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Original Research Article

Effect of Helium-Neon Laser (632.8nm) on some physiochemical Properties of Gum Arabic *(Acacia senegal)*

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Abstract

This study was aimed to modify some physiochemical properties of Gum Arabic and it's Emulsions by using laser irradiation. The sample of *Acacia senegal* Gum was collected in December 2018 from Aburai Area, Ghibaish Locality-West Kordofan State. The sample was shade dried and ground at Agricultural Research Corporation (ARC) in El-Obied. The aqueous solution of the sample was prepared with concentration 20% (w/v) and used as a test sample. Some of unirradiated aqueous solution was taken as control and the remaining portion was irradiated for different periods of time (5,10,15,20 and 25 minutes) by He-Ne Laser at 632.8nm wavelength and power 3mw using the pulse at Department of laser in Al-Neelain University – Khartoum. The irradiated samples were transported to analysis at Laboratories of Sudanese Petroleum Corporation (SPC). The results showed that there was no change in values of electrical conductivity and pH, whereas the value of the emulsifying stability and the viscosity offered by the emulsion were increased with increasing irradiation period comparing with the control. The Fourier Transform Infrared (FTIR) spectroscopy technique indicated that there was no change in some functional groups such as (O-H, C=O, C-O, and CH_2) which were accompanied with absence of (C-X) at (10, 15, 20 and 25 minute) with formation of multiple bonding of nitrogen compounds at (10 and 15 minute) due to the effect of irradiation process. This study recommends that further work should be done to test other factors which may be had an effect on the emulsifying stability, also recommends to study the effect of He-Ne laser on Gum Arabic at another wavelength.

Keywords: Gum Arabic *(Acacia senegal)*, laser-irradiation, absorbance, emulsifying stability, viscosity and IR spectroscopy.

INTRODUCTION

Gum Arabic is a natural polymer, which plays an important role in our daily life. It's one of the major exported goods from Sudan, more than 67% of world product is from Sudan [1]. The Republic of Sudan is one of the most important countries producing Gum; Senegal, Mauritania, Nigeria, Tanzania, Morocco, Ethiopia and Somalia. It's also produced in South Africa, India and Australia. Most of the Gum produced in the Sudan comes from Acacia senegal tree which growth to about 15-20 tall and has a life of about 25-30 years, it grows in poor sandy reddish soil. It's found particularly in the best quality of gums from Acacia senegal and is known as (Hashab Gum) in Sudan and also known as Kordofan Gum [2].

Gum Arabic has many uses in food stuffs, and as an adhesive material due to it's high viscosity and it's also used as an additive to make stable suspension mixtures for medical syrupiness lithography, textile, paints, inks and cosmetics.

The solubility of gum Arabic in water is 98%, in polar solvent is 19%, in non polar solvent is 15%, in a protonated solvent is 97% and in potonated solvent is 15% gum Arabic is a material having a melting point (216-220^{0}C) osmosis pressure (1.16 erg^{-1}) and free energy is (0. 64 cm^2.mole/gm^2), molecular weight (1.007x10^6-1.148x10^{6}g), and nitrogen content between (0.46%-0.58%) the refractive index of gum Arabic is (1.3337). Gum Arabic is a most important commercial polysaccharide and it's probably the oldest food hydro-colloid in current use. Gum Arabic is a high molecular weight polymeric compound composed mainly of a carbon core mixed in heterogeneous manner, including some materials in ionic form as salts of macromolecules

which have weak conductive properties (Ca^{2+}, Mg^{2+}, K^{+}) [3].

Gum Arabic often forms clear glassy masses which are usually colored, dark brown to pale yellow. Fractionation is the most important method of analysis the acidic polysaccharides in crude Gum usually exist in form of neutral or slightly acidic salts of (Ca, Mg, Na, Fe). Gum Arabic is produced from many species of acacia in African origin, chemically Acacia senegal Gum is classed in a group of substances called, oddly arabino galactan protein, composed of arabinose (17-34%) galactose (32-50%) rhamnose (16%) glucuronic acid (3- 50%) and protein (1.8 – 16%) with an optical rotation of (28^0–32^0) [4].

Gum Arabic from Acacia senegal is a complex branched hetropoly electrolyte with a backbone of 1.3 linked β.galactopyranose unites and side-chains of 1-6 linked galactopyranose units terminating in glucuronic acid or 4-5 methyl glucuronic acid residues.

Gum Arabic consists of some fractions with distinct chemical structures, where the major one is a highly branched polysaccharide, the protein in Gum Arabic is rich in hydroxypropyl and serial residues linked to carbohydrate moieties [5], Gum Arabic is considered to be a good Gum for stabilizing oil in-water Emulsion systems due to the hydrophilic affinity contributed by it's polysaccharide fractions and the hydrophobic affinity contributed by it's protein fractions because stabilization can occur in a system comprised of protein and poly saccharide components [6].

The sandy gums are very pale yellow to colorless spherical nodules, while the clay soil Gums are brown to dark brown irregular nodules. All samples are soluble in cold water and no significant difference in physical properties except for minor increase in viscosity of sandy gum. Gum Arabic can be used in the applications of Electron Spin Resonance (ESR) technique to radiation dosimeter, and modified magnetic nano particle Gum Arabic promotes lumen to blood intestinal transport of water and sodium despite choler a toxin activation these observations support a potential role for Gum Arabic in enhancing the efficacy of oral dehydration solution. There are lot of studies which have been in Gum Arabic in normal classical uses as food stuffs or as adhesive materials so this study modify some properties of gum by using irradiation process [4].

MATERIAL AND METHODS

Sample Collection

Samples of Acacia senegal gum Arabic used in this study were collected from Acacia senegal (L) trees in Aburai area – Ghibaish locality West Kordofan State Season 2018. Sample was irradiated for different periods of time (5,10,15,20 and 25 minutes) by He-Ne Laser at 632.8nmv and power 3mw). Irradiation was performed at Department of laser in Al-Neelain University–Khartoum.

Methods of Analysis

Irradiation Procedure

20% (w/v) solutions were prepared in distilled water then the samples irradiated by He- Ne laser of 632.8nm and 3mw power, the samples placed at distance 10cm from laser beam by using pulse pattern the samples exposed to radiation for different periods of time (5,10,15,20and 25 minutes).

pH of Gum solution

20% aqueous gum were prepared at room temperature then pH was measured by using pH meter model 3510 (JENWAY).

Electrical Conductivity

20% aqueous solutions were prepared at room temperature then conductivity was measured by using conductmeter model APHA 2520B.

Emulsifying Stability

Emulsifying stability (ES) was determined according to method that 20% aqueous solution was prepared (over night) at room temperature the emulsion was prepared by mixing the gum solution and sesame oil (2:1) respectively the mixture was mixed for one minute using kitchen blender (19000 RPM), the mixture was then diluted thousand times with deionized water and it was read at λ_{max} 520nm emulsifying stability was measured using spectrophotometer model (DR 4000 VHCH**)** [7].

E.S. = Reading of absorbance at time T=0/Reading of absorbance after time T (in hrs).

Viscosity

Viscosity was determined according to method described by AOAC [8]. It was measured using A(HAAKE viscotester 6plus) for 20% aqueous solution at room temperature. The relative viscosity (η_r) was then calculated using the following equation:

$$(\eta_r) = \frac{T - T_o}{T_o}$$

Where,

T = flow time of sample solution expressed in seconds.

T_O = flow time of solvent (distilled Water (DW)) expressed in seconds.

FTIR Procedure

Gum sample was loaded directly introduced into FTIR spectroscopy and scanned at 4000-400cm^{-1} at resolution intervals of 4.000cm^{-1}

RESULTS AND DISCUSSION

Table-1: Some Physiochemical properties of control and irradiated samples of 20%(w/v) Acacia senegal Gum solutions at room temperature

Irradiation time	Viscosity in cp	Percentage of viscosity	pH	Conductivity in ms
Control/zero	18	30.3%	5.1	3.27
5	22	36.6%	4.8	3.54
10	19	31.6%	5.1	3.27
15	18	31.5%	5.1	3.25
20	21	35.5%	5.1	3.46
25	19	31.6%	5.1	3.28

The results showed increase in viscosity, small change in pH and no change Electrical conductivity.

Emulsifying Stability

The emulsifying stability was tested at room temperature (See Table-2). The results showed increasing in Emulsifying stability with increase of exposure time in compression with control sample this result agree with change in viscosity and confirm that the laser irradiation is useful in this case. In addition to that there was some changed in the colour of gum Arabic samples that were subjected to laser irradiation during the experiment. This change of colour from white to reddish could be a reason for activation Fe atom in gum Arabic molecule which was induced by He-Ne laser of 632.8nm irradiation [7].

Table-2: Emulsifying Stability of control and irradiated of 20% (w/v) Acacia senegal Gum solution at room temperature

Irradiation time	E.S in the first hour	E.S in the second hour	E.S in the third hour
Control(zero)	0.985	0.986	0.992
5	0.995	0.998	1.001
10	1.000	1.004	1.005
15	1.001	1.005	1.009
20	0.997	1.004	1.008
25	1.000	1.003	1.008

E.S = Emulsifying Stability

FT-IR Analysis

Comparing the absorbance of irradiated sample with control sample found that the absorbance at (3451.34) in control assign to (OH) group stretching of Gum and Water involved in hydrogen bonding witch slightly change at rang (3228.83-3451.77) due to effect of irradiation, the bands (1635.34) in control indicted (C=O) which appear at the same region in sample during the different time of irradiated this assigns unaffected of (C=O) group stretching by the radiation (15) and the band (2105.19) in control assigns to thiocynate group witch effected by radiation in samples due to change in absorbance bands during time of irradiated, also the (CH_2) group effected by radiation according to change in the absorbance bands, the bound (C-O) slightly effected by radiation along the time of irradiated, but the bromide ion found in irradiated sample at (5minutes) but absent at (10, 15, 20minutes) and appear at (25)minutes and (COOH) absent at irradiated time (10, 25) may be due to formation of new nitrogen bounds assigns to highly effect of radiation.

Table-3: FTIR (cm^{-1}) of control and irradiated samples of Acacia senegal gum in different times

Functional group	Control	5 min	10 min	15 min	20 min	25 min
OH	3451.34	3451.77	3228.83	3264.08	3416.57	3444.29
C=O	1635.34	1635.37	1635.54	1635.08	1635.48	1635.40
Isocynate and related ion	2105.19	2107.19	2113.19	2110.81	2107.45	2098.86
CH_2 rocking	759.68	757.36	771.73	752.34	760.03	760.35
Bromide	664.86	664.69	-	-	-	664.71
COOH	1416.79	1415.72	-	1417.00	1416.57	-
C-O	1034.37	1034.41	1032.75	1034.21	1034.96	1034.30
N-bonds	-	-	2385.36	2384.03	-	-

CONCLUSION

Properties of Gum Arabic from Acacia senegal were studied using laser irradiation in different period of time (5, 10, 15, 20, 25 minutes). It was found that the effect of irradiation increase the viscosity and emulsifying stability. And FTIR results explained the

break down of some functional groups and probability of formation of others functional groups. The results showed that small change in pH and no change in Electrical conductivity.

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