Physicochemical and FTIR studies on *Acacia senegal* and *Anacardium occidentale* blends.

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Abstract

***Acacia senegal* and *Anacardium occidentale* gums exudate were obtained from a village in Jigawa state, Nigeria. Physicochemical properties were analysed for various blend ratios of *Acacia senegal* and *Anacardium occidentale* gums (namely 100:00, 80:20, 60:40, 50:50, 40:60, 20:80 and 00:100). *Anacardium occidentale* gum is brownish yellow in colour while *Acacia senegal* gum is white in colour. The two gums absorb maximally at 210 and 200 nm and their conductivity values are 132.40 and 186 µs/cm respectively. Other physical parameters of the gums were salinity (which was similar for the two gums, i.e., 0.1 µs/cm), total dissolved solid (68.40 and 87.80 for *Anacardium occidentale* and *Acacia senegal* gum respectively) and turbidity (90 and 27 FAU for *Acacia senegal* and *Anacardium occidentale* respectively). Blending at all proportion presented different colours, wavelength of maximum absorption exhibited a gradual reduction at *Acacia senegal*: *Anacardium occidentale* blend ratio of 4:1 (205 nm) and gradually stabilizes at 210 nm when the ratio was varied from 1:1 to 2:3 and finally to 1:4. Conductivity was found to decrease from 185.30 to 138.80 µs/cm as the blend ratio of *Acacia senegal*: *Anacardium occidentale* changes from 4:1 to 1:4. Similar trend was observed for salinity and total dissolved solid. The FTIR spectra of the blends reveal three set of information. For some blend ratios, the frequency of IR absorption increases with increase in intensity, in others, the frequency and the intensity decreases while in the remaining blends, some functional groups that were present in the parent gums were missing. Therefore, blending significantly alter the physicochemical and FTIR properties of *Acacia senegal* and *Anacardium occidentale* gums.**

Keywords: *Acacia senegal* gums*, Anacardium occidentale* gums, Blending, Physicochemical and functional properties

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Introduction

Gums are organic substances obtained as an exudation from trunks or branches of the tress naturally or after mechanical injury of the plant by incision of the bark or after the removal of the branch or after invasion by bacteria or fungi [1,2]. They are complex polysaccharides of high molecular weight polymeric compounds [3,4]. Application of gums in most industries cannot be overemphasized. *Albizia zygia* and some *Albizia lebbeck* gums are useful as natural emulsifiers in food and pharmaceutical industries [5-7]. *Albizia lebbeck* gum and gum Arabic are useful in the metallurgical industries [8]. Guar and some other gums have a number of applications in the mining and mineral processing industry [9]. Xanthan and Lucust bean gums are used as thickening agents in food industries [10]. In the froth flotation of base metal and platinum group metal ores, guar gum is used as a depressant of naturally hydrophobic waste minerals such as talc. The role of polysaccharide is to adsorb on the talc surface, render it hydrophilic and prevent its flotation. In the pharmaceutical industries, functional properties of Guar gum are of primary importance for controlling the release of drugs in the gastrointestinal tract, such as carrier for colon targeted drugs, for anti-cancer drugs in the treatment of colorectal cancer and for oral rehydration solutions in the treatment of cholera in adults [11].

Interestingly, useful applications of gums are based on their function properties including physicochemical, rheological and spectroscopic properties [12-15]. Some may have limited applications and hence limited demand while others may be of great demand but limited supply, indicating that their price could be comparatively high. In order to overcome the problem of scarcity and high demand for some gums (which will ultimately leads to excessive cost), blending is one of the best options of modifying functional properties of gums such that the less demanded and most demanded gums can compete with each other for industrial availability and utilization. The present study is aimed at studying the effect of blending on physicochemical and FTIR spectrum of *Acacia senegal* (AS) and *Anacardium occidentale* gum.

Materials and Methods

Materials

Crude *Acacia senegal* (AS), and *Anacardium occidentale* (AO) gums were obtained as dried exudates from their parent trees grown at Kanya babba village in Bubura local Government Area of Jigawa State (located in North west Nigeria) around mid-November during the day time using the method described by Sharma et al. [16]. The procedure adapted for the purification of the gum was the method reported by Eddy et al. [12]. Composites gums were prepared by combing AO:AS in the following proportions, 80”20, 60:40, 50:50, 40:60, 20:80 respectively. 100% of the respective gums served as the blank.

Physiochemical analysis

The moisture content of the gums and their blends were estimated using desicator method as described Dong et al. [17]. In order to estimate the solubility of the gums, analytical balance (Model. XP-3000) was used and the procedures reported by Eddy et al. [4] was adopted. The pH of the gum was determined using Oaklon pH meter (Model 1100) according to the method reported by Eddy et al. [12]. The Hach colorimeter (Model: DR/890) was used for the determination of the turbidity of the gums and their blends. The wavelengths of maximum absorption for the gums and their blends were determined by scanning the respective samples through various wavelengths using Jenway UV/Vis spectrophotometric (model: 6405) and generating a graph of absorbance against wavelength through which wavelength of maximum absorption, λ_{max} was extrapolated.

FTIR analysis

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

Quality assurance/control

In order to ensure quality data and analysis, recommended analytical methods were adopted for all analysis. Triplicate analysis was also carried out to obtained mean value and ensures reproducibility and reliability of the results obtained. Where necessary, calibration of instrument was carried out.

Results

Physiochemical parameters of *Acacia senegal* (AS) and *Anacardium occidentale* (AO) gums are presented in Table 1 while those of the blends are given in Table 2. Frequencies of IR absorption by 100: 0, 80:20, 60: 40, 50:50, 40:60, 20:80 and 0:100 blend of AO and AS by AO gums are recorded in Tables 3 to 9.

Discussion

Physicochemical parameters

From Table 1, it is evident that the colour of AS and AO gums are brownish-yellow and white respectively. When the colour of AS and AO gum blend were observed against that of AS as standard gum using the same colour identification method, the blends with 80% AS and 20% AO composition was lighter in shade and the closer in colour when compared to AS gum (Table 2).

Solubility of AO and AS gums in water was 7.7 and 10.8% respectively. The Solubility of the blends of the gum were found to vary with composition. For example, AS:AO ratios of 80:20, 60:40, 50:50, 40:60 and 20:80 displayed solubility values of 9.2, 8.7, 8.2, 7.6 and 7.1% in water respectively. These values are less than the solubility of AS gum (10.8%) indicating that blending tends to lower their solubility with respect to AS gum. However, the solubility of the gum blend increases with increase in the composition of AO gum as shown in Table 2. The pH of AO and AS gums were 5.41 and 5.11 respectively. All the gum blends exhibited pH values that are lower than the pH of the corresponding gums. Generally, for AS:AO blend, the pH increases with increasing ratio.

Measured wavelength of maximum absorbance of AO and AS gums were 210 and 200 nm respectively. Composite mixtures of AS ad AO gum slightly modified the maximum wavelength of absorbance of the gums from 205 to 210 nm for AS:AO ratios of 80:20 and 20:80 respectively. From Beer-Lambert law, absorbance of materials depends on concentration indicating that the composition of the blend is slightly altered. The results obtained clearly reveals that from blend ratio of 50:50, the maximum wavelength of absorbance for AS:AO blend remain steady at 210 nm indicating that after blend ratio of 40:60, the wavelength of maximum absorbance did not depend on the gum composition again. Generally, measurement of maximum

Table 1. *Physicochemical parameters of Acacia Senegal (AS) and Anacardium Occidentale (AO) gums.*

Physicochemical parameters	**AO gum**	**AS gum**
Colour	Brownish-Yellow	Navajowhite 1
Solubility (water), (Ethanol)	7.7, 0.0	10.8, 0.0
pH (@ 27°C)	5.41	5.11
Maximum wavelength of absorption (nm)	210	200
Turbidity (FAU)	90	27
Conductivity (µs/cm)	132.4	186
Salinity(µS/cm)	0.1	0.1
Total Dissolved Solid (TDS) mg/l	68.4	87.8

Table 2. *Physicochemical parameters of AS:AO gum blends.*

Physicochemical parameters	**AS:AO**	**AS:AO**	**AS:AO**	**AS:AO**	**AS:AO**
	80:20	**60:40**	**50:50**	**40:60**	**20:80**
Colour	Peachpuff 1	Bisque	Bisque 2	Navajowhite 2	Wheat
Solubility (water),(Ethanol)	9.2, 0.0	8.7, 0.0	8.2, 0.0	7.6, 0.0	7.1, 0.0
pH (@ 27°C)	4.53	4.88	4.94	4.81	4.82
UV Maximum absorption (nm)	205	215	210	210	210
Turbidity (FAU)	54	120	122	128	136
Conductivity (µs/cm)	*185.3*	147	133.8	139.5	138.8
Salinity(µS/cm)	0.1	0.1	0.1	0.1	0.1
Total Dissolved Solid (TDS) mg/l	94.1	74.5	67.31	70.8	69.81

wavelength of absorbance has significant analytical implication because it characterized the compound in fixing a reference wave length through which further spectroscopy analysis can be effectively examined on the compound. From the above results, it is evidence that spectroscopy analysis of AO and AS gum blends should be done with due background of their absorbance. The high wavelength of maximum absorption (λmax) noticed in the gum composites may also be attributed to high degree of conjugation which absorb light in the UV or visible regions of the electromagnetic spectrum. Measured turbidity of AO and AS gums were 90 and 27 FAU respectively. Various blends of AS:AO gums presented turbidity values that are relatively comparable to the average turbidity of the crude gums. At blend ratio of 80:20, 60:40, 50:50, 40:60 and 20:80, turbidity values were 54, 120, 122, 128 and 136 FAU. These values increase with increase in the content of AO gum, which had better turbidity than AS gum. Turbidity of AO:KS blends were the highest compared to those measured for other gum blends with similar composition. Generally, the turbidity extends from 352 to 411 FAU and increases with concentration. The present results reveal that blending of gums can significantly altered the turbidity of the composite gums. AO and AS gums have conductivity values of 132.4 and 186μs/cm respectively. AS:AO blends were found to have conductivities of 185.3, 147, 133.8, 139.5 and 138.8 for 80:20, 60:40, 50:50, 40:60, 20:80 composition respectively. Generally, conductivity of the blends tend to decrease with increase in AS content. Total dissolved solid (TDS) is a measure of the combined content of all inorganic and organic substances contained in the gum solution, in a suspended form.

Changes in physicochemical properties of polymer materials due to blending have been reported for several polymers including PCL/PMMA biopolymer [18], xanthan and locust bean gums [19], PVC/PMMA [20,21], etc. The results obtained in this study do not conflict with those reported for other polymers.

FTIR study

FTIR is a powerful instrument that can be used to study functional properties of polymer materials and their blend. Several works have been reported on the use of FTIR in studying composites materials derived from polymers. This tool was also employed in this work. As stated before, frequencies of IR absorption by 100: 0, 80:20, 60: 40, 50:50, 40:60, 20:80 and 0:100 blend of AO and AS by AO gums are recorded in Tables 3 to 9.

Functional groups associated with AS gum are C-C bending, CO_2, C-O stretch, C-H waging vibration, C-H in plane bending, C=C stretching, C-H stretching vibration, C=O asymmetric stretch, C-H asymmetric stretch, OH stretch and OH stretching. In AS gum, these vibrations occur at frequencies of 25.96, 25.67, 21.83, 25.89, 22.26, 23.06, 26.74, 26.35, 21.70, 13.89 and 20.36 cm^{-1}. In AO gum, C-C bending, CO_2 bending, C-O stretching vibration, C-H wagging, C-H in plane , C=G stretch, C-H stretch, OH stretch and OH symmetry stretch were found at 22.94, 22.28, 16.63, 25.81, 22.89, 19.50, 22.27, 11.13 and 32.08 $cm^{-1.}$ It can be seen from the above that the two gums have common functional groups. According to Eddy et al. [4] gums are polysaccharides and have similar basic constituents, explaining while they have closely related functional groups. The difference between one gum and the other is the frequency and intensity of the IR signal. This indicate that the concentration of the common constituents differ from one gum to another. In AS and AO gums C-C bending was found to occur at 479 cm^{-1} (intensity=25.96) and 476 cm^{-1} (intensity=22.94).

Table 3. *Frequencies and peaks of IR absorption by AS gum.*

Frequency (cm^{-1})	Intensity	Assignments
479	25.96	C-C bending
591	25.67	CO_2 bending
1057	21.83	C-O stretch
1268	25.89	C-H wag (-CH2X)
1424	22.26	C-H in plane bending (CH3)
1640	23.06	C=C stretch
2272	26.74	C-H stretching
2387	26.35	C=O asymmetric stretching
2939	21.7	C-H asymmetric stretch
3429	13.89	O-H stretch
3856	20.36	O-H stretching

Table 4. *Frequencies and peaks of IR absorption by AO gum.*

Frequency (cm^{-1})	Intensity	Assignments
476	22.94	C-C bending
608	22.28	CO_2 bending
1058	16.63	C-O stretch
1258	25.81	C-H wag
1420	22.89	C-H in plane bending (CH3)
1625	19.5	C=C stretch
2936	22.27	C-H stretch
3412	11.13	O-H stretch
3872	32.08	Asymmetric O-H stretching

Table 5. *Frequencies and peaks of IR absorption by 80:20 blend of AO and AS gums.*

Frequency (cm^{-1})	Intensity	Assignments
415.67	30.5386	C-C bending
587.34	30.1649	CO_2 bending
1053.17	21.7391	C-O stretch
1257.63	32.3488	C-H wag
1411.94	29.6587	C-H bend
1633.76	29.1341	C=C stretch
2927.08	27.7154	C-H aliphatic stretch
3400.62	17.0493	O-H stretch
3869.33	37.3823	Asymmetric O-H stretching

Table 6. *Frequencies and peaks of IR absorption by 60:40 blend of AO and AS gums.*

Frequency (cm^{-1})	Intensity	Assignments
418.57	24.4542	C-C bending
596.02	22.2317	CO_2 bending
878.6	30.53656	=CH out of plane
1054.13	14.1816	C-O stretch
1263.42	26.6594	C-H wag
1408.08	23.4601	C-H bend
1633.76	23.7817	C=C stretch
2383.13	38.186	C=O Asymmetric stretching CO_2
2925.15	22.652	C-H aliphatic stretch
3405.44	10.7176	O-H stretch
3874.16	33.5721	Asymmetric O-H stretching

Table 7. *Frequencies and peaks of IR absorption by 50:50 blend of AO and AS gums.*

Frequency (cm^{-1})	Intensity	Assignments
411.82	24.9741	C-C bending
573.84	25.4658	CO_2 bending
877.64	36.862	=CH out of plane
1054.13	15.6435	C-O stretch
1263.42	32.7689	C-H wag
1404.22	29.5088	C-H bend
1634.73	28.8866	C=C stretch
2926.11	28.0868	C-H aliphatic stretch
3409.3	10.6629	O-H stretch
3878.98	38.4484	Asymmetric O-H stretching

Table 8. *Frequencies and peaks of IR absorption by 40:60 blend of AO and AS gums.*

Frequency (cm^{-1})	Intensity	Assignments
421.46	26.5555	C-C bending
592.17	23.6869	CO_2 bending
878.6	34.7155	=CH out of plane
1054.13	14.201	C-O stretch
1266.31	30.6264	C-H wag
1406.15	26.9956	C-H bend
1632.8	27.4489	C=C stretch
2924.18	26.6011	C-H aliphatic stretch
3392.9	10.6106	O-H stretch
3876.08	42.3019	Asymmetric O-H stretching

Table 9. *Frequencies and peaks of IR absorption by 80:20 blend of AO and AS gums.*

Frequency (cm^{-1})	Intensity	Assignments
555.52	29.6753	CO_2 bending
877.64	40.9094	=CH out of plane
1055.1	18.1001	C-O stretch
1276.92	37.1548	C-H wag
1402.3	33.0787	C-H bend
1635.69	32.6426	C=C stretch
2924.18	31.9787	C-H aliphatic stretch
3385.18	12.1532	O-H dimer
3446.91	12.1828	O-H stretch
3862.58	42.3611	Asymmetric O-H stretching

However, with AO:AS blend ratios of 80:20, 60:40, 50:50 and 40:60, this vibration occurs at a wave number of 416 cm^{-1} (and intensity of 51.18), 419 cm^{-1} (intensity=40.35), 412 cm^{-1} (intensity=51.12) and at 421 cm^{-1} (intensity=38.94) respectively. However, this vibration was absent in the gum composite of composition, 20:80. Therefore blending of AO and AS gum gradually decreases the intensity of C-C bending vibration as the concentration of AO decreases. However, the intensity of the blends are higher than those of 100% AO or AS gum indicating that blending results in modification of the peak of absorption. In AS and AO gums, CO_2 vibration occurs at 591 cm^{-1} (intensity=25.96) and 608 cm^{-1} (intensity=22.28). However, blending of AO and AS gums at various ratios (80:20, 60:40, 50:50, 40:60, 20:80), the CO_2 functional group changed to 587 cm^{-1} (intensity=30.16), 596 cm^{-1} (22.23), 574 cm^{-1} (intensity=25.47), 592 cm^{-1} (23.69) and 556 cm^{-1} (29.68). Therefore, blending of AO and AS gums produce a composite gum that with shifted frequency and intensity indicating that there is interaction between the two gums [4]. C-O stretching occurs at frequencies of 1057 (intensity=21.83) and 1058 cm^{-1} (16.63) in AS and AO gums while C-H wagging occurs at 1268 (22.89) and 1258 cm^{-1} (25.81) respectively. In 80:20 blend of AO and AS gum, the C-O stretch was shifted to 1053 cm^{-1} (intensity=21.74), the C-H wagging vibration was shifted to 1258 cm^{-1} (intensity=32.35), C-H bending was shifted to 1412 cm^{-1} (intensity=29.66), the C=C stretch was shifted to 1634 cm^{-1} (intensity=29.13), OH stretch was shifted to 3401 (intensity=17.05) and 3869 cm^{-1} (intensity=37.38). In the 60:40 composite, a new functional group (=CH out of plane) was found at 879 cm^{-1}. C-O stretch was shifted to 1054 cm^{-1}, C-H wagging vibration was shifted to 1263 cm^{-1}, C-H bend was shifted to 1408 cm^{-1}, C=C stretch was shifted to 1634 cm^{-1}, C=O asymmetry appeared at 2383 cm^{-1}, C-H aliphatic stretch was shifted to 2925 cm^{-1} while OH stretching vibrations were shifted to 3405 and 3874 cm^{-1} respectively. The =CH out of plane vibration was also found in the spectrum of AO and AS composite containing 50:50 of AO and AS gum. This functional group appeared at 878 cm^{-1}. The C-O stretch, C-H wagging vibration, C-H bending vibration, C=C stretching vibration, and OH vibrations were shifted to 1054, 1263, 1404, 1634, 3408 and 3879 cm^{-1} respectively. The =CH out of plane signal appear at 592 cm^{-1} in AO and AS gum composite blended in the ratio, 40: 60. Similarly, C-O vibration, C-H wagging, C=C stretching and OH vibrations were shifted to 1054, 1266, 1406, 1632, 3393 and 3876 respectively. At 878 cm^{-1}, the =CH out of plane vibration was also found in the spectrum of AO/AS composite whose composition was 20: 80 (i.e., AO:AS ratio). CO stretch was shifted to 1055 cm^{-1}, C-H wagging vibration was shifted to 1277 cm^{-1}, C-H bending to 1402 cm^{-1}, C=C vibration to 1635 cm^{-1} and OH vibrations were shifted to 3385, 3447 and 3862 cm^{-1}. It is evident that there are forward and backward shifts in some functional groups due to blending. Few new functional groups that were not common to AO or AS were also formed. The intensities of the respective functional groups were also observed to change significantly. Therefore, during blending, there is interaction and the composite may possess properties or assumed a new form. The shift in FTIR frequency due to bleding obtained in this work agrees with the results obtained from others with respect to polymer-polymer blends [16,18,19].

Conclusion

This study was designed to investigate the effect of blending on the physicochemical and functional properties of AO and AS gums. From the results and findings of the study, it can be concluded that blending has significant effect on the physicochemical properties of the gums. The functional properties of the gums composites are found to be shifted in frequency and intensity of infra-red absorption as a result of blending. Therefore, functional properties of gums can be modified for broader applications through blending.

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