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Mawahib E Moniem
Department of Chemistry, College of Science, Sudan University of Science and Technology, Khartoum, Sudan

Elfatih A Hassan
Department of Chemistry, College of Science, Sudan University of Science and Technology, Khartoum, Sudan

Mohammed E Osman
Department of Chemistry, College of Science, Sudan University of Science and Technology, Khartoum, Sudan

Correspondence
Mawahib E Moniem
Department of Chemistry, College of Science, Sudan University of Science and Technology, Khartoum, Sudan

Characterization and rheological behavior of neem gum (*Azadirachta indica*)

Mawahib E Moniem, Elfatih A Hassan and Mohammed E Osman

Abstract
Samples of neem gum (*Azadirachta Indica*) collected from three locations Kordofan, White Nile, and Khartoum states, Sudan) on (2015—2017). Were investigated. The result showed that moisture content was in the range of 11.2— 12.2%, Ash content 3.0—3.3%, pH 4.2 — 4.8, specific optical rotation -65.5 — -67 nitrogen content 4.8 — 5.2%, protein 30.2 — 31.3%, acid equivalent weight 1543 —1708, Total uronic acid 11.3 — 12.5 %, intrinsic viscosity 24 — 36 cm^3g^{-1} and the number average molecular weight of the gum was $6.4x10^5$ —12.0 $x10^5$ g/mol The sugar Composition was Arabinose% 14 — 22%, Galactose% 17—24%, Xylose% 3 — 4%, Rhammnose % 2 — 4%. The Cationic composition of gum is in order Mg> Na > Ca > K, Cu, Zn, P, As, Cd, but the Pb, Fe, Ni, Ch, were not found in the samples. The result of amino acid content of gum shows that seventeen amino acids were determined. Calorific value of the neem gum was 4.3Kcal/g. The result concluded that rheological studies indicate a Newtonian behavior of the gum solutions.

Keywords: Gum neem, physicochemical properties, rheological behavior

1. Introduction

Neem tree is a member of the family Meliaceae, is a botanical cousin of mahogany. Family meliaceae consist of 52 genera and 600 species (Bailey, 1953; Rereal, 1999). And grows mainly in tropical regions. It was also, observed that the tree could survives very dry, arid conditions. It is an ever green tree, but may become leafless for a short period in certain conditions (Muthu, *et al.*و 2010) [9]. All parts of neem plant such as leaves, bark, flower, fruit, seeds and roots were used as herbal medicine (Natarajan *et al*., 2002) [11]. The leaves are used for diabetes, eczema and reduce fever. Bark of neem is used make toothpaste. The roots have the ability to heal diseases and protect against insects. Neem seeds have high oil content. Neem oil is, widely, used as insecticide, lubricant, and for variety of diseases such as diabetes and tuber-culosis. (Fukuda, and Noda, 2001).

The *Gum* from *Azadirachta indica (*neem gum*)*, it is a tasteless, soluble natural exudates of bright fellow to amber-colored, material. It belongs to the family of galactan gum and was a complex of hetero polysaccharide and proteins. Drastic degradation of the gum shows that it contains D - glucose D - glucuronic acid, L – arabinose, L - fucose, mannose and xylose (Ramakrishna, 1981) [15]. Investigation of the amino acid composition of the gum shows Alanine, aminobutyric acid, arginine, and Glysine, etc. Aspartic acid as most abundant (Anderson, 1968) [1].

An earlier communication (Ramakrishna, 1981) [15]. Reported the characterization of a high-molecular-weight glycoprotein and a large molecular size. From neem gum of protein: carbohydrate ratio 4.24:1 the carbohydrate potion of the glycoprotein consists of glucosamine mannose, arabinose, galactose, fucose. Xylose and glucose in molar ratio of 3:4:3:2:2:1:1. Furthermore, the carbohydrate-peptide link in this glycoprotein was fond to be an acylgucosa-minyl-asparaginyl bond.

Rheology is defined as the science of deformation and flow (Goodwin, 2008) [6]. In principle, definition includes everything that deals with flow, such as fluid dynamics, hydraulics aeronautics and even solid stare mechanics. However, in Rheology the intention is to focus on materials that have a deformation behavior in liquid and solid states.

2. Materials and Methods
1. Materials
Forty five samples of gum nodules fifteen for each location
The samples were dried at room temperature, cleaned by hand, ground using mortar and pestle and kept in labeled plastic containers.

3. Methods
3. 1. Physicochemical properties of the gum:
Gum samples were analyzed for moisture %, ash %, nitrogen and protein contents, specific optical rotation, intrinsic viscosity, equivalent weight and total uronic Acid according to AOAC (1990) methods.

3.2. The Calorific value
May only be used for the first time in this conduction to The calorific value of neem gum was determined according to. The IKA® C1 calorimeter system, which was calibrated standard IKA® C723 Benzoic acid tabs standard 0.5 g of gums samples were weighted (taking into account the moisture content) and placed into plastic bag, big bag or small bag which have cross cal. Val. 46383, and 46463 respectively, the bag was covered by rolling it and placed into a decomposition vessel which is surrounded by a water jacket. The sample was combusted in an oxygen atmosphere, and the calorific value of the sample was calculated from the resulting increase in the temperature.

3. 3. Sugar analysis
HPLC is widely considered sugar composition to be a technique mainly for biotechnological, biomedical, biochemical research, and for the pharmaceutical industry, is as well widely used in a lot of fields such as cosmetics, energy, environmental, and food industries (McLean, *et al*., 1983) [8].

3. 4. Cationic composition
Cationic composition was determined according to the dry ashing method (Perkin Elmer, 1994) [13] using Perkin Elmer 3110 Atomic Absorption.

3. 5. Amino acids analysis
The amino acid composition was determined according to Pellet and Young, (1980) [14]

3. 6. Rheological measurements
The 50 w/w% (based on loss on drying) gum solutions were prepared in water containing 0.005 w/v% NaN_3 as a preservative. The samples were tumble mix for 24 h and measurements were carried out at 25 ^{0}C (Han, 2007) [7].

4. Results and discussion
4.1 Physicochemical properties
Table (1) shows the physicochemical properties of *Azadirachta Indica* gum. The result showed moisture content was in range 11.2-12.2%, ash content 3.0-3.3%, pH 4.2-4.8, nitrogen 4.8-5.2%, protein 30.2-31.3%, specific optical rotation -65.6-67, intrinsic viscosity 26-36, acid equivalent weight 1543-1708, Total uronic acid 11.3-12.5% respectively. Moisture content depends on the stage of harvest and sugars. The moisture contents results were relatively in the range mentioned by Anderson (1968) [1] who claimed that moisture content of Neem gum range between 11.9 -13.0. Protein content in the sample were less than Anderson (1969) results (35.0 to 37.5). Optical rotation was greater than Anderson
(-58 to -62). Molecular weight in the samples showed wide range than Anderson (1969) who reported lesser range (5.2. x 10^5 – 7.1 x 10^5). Equivalent weight of acid was greater in the samples than what was found by Anderson who illustrated a range of 957 to 990. Uronic acid is greatly lesser than what was found by Anderson (1968) [1] (28.3).
Table 1 showed the sugar contents of *Azadirachta Indica* gum using HPLC technique were found to be Kordofan arabinose (18%), galactose (20 %), xylose (3%) and rhammnose (2%), while in White Nile location arabinose (14%), galactose (17%) xylose (3%) and rhammnose (3%). in Khartoum location. And arabinose content (22%) galactose (24%), xylose (4.26%) and rhammnose (4.26%).

Table 1: physicochemical properties Neem gum (composite)

Properties/ Location	Moisture %	Ash %	PH	Nitrogen %	Protein Content	Specific Optical Rotation	Intrinsic Viscosity	Molecular Weight	Acid Eq. Weight	Arabinose %	Galactose %	Xylose %	Rhmmnose %	Uronic Acid
Kordofan State	11.7	3.3	4.2	4.8	30.2	-65.6	24.2	$6.4x10^5$	1543	18	20	3	2	12.5
White Nile State	11.2	3.2	4.8	4.9	30.4	-65.5	26.3	$10.8x10^5$	1628	14	17	3	3	11.9
Khartoum State	12.2	3	4.7	5.2	31.3	-67	36.2	$12.0x10^5$	1708	22	24	4	4	11.3

4.2. Cationic composition
Table 2 the cationic composition of neem gum from the three locations. The most valuable cation were Mg followed by Na, Ca, K, Cu, Zn, P, As, Cd but the lead, Iron, Nickel and chrome were not found in the samples.

Table 2: Cationic composition of Neem gum from three locations.

Cation	Khartoum State	White Nile State	Kordofan State	Unit
Ca	12.600	9.6700	10.200	Mg/g
Mg	57.100	52.900	38.900	Mg/g
Zn	0.0710	0.0780	0.5800	Mg/g
Pb	0.0000	0.0000	0.0000	Mg/g
P	0.0200	0.0400	0.0400	Mg/g
Na	13.939	24.545	18.409	Mg/g
K	6.6870	11.932	6.2050	Mg/g
Cu	0.1852	0.1367	0.1136	Mg/g
As	31.4	55.7	32.2	Ppm
Cd	25.1	14.4	31.6	Ppm

4.5. Amino acids composition

Table 3 shows The amino acid profile for the samples of *Azadirachta Indica* gum expressed in mg/g. Asparagine, Threnine, Serine, Glutamine, Proline, Glysine, Cysteine, Alanine, Valine, Methionine, Isoleucine, Leucine, Tyrosine, Phenylalanine, Histidine, Lysine, and Araginine were the principal amino acids in *Azadirachta Indica* gum.

Table 3 Amino Acid of Neem gum from three locations

No.	Name	White Nile (mg/g)	Kordofan (mg/g)	Khartoum (mg/g)
1	ASP	12.55	6.32	21.23
2	THR	4.39	2.04	10.49
3	SER	1.75	0.55	6.58
4	GLU	7.31	9.93	14.54
5	PRO	11.06	10.90	14.96
6	GLY	3.03	1.92	5.90
7	ALA	9.73	8.72	8.73
8	CYS	2.45	3.22	0.31
9	VAL	13.64	10.46	19.04
10	MET	0.19	0.14	0.71
11	ILE	8.69	6.75	13.32
12	LEU	12.39	9.20	16.01
13	TYR	3.60	1.73	5.19
14	PHE	10.67	7.64	16.19
15	HIS	4.32	3.04	8.20
16	LYS	3.88	5.77	7.66
17	ARG	7.73	8.05	22.43

Table 4: Calorific Value of Neem gum from three locations composite

sample name	sample location	sample weight	Bag Cal. value J/g	Gross cal. Value	Net Cal. value j/g	net.Cal.value. cal/g	Cal.Value Kcal/g
A. *Indica* gum	Composite	0.5121	46463	16037	17829.2	4259.5	4.26

4.6 Calorific value

Table 4 showed The calorific value of *azdirachta indica* gum was about 4.26 Kcal/g This Calorific value is very low. That's mean the gum very suitable to used as food additives.

4.7 Intrinsic viscosity

The Intrinisc vicosity of *Azadirachta indica* gum was measured using U-tube Ostwald Vicometer. They are no significant different between three locations. The result shows in figure 1 are found to be kordofan 24 cm^3g^{-1}, White nile 26 cm^3g^{-1} and Khartoum 36 cm^3g^{-1}.

4.8 number Avarage Molecular weight

The molecular weight was messured using osomometer they are different between three locations. The shows in Figur 2 are found to be Kordofan 6.4x10^5 g/mol, White Nile 10.8 x10^5 g/mol, Khartum 12.0 x10^5 g/mol.

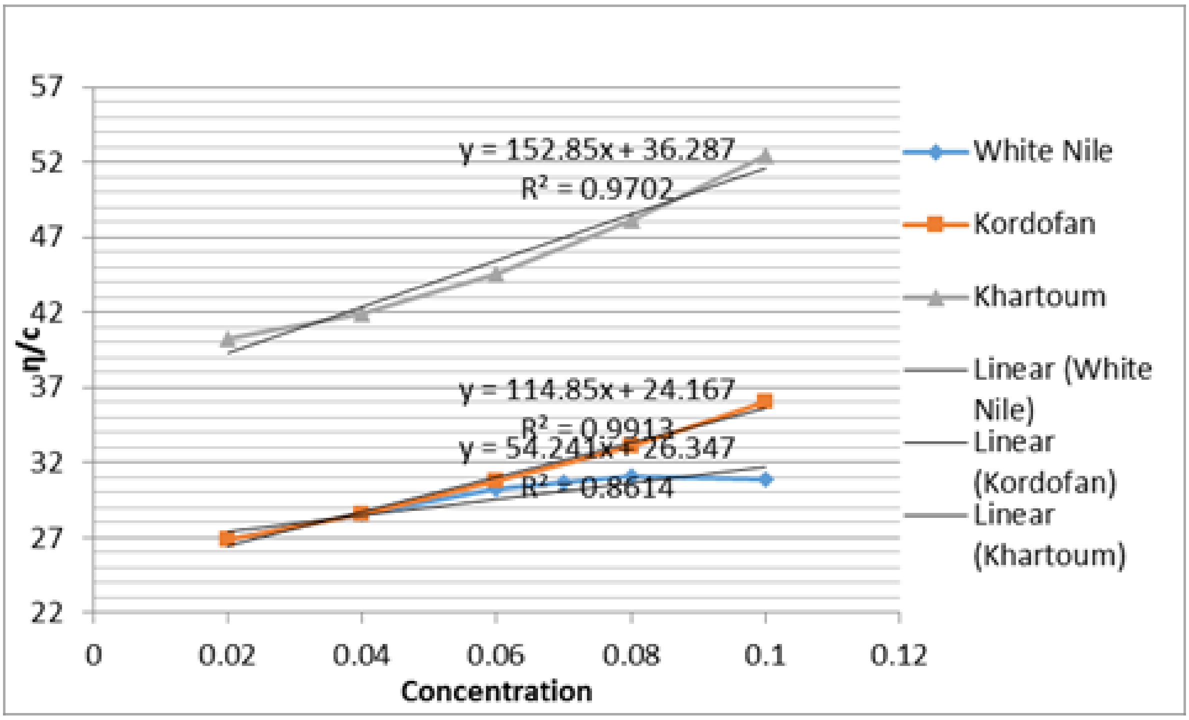

Fig 1: Intrinsic viscosity: (η/c) Variation with concentration

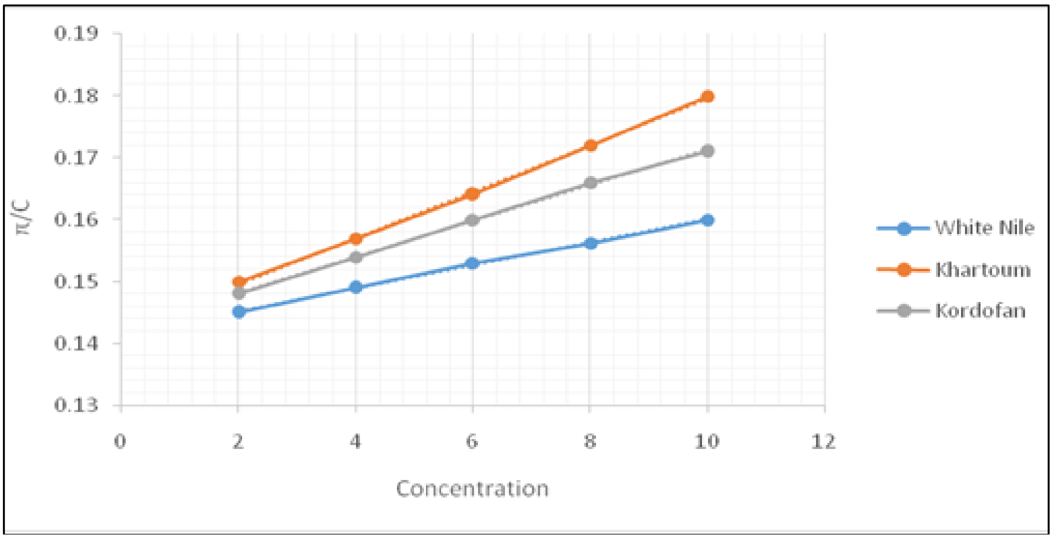

Fig 2: Number average molecular weight

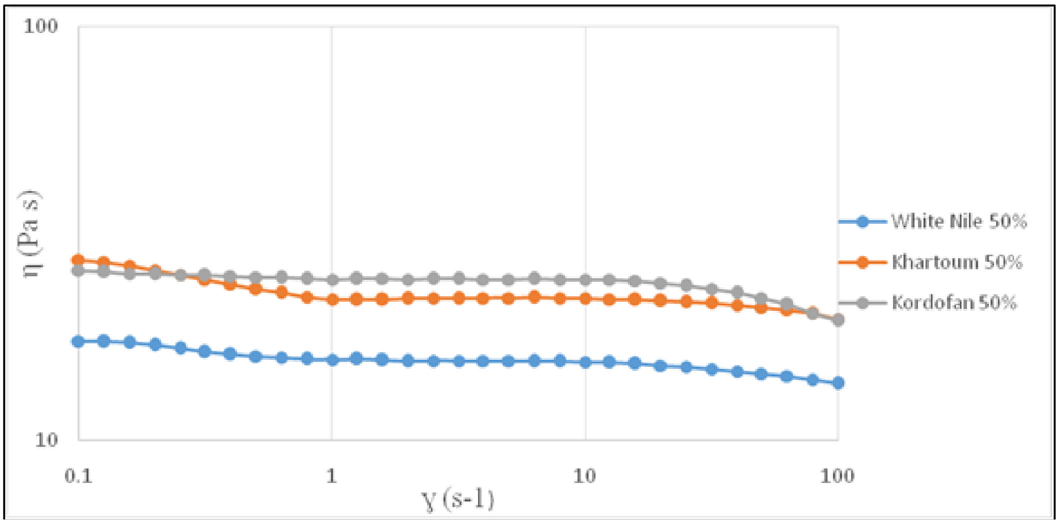

Fig 3: The dynamic Rheology of Neem Gum

4.9 The dynamic Rheology

Figs 4. Showed that the loss modulus (G ʺ) was higher than the storage modulus (G′) which indicates that the des not exhibit gum is viscous, not, elastic or visco elastic. (Xiaobei Li, *et al.*, 2009) [18].

4. Conclusion

Azadirachta indica gum showed physicochemical properties reflecting its resemblance to acacia *Senegal* gum and also acacia Seyal gum too.

The Rheology of *Azadirachta indica* indicates that the gum shows that the gum is simply a Newtonian fluid behavior, despite the high protein composition.

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