CERTIFICATION

This is to certify that I have supervised, read and approved this project report which I found adequate both in scope and quality for the partial fulfillment of the requirement for the award of bachelor of engineering (B.Eng.) degree in chemical Engineering.

ENGR. GEORGE ARPAN
PROJECT SUPERVISOR

DATE

DR MATTHEW EDOGA
SINOR DEPARTMENT

DATE

DR J.O ODIGURE
HEAD OF DEPARTMENT

DATE

EXTERNAL SUPERVISOR

DATE

DECLARATION

I hereby declare that this project work is my original work and has never to my knowledge being submitted elsewhere before.

PRECOIUS LAWANI ***DATE***

TABLE OF CONTENTS

Table of Contents **Pages**

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ABSTRACT

Acacia tree is one of the cheapest sources of adhesive used for non-structural applications. It is readily available especially in the tropics typical of northern Nigeria. Various acacia species normally produce juices that are used in formulating gum Arabic. In this work therefore, gum arabic was developed from solid acacia juice obtained from the northern Nigerian

About 40 grams of solid acacia juice was dissolved in 60 percent of hot water at 100°c for 12 hours, and subsequently formulated with about 0.03g of stabilizer (sodium chloride). Moreso, some of the physicochemical properties of the adhesives were determined.

The stabilized adhesives possess viscosity of 4.76cp. It was observed that the viscosity of the stabilized adhesives decreased as the temperature as well as the quantity of sodium chloride decreased. Furthermore, the pH of the adhesives (Experimental samples) also decreased as the quantity of the stabilizer decreased. Whereas the pH of the commercial gum was found to be slightly acidic (6.74). The viscosity of the same commercial gum compared favorably with that of the experimental adhesives. The experimental samples (adhesives) were basic whose pH range was 9.31 – 9.55.

CHAPTER ONE

INTRODUCTION

Adhesives are substances capable of holding material together by surface attachment with the ability to sustain the designed load requirement without deformation or failure.

Adhesive can be classified based on their applications and setting, chemical composition cost and stability for various adherends and end products. The great volume of wood adhesives for structural application are thermosetting phenol-formaldehyde (PF) or urea formaldehyde (UF) polymer or their derivatives whiles adhesives such as epoxy urethane and polyvinyl acetate are used as assembly gives with wood for home projects and other non-structural application. In the late eighties, glue and other adhesive products were manufactured from hides and bones. Due to the low-level of production in this country it is therefore imperative that the alternative sources of adhesive raw-materials be investigated. It is on this ground that the present work is trying to develop wood adhesive from solid-acacia juice.

Acacia is a genus of tree and shrub of the mimosa tribe of the pea family, with approximately 450 species widely scattered in warm regions, perhaps three hundred in Australe and a few in southern united state. In this research project we choose a particular species which is the acacia senegal.

A few are herbaceous, but most are quick-growing, short-live shrubs with finely divided, often fernlike leaves or narrow expansion on the leaf stalk taking the place of leaves. The Egyptains utilize gum Arabic From the acacia tree. Acacia juices (by-products) were among the earliest natural polymers to be exploited commercially and still find extensive use today as gum Arabic and extenders for most wood adhesives.

Gum Arabic is a natural adhesive developed from the solid, acacia by product. It is mostly used as paper gum (walling of paper) and as adhesives for particle board manufacture. Gum Arabic although possesses some good qualities, but has poor stability durability. Effort have been geared towards stabilizing it with some salts among which are halide ions, beinzimidozoles, benzotrnazoles and mercaptotetrazoles. The problem till today remains unsolved.

The objective of this present study therefore is to develop and stabilize gum Arabic prepared from acacia juice that may be used in wood and paper industries. The physicochemical properties of the adhesive will also be investigated.

CHAPTER TWO

LITRATURE REVIEW.

2.0 Acacia is the common name for plant of the genus acacia of the legume family, leguminosea. The genus contains many familiar and useful species. Acacias are known as wattles in Australia and as thorns in eastern Africa, and are some times sold by florists as mimosa in Europe and north Africa.

World climatic zones that have a long, dry winter and a short wet summer often support a shrubby vegetation known as thorn scrub and savannah. Acacia trees constitute much of the vegetation in such climatic regimes. The trees are characterized by their umbrella shape, with basal branching of the stems, the foliage forms a flattened or curved crown. The flowers usually yellow, grow in crowded globes head or cylindrical spites are common, and the central America bull-horn acacia, acacia Senegal, host a pulp-eating that hollow's out them. Acacia can tolerate long periods of drought and because of the thorns, survive heavily grazed area.

Acacia are used as ornamentals in tropical and sub-tropical gardens, as shade tree and as indoor plants. Livestock are fed from the leaves of some acacias in Australia and some parts of Africa, the seeds or pods of other acacia are eaten by humans. Australians use acacia wood for railroad ties, wheels, handles, and furniture. Some pods yield a substance use for washing silk and as shampoo. Acacia are also sources of gums, tannin and a dye called clutch.

Various classification of acacia have been made by botanist, there more than 400 species of acacia, but this research project will be specifically on acacia Senegal, among the acacia species are:-

i) Acacia macrothyras
ii) Acacia Senegal
iii) Acacia dudgeoni
iv) Acacia gourmaensis
v) Acacia laete
vi) Acacia compylacant
vii) Acacia macrostachya
viii) Acacia sieberiana
ix) Acacia nilotica
x) Acacia seyel
xi) Acacia heclii
xii) Acacia gerrardii
xiii) Acacia albida and so on

The above classification was based on the propensity of the tree to release nitrogen cyanide.

2.1 History of acacia Senegal.

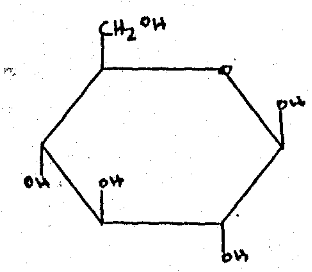
This small tree, one of the chief source of gum Arabic, is readily recognized by the triple spines at the base of the bran-chalets. This character is shared with the very similar acacia dudgeonii, and occasionally a third spine is met within acacia latex. It extends from Senegal to north-eastern Africa and South to Mozambique.

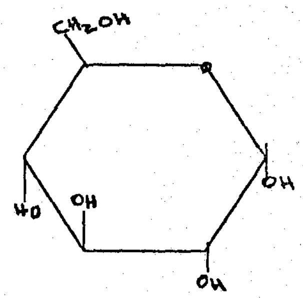
Gum Arabic also called acacia gum is exudation of the small tree acacia Arabic, and various other species of acacia trees. Sennear-gum is gum Arabic exported from Arabic port on the red dry regions of North-west Africa and some parts of Nigeria e.g Maduguri, Makukele, Zugaru e.t.c. Gum taiha, taica gum or talh gum, is a brittle and low grade of gum Arabic from the North Africa acacia, acacia tenocarpa. Gum Arabic is used for adhesive, for thickening inks, in textile coating and in drug and cosmetics emulsion. As a binder in pharmaceutical table the powder act as a disintegrating agent to make tablet easily soluble in water. In confectionery glazes it prevent crystallization of the sugar.

To obtain the gum, the trees are wounded and the sap is allowed to flow out, forming yellowish, transparent lump. It is also marketed as a white powder of 120 meshes, soluble in water, but insoluble in alcohol. Gum Arabic is a mixture of calcium, magnesium, and potassium salts of arabic acid, in a complex of the saccharides arabinose, galalactose, rhamnose or manno-methylose and the open chain glecuronic acid. It has a molecular weight of 240,000. For drug uses, gums are selected, blended, and ground to a powder of uniform characteristics. It is used as a stabilizer and binder in coatings adhesive, phamarceuticals and in low-calorie food-stuffs. The wood of the gum Arabic tree is the stainwood of the near east, valued since ancient times for it's great durability. It is light in weight, hard, closes grained, and has as orange-brown colour that darkens with age. But the satinwood of brazil, known also as setting is a yellow wood from a large tree Aspidisperma eburneum, usual for images.

2.1.1 CLASSIFICATION OF GUM.

The term gum denote a group of industrially useful polysaccharides or their derivatives that hydrate in hot or cold water to form viscous solutions or dispersions. Gum are classified as natural and modified gums. Natural gums are produced principally in Africa or Asia and are obtained from seeds, seaweed or exudates from tree. All hydrocolloids from plant or microbes are polysaccharides. The hydrophilic groups can be either nonionic, anionic or cationic chemically, the polysaccharides are composed of pentoses or more commonly hexoses. The stereo-chemistry ring is either cis (□) or Trans (□), as shown in the following structures.





β-D-glucose α-D-glucose

Source	Gum	Food consuption (tons)
Tree exudates		
Acacia Astragalus Steoculia urens Anageissus latifolia	Gum Arabic Gum tragacnth Gum karaya Gum ghatti	5600

2.1.2 <u>Chemical and physical properties of Gum.</u>

Polysaccharide gums dissolve or swell in water although in many cases high temperature and vigorous agitation are required before complete dissolution is achieved. Solutions formed are usually thick and viscous even at low concentration (1%) and the resultant viscosity will depend on the molecular size, shape and charge of the individual gums. The viscosity charged polysaccharides is usually reduced drastically by the addition of electrolytes and at low pH. As is typical of polymers, gum solutions are non-Newtonian in behavior rate owing to the disentanglement of molecular coils and their alignment in the direction of the field of flow. Solutions are also often thixotropic with their original viscosity being restored with time on standing commercially, mixture of gums are often employed since synergistic effects may be observed, with the resultant viscosity being greater than the viscosities of either of the individual gum alone at the same total polymer concentration.

Under certertain conditions some gums will undergo a degree of intermolecular association in solution with sections of polymer chain on different molecules coming together and creating junction zones, which leads to the formation of three dimensional gel network, solutions containing as little as 1% gum or even less are capable of forming strong gel. However, water leakage, referred to as synersis, often occurs with time as a consequence of increased polymer Chain aggregation. Syneresis can be reduced by the addition of nongelling gum and this also tends to improve the freeze-thaw stability of the gel. The gelling temperatures and physical properties of gels, including their strength, elasticity, brittleness, hardness, e.t.c. a considerably for different gums and gel may be thermally reversible or irreversible.

Gum are predominantly hydrophilic and in solution have a strong tendency to undergo hydrogen bonding in water molecules. Water molecules that are bonded to the polymer chain are prevented from freezing. In systems containing sugar or ice crystals, gum can retard crystal growth by adsorbing onto crystal or by competing for available water molecules.

Gum exudates differ considerably chemically. They generally have a highly branched complex structure and often consist of two or more distinct fractions. Gum Arabic (Acacia Senegal) consists of three water-soluble fractions, namely an arabinogelactan (90%) and two arabinogalactan- protein complex's which differ in their molecular size and in the proportion of proteinaceous material associated with each. The carbohydrate structure of the three fractions is similar each containing a □-1,3-linked galactopyranose residues. There is extensive branching from both the main chain and the side-chains. The overall sugar composition is D-galactose 44%, L-arabinosa 25%, D-glucuronic acid 15.5% L-rhamnose 14% and 4-0-methyl glucuronic acid 1-5%. The ironic acid and rhamnose residues terminate branches.

2.1.3 CHEMICAL COMPOSITION OF GUM ARABIC.

This resin gum arabic just like any other resin has a chemical composition which are highly branched polymer of galactose, rhamnose, arabinose, and glucuronic acid. It is well known that gum arabic is a mixture of calcium, magnesium, and potassium.

2.1.4 NATURE OF GUM ARABIC.

Gum arabic is a water soluble gum but insoluble in alcohol. Gum arabic obtained from acacia Senegal tree, is produced commercially as a white power, and is used in the manufacturing of Inks, in textile finishing and adhesive.

Gum Arabic is the most widely exploited tree gum exudate. It is extremely soluble in water and solutions containing up to 50% gum can be prepard. Solution viscosity is vary low compared to other polysaccharides. The gum undergoes autohydrolysis when heated at high temperatures for a prolonged period, resulting in the precipitation of the protein-rich fractions. Gum arabic is very effective at stabilizing oil-in-water emulsions and it has been shown that it is the minor arabinogalactan-protein complex fractions which have ampliphilic characteristics and give rise to this functional properties it's abiity to act as an emulsion concentrates for the soft drinks industry and also in the production of spraydried encapsulated flavours for use in dry package products such as soup and cake mixes. In the latter case, the gum forms a film around the flavour particle, preventing Oxidation and evaporation, and it's high solubility facilitates rapid flavour release when the dried flavours are introduced into water. Gum Arabic is widely used in confectionery products particularly those with high sugar content such as pastilles where it function by retarding sugar crystallization. It is also used to emulsify oils in toffees.

2.2 PREPARATION AND CHARACTERIZATION OF GUM FROM ACACIA SENEGAL

gum from Acacia Senegal was fractionated using hydrophobic affinity chromatography characterization, including identification of sugars and determination of protein and amino acid contents, was undertaken for each fraction, together with measurements of molecular mass and molecular-distribution using laser light scattering and gel permeation chromatography. Results indicated that the gum consist of 3 distinct components. Fraction 1 (88.4% of total gum) is an arabinogalactan with the molecular mass 2.79×10^5 and is deficient in protein-fraction 2 appears to consist of, on average 5 carbohydrate blocks of molecular mass approx. 2.8×10^5 convalently linked through a chain of amino acid residues. Fraction 3 (1.24%) contains approx. 25% of the total protein and consists of one or more glycoproteins, whereas the proteinaceous competently hydroxyproline and Seiren, this is not the case for fraction 3.

2.2.1 USES OF GUM ARABIC

Although many plant gum exudates are known, only gum Arabic, ghatti, karaya and tragacanth have wild industrial use. Gum Arabic is used mainly as a stabilizer and thickener in food and also used thickening Inks, in textile coatings, in drug, cosmetics emulsions. As a binder in pharmaceutical tablet the powder act as a disintegrating agent to make the tablet easily soluble in water. In confectionery glazes it prevent crystallization of the sugar. It can also be used to produce adhesive of which this project is mainly about.

2.2.2 Production of gum arabic

Several plant exude, as a result of pathological infection or physiological malfunctioning of the system. In the first cartergory is a phenominon termed gymmosis because it result in the exudation of gum like substances. This may because by micro-organisms insects, mechanical indury or physiological disturbance in the plant. Gummosises is frequent in species belonging to pronoideae and meliaces in which the combium,instead of forming normal wood element give, rise to groups of perenchyma cells. gummosis starts in the core of these parenchymatous group, which then proceed to the periphery. A cavity is formed in the center and the fills with gum, and the cell disintegrate. In several species of Alcacia, gummosis is a common phenomenon e.g alcacia senegal, from gum arabic is commercially extracted. However, similar sap exudation occurs in the bark. A watery sap exudes from a hold created by damage in the main tree trunks of teak. Fluid starts 00zing from an ovalhole on the main trunk of trees more than 25 year old. The teak tree is decidous and the maximum flow rate is form. The flow rate has been monitor diurnally, and 100 to 200ml of the fluid could be collected in a single night.

The condition begins with the formation of a water, blister on the trunk that later exudes. When affected trees are felled, a large crevice can be seen in the trunk that is probably form by spliting the wood. Affected tree hold several liters of fluids inside this crevice.

CHAPTER THREE

3.0 EXPERIMENT.

3.1 TREATMENT.

The solidified acacia extract used for the development of the adhesives was first screened to remove sandstone, wood particles and other foreign body that were sticked to the extract. The preparation techniques used in this case was hot water dissolution and sieving methods.

3.2 PREPERATION OF THE ADHESIVE.

About 40g of the treated acacia extract was mixed with about 60% of hot water at temperature of 100°c for 12 hours, after that the dissolved mixture was sieved and weighed in a weighing balance. The mixture was collected in a beaker booml, it was heated in a hot metal plate to the temperature of 100°c for 30minutes, to achieve homogeneity, the mixture was agitated with a glass rode until a targeted viscosity was obtained. The content was cooled in a water bath until the temperature was 27°c.

3.3 DETERMINATION OF SPECIFIC GRAVITY.

The specific gravity of the adhesive produces was determined with the aid of specific gravity bottle. The procedure involved pouring water into the specific gravity bottle and instating the instrument untill the fleet was steady and the reading, reads from the calibrator.

Adhesives was now used in place of water and the value read from the calibrator.

3.4 STABILIZATION OF THE ADHESIVES.

Stabilization of the produced adhesives was carried out by the addition of sodium chloride wihich was very soluble at temperature of 75°c upward. 25ml of the adhesives at the temperature of 75°c was taken in a beaker and 0.15g of sodium chloride was added and stirred with a magnetic stirrer for some time, at temperatures of 65°c and 60°c respectively.

The viscosity of each adhesive at 27°c was determined. The pH was equally determined and the density was calculated. These were done for about 4-5 times by adding different grams of salt to it.

3.5 VISCOSITY DETERMINATION.

The viscosity of the stabilized adhesive was determined with the aid of thistle funnel. The time taken for the whole content to run down the funnel was noted, using stopwatch. From this result the viscosity of the sample was calculated (see Appendix). The procedure was repeated for commercial gum.

3.6 MEASURMENT OF ADHESIVS pH

The pH of the stabilized adhesive was measured with the a pH meter. 20ml of the sample was collected in a beaker and the P^H determined by inserting the P^H meter electrode into it. The value was read from the instrument. The procedure was repeated for commercial gum.

CHAPTER FOUR

4.0 RESULTS.

4.1 The results obtained from this work are presented in table 1- 5.

TABLE :1.0

The composition of acacia extract from acacia plant

ACACIA JUICE	WEIGHT (Kg)
Acacia latex freshly extcruded	6.8
Gum Arabic after some hours	5.69
When dry	1.18

TABLE 2.0

Drying periods of extracted latex

S/N	DATE	TIME	WEIGHT (g)
1.	7-9-2000	11:30am	160
2.	8-9-2000	11:30am	91.0
3.	9-9-2000	10:20am	80.7
4.	10-9-2000	11:am	77.0
5.	11-9-2000	11:36am	76.07
6.	12-9-2000	11:15am	75.0

Table 3.0

The results obtained from from production and stabilization of gum arabic adhesive from acacia juice

S/N	Weight of dry gum Arabic	Volume of Nacl (g)	Volume of adhesive produce (g)	Density g/cm^2
1.	2.5	50	38	1.02
2.	2.5	50	38.5	1.02
3.	2.5	50	38	1.02

Table 4.0

Acacia extract adhesives stabilization

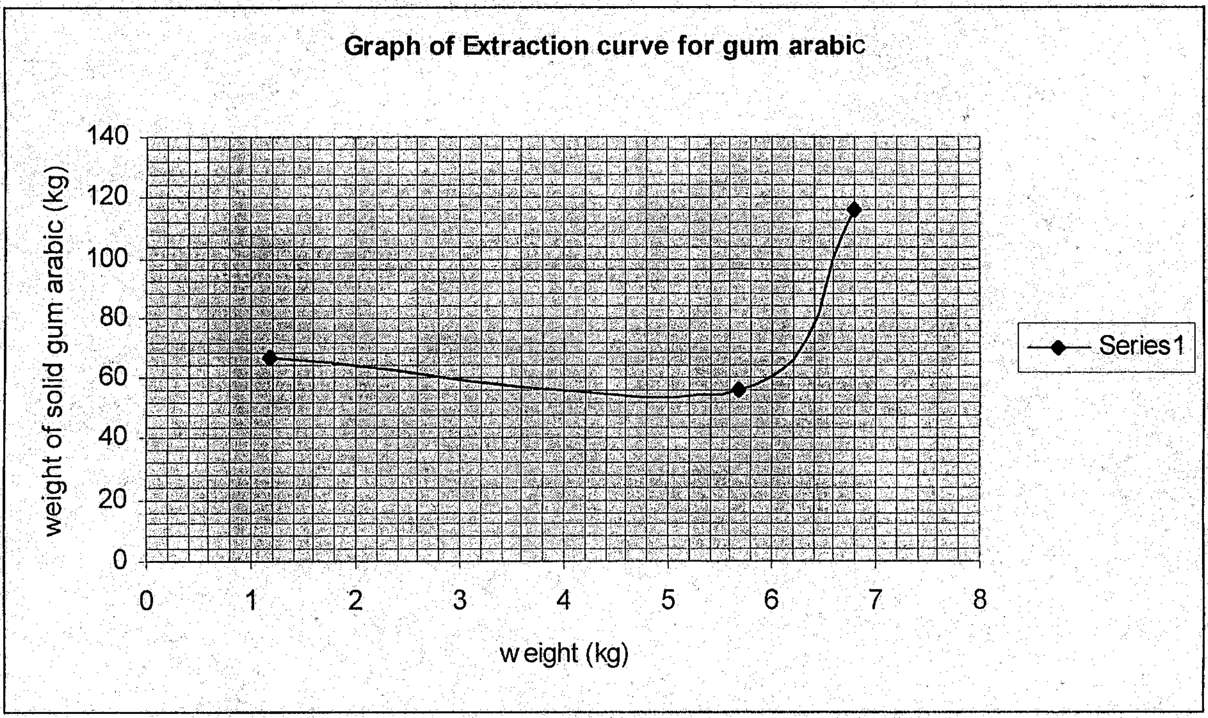
S/N	Volume of sample (g)	Quality of sodium chlorate (g)	Temperature in ^oC	PH	Density g/cm	Time sec	Vixosity $\mu x 10^6 cp$
1.	25	0.15	75	9.55	1.026	272	8.056
2.	25	0.10	65	9.36	1.024	172	5.0919
3.	25	0.8	60	9.3	1.023	125	3.6969
4.	25	0.8	50	9.31	0.23	125	2.6969
5.	25	0.03	40	9.21	0.22	125	2.7689

Table 5.0

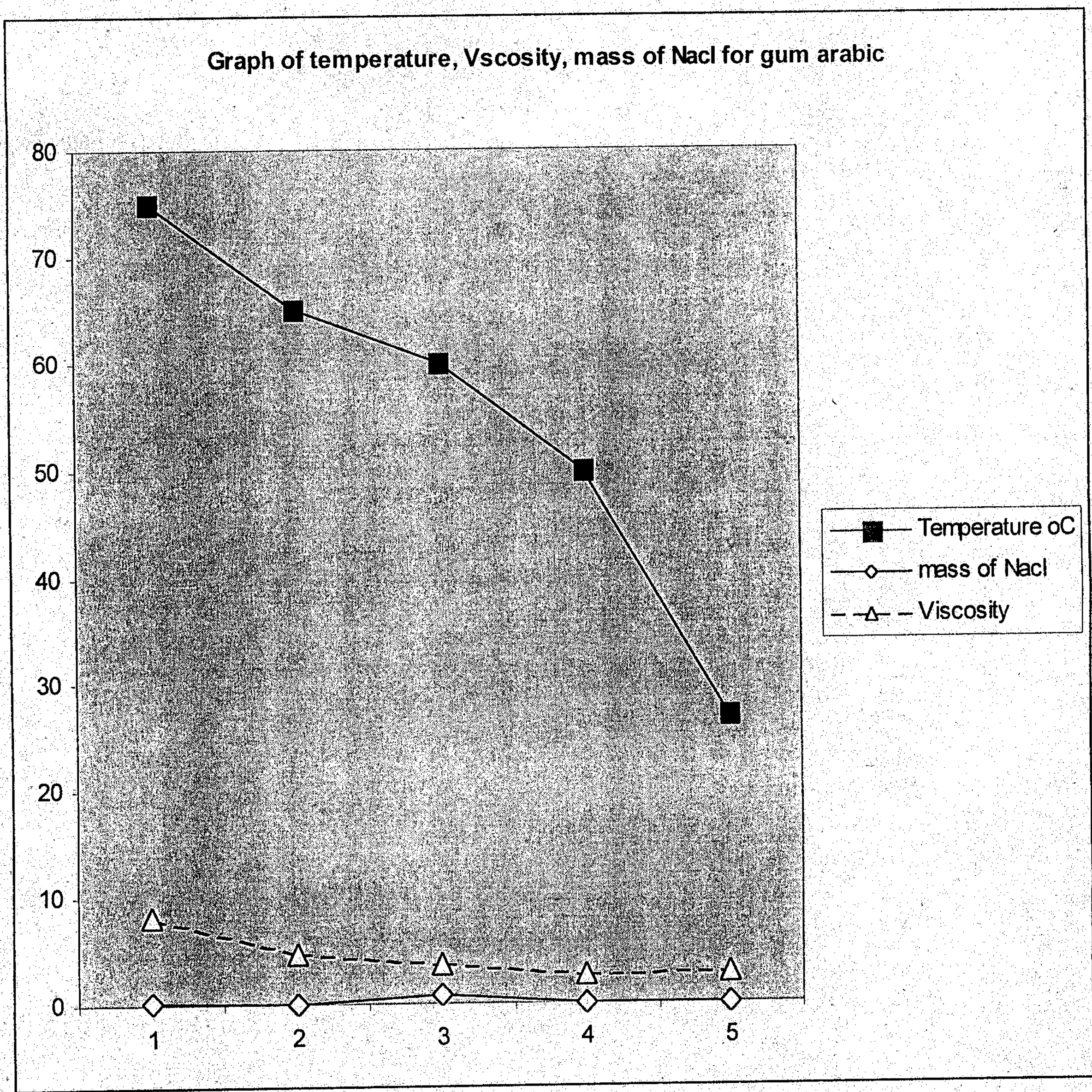
<u>Commercial Gum</u>

S/n	Volume of Sample	PH	Density g/cm^3	Time Sec	Viscosity μ x10^{6}cp
1.	25	6.74	1.03	160	4.7644

The extraction curves for acacia extract was drawn using the respective data. Also graph of temperature, viscosity versus quantity of sodium chloride added was plotted.



Graph of Extraction curve for gum arabic
weight of solid gum arabic (kg)
140
120
100
80
60
40
20
0
0
1
2
3
4
5
6
7
8
w eight (kg)
Series1


Graph of temperature, Vscosity, mass of Nacl for gum arabic
80
70
60
50
40
30
20
10
0
1
2
3
4
5
Temperature oC
mass of Nacl
Viscosity

CHAPTER FIVE

5.0 DISCUSSION OF RESULTS

From the graph it is observed that the stabilized adhesives decreases as the temperature and quantity of sodium chloride decreases.

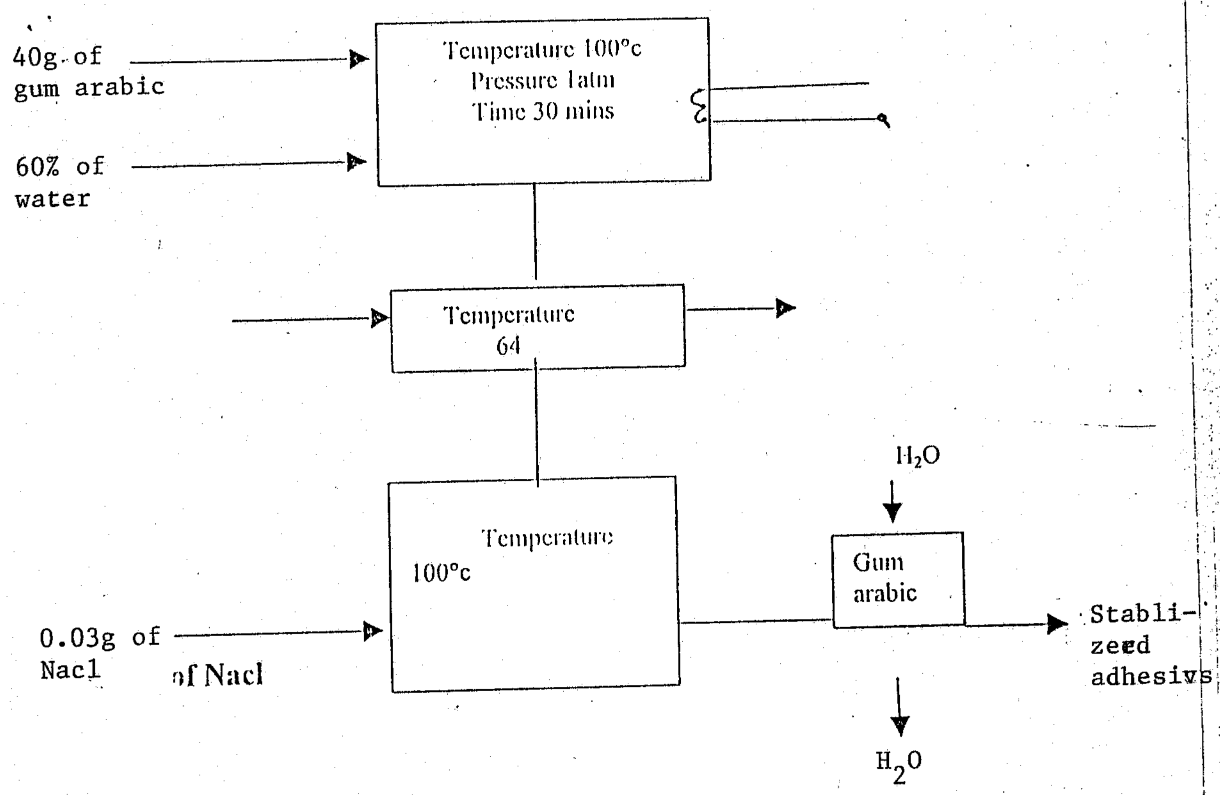
The pH of the adhesives depend on the quantity of sodium chloride added. As the quantity decreases the pH also decreases however it was basic.

The pH of the commercial gum was found to be slightly acidic (e.g. 6.74) while gum arabic produced from this work was found to be between 9.31-9.55. Where the commercial gum was a bit acidic and the experimentally produced one was basic. This could be due to the stabilizer used.

The viscosity of the commercial gum was found to be 4.7644×10^6cp. and the stabilized gum arabic developed in our laboratory possessed the same viscosity at and the temperature of 64°c and concentration of 0.098g of sodium chloride for gum arabic.

4.7644x10

Fig. 5.5 PROCESS FLOW DIAGRAM FOR PRODUCTION OF GUM ARABIC ADHESIVES.



CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUTIONS

The development and stabilization of gum arabic adhesive using acacia extract was carried out. Adhesives produced from acacia Senegal is more stable than that of other unstabilized acacia species, it is much more tacking than the unstabilized gum arabic and more importantly it compared favourably with the commercial gum arabic.

6.2 RECOMMENDATION.

After carrying out the laboratory work, there is need to make some recommendations.

1) Other various stabilizers should be looked into so as to determine their suitability for stabilizing gum arabic from acacia.
2) There is the need, for any other person seeking to carry out further research on this process to check the effect of concentration of dilute Nacl salt on this process
3) 1t is equally recommend that a detailed economic analysis of this project be carried out to ascertain the economic feasibility of the process.

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APPENDIX.

Calculation or derivation

From graph using 1

$$\text{Cradient } M1 = \frac{AB}{BC} = \frac{10.6}{0.044}$$

$$= 20.41°C\ C/g$$

$$C_1 = 43.5°c$$

$:.\quad T = M_1\, x + C_1$-(19)

substituting the respective values we have

$T = 204.30 \text{ x } 43.5$---------------(2)

Using 2

$$\text{Gradient} + M2 = \frac{AB}{CB}$$

$$= \frac{1.7 \text{ x } 10^6}{0.03}$$

$$= 56.67 \text{ x } 10^7 \text{ cp/g}$$

$M = M2^x + C_2$ ----------------------------(3)

$O = M_2\,(0.02) + C_2$

⇨ $C_2 = -1.1334 \text{ X } 10^6$

$:.\ M = 56.67 \text{ X } 10^7\ x - 1334 \text{ x } 10^6$------------------(4)

From equation 2

$$x = \frac{T-43.5}{204.20}$$ -----------------------5

substituting 5 into 4 we have

$M = 56.67 \text{ x } 10^7 \text{ x } [\,T-43.5] - 1.1334 \text{ x } 10^6$----------------6

e.g for $N = 4.7644 \text{ x } 10^6$

we have

$4.7644 \text{ x } 10^6 = 2.727 \text{ x } 10^5\ [\,T-43.5\} - 1.1334 \text{ x } 10^6$

$5.8978 \text{ x } 10^6 = 2.777 \text{ x } 10^6\ [\,T - 43.5\}$

⇨ $T.T- 43.5 = \frac{5.8978 \text{ x } 10^6}{2.720 \text{ x } 10^5} = 21.65$

⇨ $T = 65°c$

⇨ Similarly for graph 6

⇨ T= 170 x 47--7

⇨ And ὶ= 7.7291 x 10^5 [T-47] – 5.25 x 10^5 -----------8

Sample calculated for density.

Specific gravity = 1.02 from table 3

:. Density = 1.02 x 1 g/cm^3

'calculation of viscosity

volume of adhesive v= 25ml (cm^3)

time taken to run through the thistle funnel

T= 272 see length of heistle funnel limb = 29.5cm^3

Density of adhesive = 1.026 g/cm^3

Acceleration due to gravity = 980cm/5^2

Mass of the adhesive = volume x Density

25 x 1.026 = 25.65g

force = 25.65 x 980 = 25137 gcm/5^2

volumetric flow rate $= \frac{V}{Time} = \frac{25}{272} = 0.0919cm^3/5$

$\frac{\text{Volumetric flow rate}}{\text{Length of the lumb}} = \frac{0.0919}{29.5} = 0.00312cm^2/5$

:. ὶ (viscosity) $= \frac{F}{\frac{\text{volumetric}}{\text{length of the limb}}} = \frac{25.37}{0.00317} = 8.056^7 \times 10^6 cp$

DEVELOPMENT AND STABILIZATION OF ADHESIVES FROM ACACIA JUICE

BY

LAWANI PRECIOUS EDITH

MATRIC NO. 96/5436EH

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