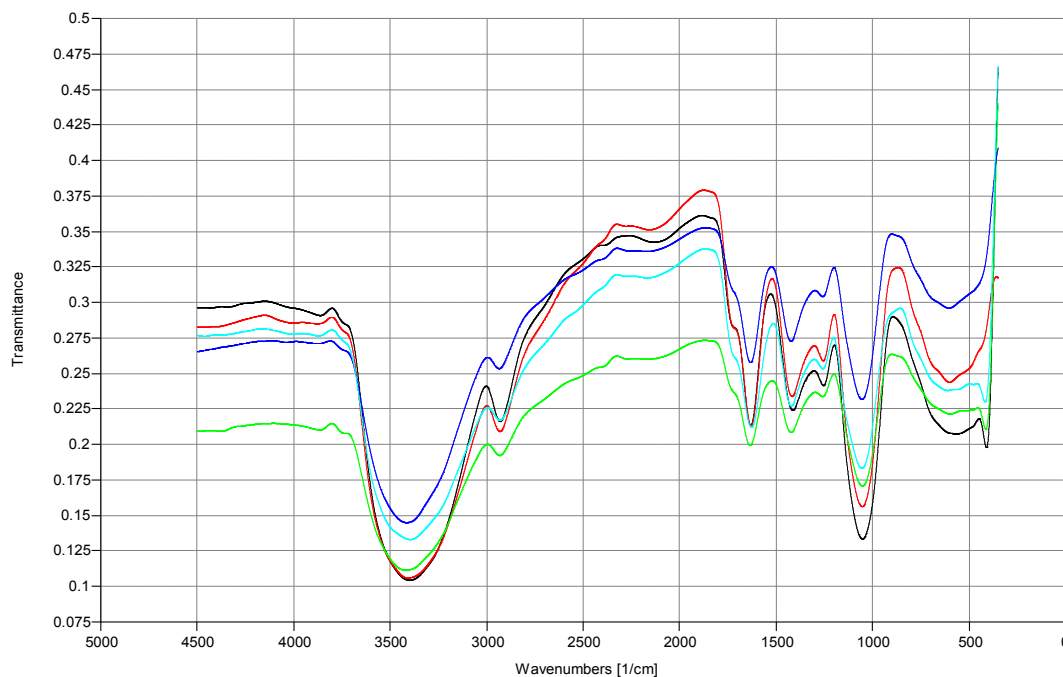


Fig. 10. IR spectrum of the blends of *Acacia senegal* and *Khaya sengalenses* gum
 — = (AS:KS) 80:20, — = (AS:KS) 60:40, — = (AS:KS) 50:50, — = (AS:KS) 40:60, — = (AS:KS) 20:80

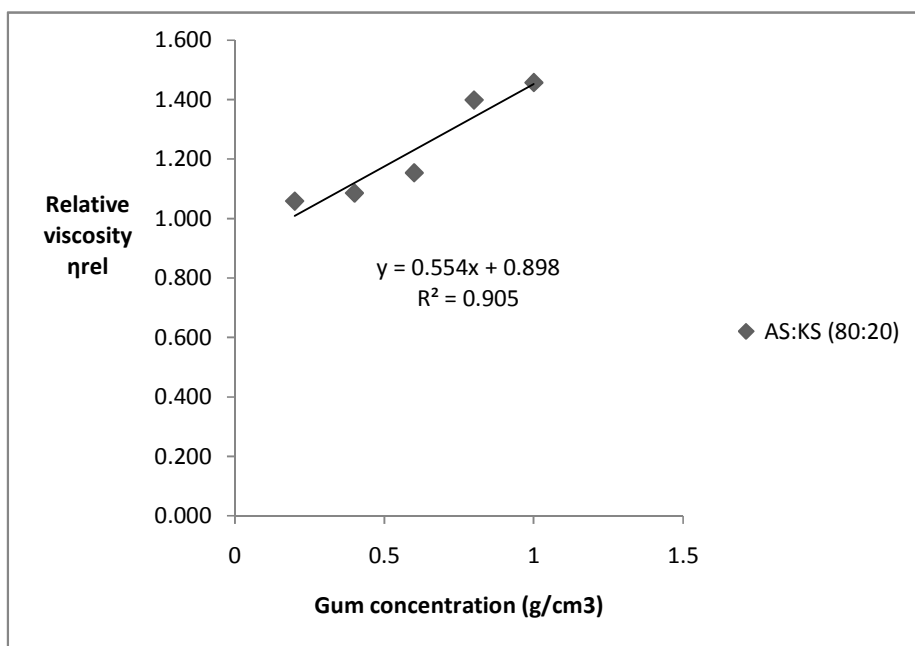


Fig. 11. Tanglertpaibul and Rao model plot for Intrinsic viscosity of AS:KS blends

4. CONCLUSION

From the results and findings of the present study, the blend AS:KS (20:80) was found to

have an intrinsic viscosity 69.07 dl/g which was higher than the reference gum Arabic, this research has made a breakthrough by introducing a novel gum made from natural

abundant resource with better quality than the popular and readily available gum Arabic [19], other deductions made from this work includes

Rheological modeling revealed that the viscosities of the gums vary with temperature, concentration of gum and concentration of electrolyte.

All the gum blends AS:KS in Table (3) (above) were found to have random coil conformation, while the activation energy of flow and enthalpy change of the gums flow were found to drop in an insignificant amount as the composition of KS gum increases. The intrinsic viscosity were found to increase in the As:Ks blends when Ks gum was added to the blend.

The interaction parameter α for all As:Ks blends with exception of 50:50 and 80:20 indicates a strong attraction within the blends in an aqueous solution, but this interaction vanishes as salt was added.

COMPETING INTERESTS

We the authors' declare that we have no conflicting interest pertaining to the publishing of this Journal article.

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