American Journal of Chemistry and Materials Science
2019; 6(2): 25-29
http://www.openscienceonline.com/journal/ajcms

Investigating Electric Conductivity of *Talha* Gum (*Acacia Seyal*), *Hashab* Gum (*Acacia Senegal*) and Their Blending Mixtures, Sudan

Elhadi Mohamed Ibrahim Elzain*, Binaat Grib Mastuor Ahmed

Institute of Gum Arabic Research and Desertification Studies (IGARDS), University of Kordofan, El-Obeid, Sudan

Email address

drelhadibrahim@yahoo.com (E. M. I. Elzain)

*Corresponding author

To cite this article

Elhadi Mohamed Ibrahim Elzain, Binaat Grib Mastuor Ahmed. Investigating Electric Conductivity of *Talha* Gum (*Acacia Seyal*), *Hashab* Gum (*Acacia Senegal*) and Their Blending Mixtures, Sudan. *American Journal of Chemistry and Materials Science.* Vol. 6, No. 2, 2019, pp. 25-29.

Received: January 28, 2019; **Accepted**: April 2, 2019; **Published**: April 26, 2019

Abstract

The study aimed to reveal whether gum *Talha* (*GT*), gum *Hashab* (*GH*), and their blending mixtures could have electric conductivity (EC). It is also aimed to know the effect of temperature and added electrolyte (NaCl) on their conductivities. Samples were collected directly from the field. One pound of each sample was collected by random sampling techniques. Primarily tests for moisture content, pH, ash, optical rotation were conducted to assure the specification of gum type. Ten different concentrations 0.5 – 5.0% were prepared from each sample. The EC were recorded by conduct-meter. The results were analyzed by Excel program and explained by tables and figures. The total dissolved salts (TDS) for *GT* and *GH* were also calculated. *GT* gave EC in the range of (0.06-0.86ꟽs), and *GH* in the range of (0.10-0.96ꟽs) for the chosen concentrations. The results showed that the maximum EC is reached when the concentration of gum solution is about 3%. The EC decreases with increasing concentrations, therefore this 3% concentration is recommended as an optimum for any further EC studies. The relationship between conducting property and temperature was also investigated, using the concentration of 3%. *GT* and *GH* gave EC values in the range of (0.12 - 1.10 ꟽs) and (0.06 - 1.31ꟽs) respectively. The relation between conducting property and the concentrations of 1.0 -9.0 mls of electrolyte (NaCl) of stock concentration 0.1M, had been added to 3% gum sample solutions, to have total volumes adjusted to 10 ml. *GT* gave EC values (0.06-1.51ꟽs) and *GH* gave EC values (0.10-1.72ꟽs). The study revealed that, *GT* is less conducting than *GH*, and also confirmed that, there is linear relationship between EC and the amount of TDS. The study also showed that, the EC increases with increasing the temperature, or adding the electrolyte (NaCl). The study also confirmed that, the conducting properties for either *GT* or *GH* could be increased by mixing with 10%fromthe other gum, as minimum.

Keywords

Gum Arabic, Electric Conductivity, *Acacia Seyal*, *Acacia Senegal*, *Gum Talha*, *Gum Hashab*, Blending Mixture

1. Introduction

1.1. General Properties of GA

Most plant families have some species that exudates gums, but only few are economically useful. Gums are natural polymericorganic substances obtained as exudates from trunks, or branches of trees, spontaneously or after mechanical injury of the plant, by injection or removal of the branches or after invasion by bacteria or fungi. The exudates become hard nodules or ribbons on dehydration to form a protective sheath against micro-organisms. The hard nodules form clear glassy masses which are usually colored, with tints to dark brown colors. The name gum Arabic (GA) is assigned for the gum obtained from both *acacia Senegal* and *acacia Seyal* trees. The trees are distributed south of Sahara Desert, in a continuous beltextending from west to east in Africa, known as the gum Arabic belt. GA is a natural product, composted of a solid mixture of polymeric compounds, of hydro-colloidal polysaccharides, mainly carbohydrates of high molecular weights, such as arabinose, galactose, and some peptides including nonmetallic and metallic elements, such as: Ca, Mg, and K salts, and other minor minerals are also detected [3]. *GT* is yellowish brown solid material. The drying nodules and tears are brittle and can easily break into siftings and dust. It is odorless and has stringent taste. Raw gum may contain extraneous materials such as sand and pieces of barks. The *GT* consists mainly of an acidic arabino -galactan protein complex, which on hydrolysis yields galactose, arabinose, ramose, glucuronic acid and 4-methoxy glucuronic acid [1].

1.2. Chemical Composition and Molecular Structures of Gum Arabic

The physical and functional properties of gums depend upon their chemical composition and molecular structure. There is a growing interest in the relationship between the chemical composition, molecular structure, physical characteristics and functional properties of gum exudates.

GA is a slightly acidic complex compound, composed of polysaccharides, glycol-proteins and their calcium, magnesium and potassium salts. The analyses of monosaccharide sugar composition have shown that *GT* has a lower rhamnose and glucuronic acid content than *GH*, but higher content of arabinose. The principal amino acids present in the *GA* are the hydroxyl proline, serine, aspartame, threonine and proline [8]. The chemical composition, which depends on the geographical origin, weather conditions at the time of harvest, type of soil, age and genotype of the tree and the processing conditions, also determines the quality of the gum [14].

1.3. Uses of GA in Foodstuffs

GA is extensively used in a variety of industrial applications, due to their emulsification, microencapsulation, thickening and stabilization properties. GA finds wide application as a flavor encapsulation in dry mix products such as puddings, desserts, cake and soup mixes and is also used to emulsify essential oils in soft drinks and to prevent sugar crystallization in confectionary products. GA has many uses in food material and as adhesive material due to its high viscosity and also used as additive to make stable suspension mixture. According to (JECFA) and (FDA) GA is generally recognized as safe. They also declared that GA does not cause any genetic mutations. The American National Institute for Health (NIH) also stated that GA is not carcinogenic.

***Table 1.** Shows physical and chemical characteristics of GA [7].*

Parameters	Gum Hshab (GH)	Gum Talha (GT)
Moisture Content	10	2.6
Optical rotation angle)	-26° to-34°	+45 to +60
Viscosity (ml/g)	16	14
Nitrogen%	0.3	0.15
Protein%	2.4	1
Rhamnose%	14	-
Arabinoose%	27	44
Galatose%	35	36
Uronic Acid%	21	16
Molecular weight	105	106

1.4. Uses of GA in Industrial Applications

GA is used in medical syrupiness, and in the preparation of etching and plating solutions in the lithography industry. It is used as a dispersant in paints and in keeping the pigments and active components uniformly distributed throughout the product. In the textile industry, it is used as a thickening agent in printing pastes for the coloration of knitted cellulose fabrics. Other applications; in ink, polishes, insecticidal /acaricidal emulsions, paints, pigment, cosmetics, and ceramics manufactures [6, 12, 13].

1.5. Conductivity

Conductivity is the ability, or power to transmit or conduct an electric charge, and it is a measure of how well a solution conducts electricity, or ions. Increasing the concentration of ions, the higher is the conductivity. The importance of conductivity measurement is an extremely wide spread and useful method, especially for quality control purposes. Surveillance of feed water purity, control of drinking water and process water quality, estimation of the total number of ions in a solution or direct measurement of components in process solutions can also be performed using conductivity measurements. The high reliability, sensitivity and relatively low cost of conductivity instruments make it a potential primary parameter of any good monitoring program. Some applications are measured in units of resistivity, the inverse of conductivity. Other applications require the measurement of total dissolved solids (TDS), which is related to conductivity by a factor depending upon the level and type of ions present. Conductivity measurements cover a wide range of solution conductivity from pure water at less than 1×10-7 S/cm to values of greater than 1 S/cm for concentrated solutions. In general, the measurement of conductivity is a rapid and inexpensive way of determining the ionic strength of a solution. However, it is a non-specific technique, unable to distinguish between different types of ions, giving instead a reading that is proportional to the combined effect of all the ions present. The ability of an aqueous solution to carry an electrical current depends on number of factors, such as the concentration, mobility of ions, presence of organic alcohols and sugars, valence of ions, temperature, etc…. The factors that influence the reliability of accurate measurements are mentioned in the technique sections covering the application. Conductivity is determined by numbers of ions present as a result of minerals or other compounds in the water. Most conductivity measurements are made in aqueous solutions. Other ions responsible for the conductivity come from electrolytes dissolved in the solution. (Salts like sodium chloride and magnesium sulfate or, acids like hydrochloric acid and acetic acid, or bases like sodium hydroxide and ammonia). Although water itself is not an electrolyte, the unit of measured conductivity is expressed as ohm^{1-}.

1.6. Problem Statement and Justification

The GA plays an important role in our daily life [2]. It is the most important commercial polysaccharide and it is probably the oldest food hydro colloid in current use [3].

GA is highly soluble in water up to 50% and insoluble in ethanol [4]. The solution is characterized by hydrogen-bonding, and has some intrinsic semiconducting properties [2]. The *GH*, which is obtained from *acacia Senegal* trees, is composed of carbohydrate units being linked to protein cores, mixed in heterogeneous manner including some metals in ionic forms as salts of macro molecules. In addition of that, there are some polysaccharides have the tendency to associate in aqueous solution and this affects their functionality and industrial applications, due to its influence of the molecular weight and size of the molecule, which also determine how the molecules interact with each other [9].

The hydrogen bonding, hydrophobic association and electrostatic interactions, depend upon the concentration and presence of protein components that affect the ability to form supra molecular complexes, all of which are properties possessed by GA. The molecular association in GA can lead to an increase in molecular weight in the solid state by maturation under controlled conditions of heat and humidity [10]. The role of protein components present in the gum is to enhance molecular association under different processing conditions. It was observed that these protein moieties promote molecular association through hydrophobic interactions that influence the size and proportionality of the high molecular weight AGP, thus improving its emulsifying potential [11].

Previous studies have shown that a synthesized GA – Graft – Poly-aniline polymeric biomaterial, acquires electrically active oxidation- reduction property [5]. A Study had been conducted by [2], illustrated that aqueous solutions of *GH* have semiconducting properties at different temperatures and concentrations.

This research aimed to study whether the solutions of *GT*, can conduct electricity at different concentrations and temperatures. And also to find the higher and lower limits of concentrations and temperatures that are required for optimum EC when mixing the *GH* with *GT*.

1.7. The Objectives

To

1. study the EC of *GT*.
2. evaluate the effect of temperature and concentrations on EC.
3. compare the results that obtained for *GT* to that of *GH*.
4. explain the effect of blending *GT* with *GH* on improvements of conductivity?

2. Materials and Methods

2.1. Collection and Preparation of Samples

Samples of *Acacia Senegal and Acacia Seyal* gum were collected by standard methods of samples preparation, as natural exudates nodules from the trees, with the assistance of the forestry officers, and with the help of GA Company Staff. The gum samples were collected during October to December in season of gum harvesting in Kordofan. The gum nodules were dried at room temperature, and then cleaned by hand to ensure they were relatively free from sand, dust and bark impurities, then ground, sieved and kept in a labeled container for analysis …

2.2. Materials & Chemicals

Conduct meter, magnetic stirrer, 100ml. beakers, 10ml cylinder, sensitive balance, thermometer, gum samples, sodium chloride, and distilled water.

2.3. Methods

1. Every time, accurate weights of gum were dissolved in 100ml of distilled water, and the concentrations were calculated.
2. The EC values for a series of concentrations were measured at room temperature (RT, 25°C).
3. The values of TDS were calculated from the EC values, by multiplying with a factor of 0.64.
4. Different amounts of sodium chloride were added, to each of the concentrations, and the EC values were measured at RT, and at other different temperatures.

3. Results and Discussion

Table 2. *Shows EC and TDS values at varying concentrations of GT at RT.*

Concentration (%)	Conductivity (μS)	TDS	Concentration (%)	Conductivity (μS)	TDS
5.0	0.86	0.51	2.5	0.35	0.22
4.5	0.70	0.45	2.0	0.38	0.24
4.0	0.61	0.39	1.5	0.21	0.13
3.5	0.48	0.31	1.0	0.12	0.08
3.0	0.42	0.27	0.5	0.06	0.04

The *GT* solution has EC which is proportional to TDS. The EC values increase with increasing the concentration of the *GT* solutions, up to the concentration of 5.0%.

Table 3. *Shows EC and TDS for varying concentrations of GH at RT.*

Concentration (%)	EC (μS)	TDS	Concentration (%)	EC (μS)	TDS
5.0	0.96	0.61	2.5	0.43	0.28
4.5	0.89	0.57	2.0	0.34	0.22

Concentration (%)	EC (мS)	TDS	Concentration (%)	EC (мS)	TDS
4.0	0.74	0.47	1.5	0.26	0.17
3.5	0.56	0.36	1.0	0.22	0.14
3.0	0.61	0.39	0.5	0.10	0.06

The *GH* solution has EC, but the values are greater than that for *GT*

The EC values increase with increasing the concentration, due to the increase of the ions in gum solution, and the EC values are proportional to TDS values.

Table 4. *Variation of EC values with concentrations and temperature, for GT solutions.*

	Con	100°C	90°C	80°C	70°C	60°C	50°C	40°C	30°C	20°C
Concentration %	5.0	1.10	0.93	0.87	0.84	0.80	0.76	0.73	0.70	0.66
	4.5	0.80	0.79	0.82	0.73	0.70	0.74	0.69	0.60	0.58
	4.0	0.85	0.83	0.79	0.78	0.75	0.70	0.70	0.66	0.60
	3.5	0.67	0.65	0.62	0.61	0.58	0.55	0.52	0.51	0.50
	3.0	0.72	0.69	0.68	0.65	0.69	0.57	0.57	0.51	0.49
	2.5	0.62	0.52	0.54	0.51	0.44	0.43	0.41	0.35	0.36
	2.0	0.79	0.75	0.74	0.71	0.69	0.66	0.63	0.59	0.58
	1.5	0.54	0.49	0.47	0.45	0.44	0.42	0.40	0.39	0.35
	1.0	0.38	0.34	0.32	0.31	0.30	0.29	0.27	0.26	0.23
	0.5	0.22	0.20	0.19	0.18	0.17	0.17	0.16	0.14	0.12

Table 5. *Variation of EC values with concentration and temperature, for GH solutions.*

	Temperature ºC									
	Con	100°C	90°C	80°C	70°C	60°C	50°C	40°C	30°C	20°C
Concentration %	5.0	1.31	1.31	1.29	1.26	1.24	1.17	1.12	1.08	1.08
	4.5	1.01	0.98	0.96	0.93	0.91	0.90	0.81	0.81	0.76
	4.0	1.03	0.96	0.94	0.91	0.88	0.85	0.78	0.77	0.75
	3.5	0.80	0.73	0.73	0.72	0.64	0.65	0.63	0.58	0.62
	3.0	0.98	0.95	0.87	0.82	0.76	0.75	0.71	0.67	0.70
	2.5	0.70	0.69	0.68	0.66	0.63	0.6	0.54	0.53	0.48
	2.0	0.69	0.63	0.61	0.57	0.53	0.53	0.48	0.44	0.44
	1.5	0.58	0.56	0.49	0.47	0.42	0.40	0.37	0.36	0.35
	1.0	0.33	0.31	0.30	0.29	0.25	0.24	0.23	0.21	0.20
	0.5	0.11	0.10	0.10	0.10	0.09	0.09	0.08	0.07	0.06

The EC values for *GT&GH* solutions increase with increasing temperature, but the *GT* solution is less conducting than the *GT* under the same conditions.

Table 6. *Variation of EC of GT solution with concentrations and amount of the electrolyte added at RT.*

	Amount of NaCl (mls)										
	Con.	0ml	1ml	2ml	3ml	4ml	5ml	6ml	7ml	8ml	9ml
Concentration %	5.0	0.80	0.83	0.94	1.08	1.13	1.23	1.31	1.41	1.50	1.51
	4.5	0.70	0.79	0.85	0.90	0.95	1.01	1.09	1.15	1.21	1.28
	4.0	0.61	0.70	0.78	0.89	0.95	1.05	1.14	1.22	1.29	1.37
	3.5	0.56	0.63	0.72	0.81	0.88	0.98	1.05	1.13	1.21	1.30
	3.0	0.65	0.74	0.86	0.97	1.08	1.18	1.26	1.36	1.46	1.54
	2.5	0.40	0.49	0.59	0.69	0.78	0.86	0.85	1.02	1.11	1.17
	2.0	0.38	0.48	0.59	0.68	0.78	0.88	0.97	1.05	1.14	1.23
	1.5	0.21	0.30	0.39	0.48	0.57	0.67	.75	0.84	0.92	1.00
	1.0	0.12	0.22	0.31	0.38	0.48	0.56	0.65	0.74	0.82	0.89
	0.5	0.06	0.16	0.26	0.34	0.43	0.52	0.60	0.68	0.75	0.85

The EC increases with the amount of NaCl added, because of the increasing ions concentrations.

Table 7. *Variation of EC values of mixed GT & GH solutions, with varying concentrations and temperatures.*

Con%	100c	90c	80c	70c	60c	50c	40c	30c	20c
4.5T+0.5H	1.10	1.02	0.99	0.95	0.91	0.90	0.85	0.82	0.77
4T+1H	1.21	1.18	1.24	1.18	1.17	1.13	1.08	0.99	1.05

Table 8. *Variation of EC of the mixed GT&GH solutions, with different concentrations, and different amounts of electrolyte (NaCl) added at RT.*

Con%	0ml	1ml	2ml	3ml	4ml	5ml	6ml	7ml	8ml	9ml
5H+0.5T	0.92	0.95	1.01	1.11	1.16	1.22	1.28	1.33	1.38	1.45
4.5H-0.5T	0.88	0.86	1.03	1.09	1.16	1.22	1.28	1.34	1.40	1.47
4H+ 1T	0.94	1.01	1.07	1.15	1.23	1.23	1.29	1.34	1.41	1.47

Table 9. *Variation of EC for mixed low GH and high GT with different concentrations of electrolyte (Na Cl), added at RT.*

Con%	0ml	1ml	2ml	3ml	4ml	5ml	6ml	7ml	8ml	9ml
5T+0.0H	0.78	0.66	0.98	0.99	1.06	1.14	1.18	1.27	1.33	1.39
4.5T+0.5H	0.66	0.76	0.84	0.91	0.99	1.05	1.11	1.18	1.28	1.32
4T+1H	0.71	0.76	0.84	0.91	0.99	1.04	1.09	1.16	1.21	1.28

The EC values of GH solutions Increase when mixing with GT solutions.
The EC values of GT solutions decrease when mixing with GH.
The EC values of GH solutions decrease when mixed to GT, with or without added NaCl, at RT.

4. Conclusion and Recommendations

GT is less conducting than *GH*. The EC increases with increasing temperature, or adding an electrolyte (NaCl). The conducting property for either *GT* or *GH* could be increased by mixing with 10% of the other gum, as minimum. It seems to be possible to alter some physical properties of gums, intent ally by special treatments.

The study recommends investigating the effect of other parameters on gum Arabic properties, for example;

1. adding; EDTA to modify the chelating of metal ions in gums, or
2. grafting with other macro molecules such as peptides, carbohydrates…, to change the matrix effect or the viscosity of gum solution,
3. doping gums with some transition or inner-transition metal ions, to change the magnetic or optical properties of gums, etc …

References

[1] Awad Elkareem, M, M, E (1994), Analytical Studies on some Crude and Processed Gum Arabic Samples with Regard to Quality Aspects. M. Sc., Thesis, University of Khartoum. Sudan.

[2] Elzain, Elhadi. M. I., Mobarak, Layla M. Dirar, M, Investigating the Electric Conductivity, Magnetic Inductivity, and Optical Properties of Gum Arabic Crystals *J. Basic. Appl. Chem.*, 2012, pp 35 -49, Textroad Publication, www.Textroad.com

[3] FAO, Rome (1990), Specifications for Identify Certain Food Additive.

[4] Ali, E. M. O. (1998), Nitrogen and Specific Rotation as Qualifying Indices for Gum Arabic Derived from Acacia Sengal (L) Wild. M.Sc. thesis, University of Kordofan.

[5] Tiwari, Ashutosh, Gum Arabic – Graft-Polyanaline: An Electrically Active Redox Biomaterial for Sensor Applications, J. of Macromolecular Science, Part A, Pure and Applied Chemistry (2007), 44, 735-745.

[6] Karamalla, K. A. (1995), Gum Arabic Chemistry.

[7] Sidding, N. E. Osman, M. E. Phillips, William, P. A. (2005). Studies acacia exudates gums, Part IV, Distribution of molecular components ion Acacia Seyal in relation to Acacia Senegal, Food Hydrocolloids.

[8] Gashua, Ibrhim Bable, (2016).Investigation of the molecular structure, composition and Biophysical properties of Gum Arabic, University of Wolverhamptom Ethiopia.

[9] Montenegro, M.A. Boiero, M. L. Valle, L. and Borsarelli, C. D. (2012).

[10] Assaf, S. Phillips, G. O. Aoki, H. and Sasaki, Y. (2007).Characterization of the Properties of Acacia Senegal, (L.). Wild Var. Senegal with enhanced properties (Acacia Sengal) Super Gum): Part 1 Controlled Maturation of Acacia Senegal var. to increase viscoelasticity and produce a hydro gel form and convert a poor into a good emulsifier. Food Hydrocolloids.

[11] Assaf S., Sakata, M., McKenna C., Aoki H., and Phillips G. O. (2009), Molecular Associations in Acacia Gums and Structural Chemistry, 20. pp. 325-336.

[12] Mukhtar, Leiala (2006), Electro conductivity of Gum Arabic from Acacia Sengal, Kordofan University, Sudan.

[13] Ahmed, 2018, Mohammed Khalifa Daia Elnor, Uses in geometry of gum Arabic, University of Kordofan.

[14] Idris et al., (1998); Flindt et al., 2005; Josiah et al., Gum 2008; Yebeyen, Lemenih and Faleke, 2009; Lelo Ab.