IE PRODUCTION OF GUM FROM CASHEW TREE LATEX

BY

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NOVEMBER 2004

CERTIFICATION

This is to certify that the project was supervised and approved by the following under listed persons on behalf of the chemical engineering department, school of engineering and engineering techr ology, federal university of technology, Minna.

.... 22nd NOV 2004. ....

Project Supervisor date

(Engr. O.S. Azeez)

....

Head of department date

(Dr. F. A. Aberuagb:)

....

External Supervisor date.

DECLARATION

I Obi Vivian Ify declare that this project report is original report of my experimental work and to the best of my knowledge has not been presented elsewhere for the award of certificate or degree.

....

Student signature

22nd Nov. 2004

....

Date.

DEDICATION

This work is dedicated to Almighty God for seeing me through my degree programme; and to my mother for all her moral and financial support, also to my siblings who were always there for me and whose continues support have seem me through.

ACKNOWLEDGEMENT

This project benefited immensely from well-appreciated helping hands, I say thanks to Almighty God for his Grace and mercy.

To my mother Mrs. Kate .I. Obi and to all my Sister and brothers for all there moral and financial support, may God bless you all.

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Also to everyone that has also contributed in one way or the other, I say a big thank to you all.

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ABSTRACT

The purpose of this research work is to produce gum from cashew tree latex, which can acts as a substitute to gum Arabic. The method used includes drying and size reduction of the exudates gum, sieving of the gum to remove impurities, dissolving of gum in distilled water, filtration to remove polysaccharide waste, concentration of the gum and stability of the gum. The additives used in stabilizing of the gum includes; Glycerin, starch and Zinc oxide. The pH and Viscosity on addition of various percentage concentration of stability were determined. The best quality was gotten from the gum with viscosity and pH of 4.52 Ns/m^2 and 4.20, this because of it falls within the range of natural pH of gum from acacia Senegal with range 3.9 – 4.9. The gum can be used as an alternative for synthetic adhesive used presently for stamps and envelopes.

CHAPTER ONE

1.0 INTRODUCTION

GUMS, RESINS AND LATEXES

Apart from essential oil, which provides an array of flavours and fragrances, gums, resins and latexes are perhaps the most widely used and traded category of non-wood first products other than items consumed directly as foods, fodders and medicines.

Substances frequently called gums are hydrocarbons of high molecular mass; others are petroleum products rubber latex. Synthetic polymeric gums, basalms and resins (novel internet materials, 2002).

Recently the term 'gum' as technically employed in industry refers to plant or microbial polysaccharides and their derivations that are capable of forming dispersions in cold or hot water producing viscous mixtures or solutions.

The latter references to the term gum mean soluble cellulose derivatives and those derived from, and modifications of other polysaccharides that in their original state would be insoluble. Thus the definite of gum can include mucilaginous polysaccharides. Modification of gums and the addition of gums in soluble even in low concentration can affect the viscosity of dispersion.

Cashew tree gum represented non-conventional alternatives the art began in china centuries ago. Reaching its climax of development during the 'ming dynasty' (1368-1644AD) and climber sin which the terms are alternate mostly pinnate.

The resin is synthesized in the epithelial cells having canals and then secreted into these internal cavities.

Synthesis generally occurs in all organs of the plant with different qualitative composition, appearing to be genetically controlled and little influenced by environmental condition.

Cashew gum is similar to gum Arabic and may be used as a substitute of liquid glue for paper, in the pharmaceutical and cosmetic industries as an agglutinant for capsules and pills and in food industry as a stabilizer of juices. It can also be utilized in the making of cashew wines.

Research has already been carried out in respect of its in the making of ink and vanishes.

Cashew gum extraction represents one more source of revenue for the producer, in addition to the cashew nut.

Cashew gum is a complex polysaccharide of high molecular mass, on hydrolysis it yields galactose, thermoses and galacturonic acid. The variation innacid number is influenced not only by the source of the sample but also by its age.

The sticky exudates from this tree darken and thickens rapidly on expose to air. When applied as a vanish provides remarkable protection, as is unchanged by acids, alkalis alcohol or heat up to 70^0c.

A occident (cashew tree) and A. nanum produce cashew gum, a substitute for gum Arabic. Not only are they good adhesive but they also contain a small amount of cashew oil, which can be used as an insect repellent or as a lubricant in the electrical insulation of aeroplanes.

Comparative studies among specimens of gums obtained from geographical areas have been made, the result indicate that there are significant variations in properties associated with climatic conditions such as the compositions. Studies of exudates gums from species belonging to the family Anacardicene have been mainly on representatives of the genus Anacardium and Spongras. In A. occidentale, galacturonic acid is not observed, suggesting a combination of agalacturonic and 4-0-methyl glucuronic acid not commonly found in the family Anacardiaceae (Novel Internet material, 2002.)

The cashew tree belongs to the botanical family Anacardiaceae that contains 60-80 groups and about 600 Species distributed, but with a few group in northern temperate regions and some native to the semi-arid coast of Brazil.

Economically, the family is important for various reasons. The family includes resinous trees, shrubs.

The gum is composed of complex branched heteropolysaccharides and their Calcium, Magnesium, Potassium and Sodium salts with a weight average molecular mass of about 1.5 x 10^4g (Mc Graw – Hill Encyclopedia of Science and Technology, Vol 2 Page 654.)

Hydrolysis of sample of gum from Brazil gave the following composition; 70% galactose, 5% arabinose, 11% glucose, 4% rhannose, 1% Mannose and 6% Glucoronic acid.

1.1.0 AIMS AND OBJECTIVES

The aims and objectives of this research work is to produce a gum for usage in postal stamps, envelopes, in pharmaceutical and cosmetic industries as an agglutinant for capsules and pills and in food industry as a stabilizer of juices using cashew tree latex, a local source of raw material that will reduce the cost of production and therefore conserve Nigerian foreign reserve.

CHAPTER TWO

2.0.0 LITERATURE REVIEW

2.10 ADHESIVE AND GUM

Substances frequently called gums are hydrocarbons of high molecular nass; others are petroleum products, rubber-latex synthetic polymeric gums, balms and resins.

Recently, the term gum as technically employed in industry refers to plant or microbial polysaccharides and their derivatives that are capable of forming dispersions in cold or hot water producing viscous mixtures or solutions.

Gums are classified as natural or modified gums. Natural gums are based on their botanical origin example plant exudates from cashew gum, seed and gum by microbial fermentation. Modified gums are produced by pure chemical synthesis example cellulose and starch derivatives.

Gums are called after their place of origin or the part from which they are exported example gum Arabic from the Arabian part. The true gums are characterized by solubility in water; there are three types namely,

i) Soluble example Senegal gums

ii) Semi-soluble example Ghatti gums

iii) Insoluble example tragacanth gums

The term gums means soluble cellulose derivative and those derived from modifications of other polysaccharides that in their original form would be insoluble.

Thus, the definition of gum can include mucilaginous polysaccharides.

2.2.0 TYPES AND USES OF SOME TREE EXUDATES

i) Cashew gum

From research it is understood that cashew gum is similar to gum Arabic.

Cashew gum is sticky exudates of A. occidentale, a tree that grows wild in many tropical and subtropical countries. Although cashew gum has not found many individual uses, its application in the field of pharmacy has been described. The gum is a complex polysaccharide, comprising 61% galactose, 14% arabinose, 7% rhamnose, 8% glucose, 5% glucurine acid and 2% other sugar residues.

Elementary analysis revealed water content 7.4%, total protein measured about 0.5%, total lipids, 0.06% fibers, 0.95% ash, 0.95% ash. The total carbohydrate was 98%.

USES OF CASHEW GUM

Cashew gum is used primarily in industrial application for binding books, as adhesives for envelopes, label, stamps and posters.

It is use as an additive in the manufacturing of chewing gum become of its thickening power. It is used as a jelling agent in canned food and jellies for fruit jam and pastries.

Cashew gum has an unlimited application in a wide range of products in the cosmetic industry. It is also used as binder in pharmaceuticals tablets. And also as stabilizer and thickener in chocolate, milk and of fats in the manufacturing of salad dressing.

2.2.3. GUM ARABIC

Gum Arabic has a close similarity work cashew gum. Gum Arabic, hardened exudates obtained from the tree of acacia Senegalis. The exudates are usually contaminated and discolored by dyes from tree bark.

Its solubility in water is extremely high sometimes as much as 50%, where as that it the natural gums cannot be more than 5% because of their high degree of gum Arabic makes it particularly useful as a stabilizer and emulsifier and these are the quality sought after by the user.

USES OF GUM ARABIC

The main function of the gum is to retard or prevent crystallization of sugar and it also acts as an emulsifier keeping the fat uniformly distributed throughout the product.

Gum Arabic is also used as an additive the manufacturing of chewing gum because of its thickening power. It is also used to modify the consistency of certain foodstuffs by increasing moisture-holding capacity.

It is used as an adhesive or binders in pharmaceutical tablets. Gum Arabic has unlimited application in a wide range of products in cosmetic industry. In lotions and protective cream, it stabilizes the emulsion, increases the viscosity, which adds a smooth feel to the skin and forms a protective coating. In industry, it is used as adhesive for envelopes, labels and stamps.

2.2.4. KARAYA GUM

Karaya gum is used in the power form as a dental adhesive.

It thickening characteristics, relatively solubility and it resistance to bacteria makes it particularly suitable for its purpose.

Other important uses mainly are in pharmaceutical industry as in the production of laxatives, it is also in the textile and paper industries.

2.2.5. GUM TRAGACANTH

Gum tragacanth has a relative stability when subjected to heat and acids.

The food industry is the main user of this gum; it is particularly appreciated for its properties as a stabilizing and emulsifying agent.

Other important uses are in the pharmaceutical and cosmetic industries; it is also used in toothpaste, hair lotions and body creams.

Other exudates and extracts including; gum locust, bean gum, gum ghatti have found different uses in industries depending on their characteristics or properties.

2.3.0 METHODS OF PRODUCTION OF GUM

The methods of gum production includes,

1. Steam and solvent methods.
2. Tapping method.

2.3.1 STEAM AND SOLVENT METHOD

This is the industrially employed method, which involves the collection of the tree bark, cutting the bark as to reduce the size to splinters and the use a suitable solvent to leach the splinters.

Water soluble gum, water is used as a solvent and this is done either cold or hot but insoluble gum as in the case of gum naval stores are obtained from gum oleo resin collected from tapped piped trees.

Soluble process involves cutting over prune forest stamps and trash wood, which provide the raw materials. The wood is first grinded in a wood hog and then reduced into a battery of extractors where they upon a false button and stream under pressure is admitted to the bottom for solvent recovery.

The extractors are built of acid resistance stainless alloys and operate at pressure of 446-500Kpa. The solvent counter currently extracts the clips.

The solvent may be Naphtha, the residue from the first evaporator is sent to an intermediate evaporator.

The vapours from the evaporator are led into the upper part of the continuous fractional column and the residue is sent to the furnishing evaporator.

2.3.2. TAPPING METHOD

Many plants secrete gum only form injured area by sealing the wound as gum prevents further injury from bacteria and fungi and also prevents excessive loss of water.

Therefore gum ooze out of the tree and with time on exposure to atmosphere it hardens to form dry gas if small hardened drops which are then collected and purified.

2.4.0 ORIGIN OF CASHEW TREE

The cashew tree belongs to the genus Anocordium, a member of the family of the anacardiaceace. The English name "cashew" is derived fro the portugese name of similar promucration "caju" which in turn comes the tupi-Indian word "acajen".

Food value

When cashew fruit s fully ripped, the apple can be eaten fresh or can be used in making Jams, Jellies, pie stock, Vinegar, chutney, alcohol and with unripe apple it is used in the preparation of carried vegetables and pickles.

Another important product of cashew is the cashew nut shell liquid, a brown, sticky and caustic liquid found between the other and in skins of the shell. Cashew nut shell liquid (CNSL) is used in making adhesives, inks, paints and a mixture of 5% CNSL and 95% kerosene or diesel oil has been found to be an effective mosquito larvicide's.

Cashew is also an excellent species for reforestation, it can greatly reduce soil erosion and slow the flow of water and minimize flash flood.

2.50 PLANT EXUDATES.

Cashew gum is a sticky exudates. The gum is a complex polysaccharide, comprising 61% galactose, 14% arabinose, 7% rhamnose, 8% glues, 5% glucoronic acid and 2% of other sugar residues.

Since it is soluble in water, its further characterization is desirable with a view to incorporating it is in porous combination of other polysaccharides or protein.

The properties of cashew gum which includes the following; the cashew gum is non-toxic, odorless, tasteless, and yield an aqueous solution, it is soluble in water and insoluble in oil and in most organic solvents.

The viscosity of cashew gum is measured by Brooke field viscometer.

The cashew gum also possesses an anticoagulant properties, they also have antibiotic activities such as influencing various viral infectious where molecules are widely separated, the viscosity shows slight dependence (Mc Graw Hill Encyclopedia of science and Technology, vol. 6 page 418).

2.5.1. POLYSACCHARIDE

Polysaccharides have been described as a high molecular weight polymers formed by condensation of many monosaccharides units or derivatives (Dyke, S.F. 1960). They have also been described as polymeric substances, the building blocks of which are monosaccharides. From the fire going polysaccharide could be said to be long chain carbohydrate molecule built from some monosaccharide such as galactose, rhamnose, glucose etc. or their derivatives.

Polysaccharide could be classified based on their chemical compositions. In this regard, a polysaccharide which yields only one type of monosaccharide on hydrolysis is called a homoglycan example starch while these yield two or more types of monosaccharide are called heteroglycan e.g. cashew gum polysaccharide could also be classified based on linearity, (polysaccharide without chain e.g. amylase) and branched (polysaccharide with side chains e.g. cashew gum).

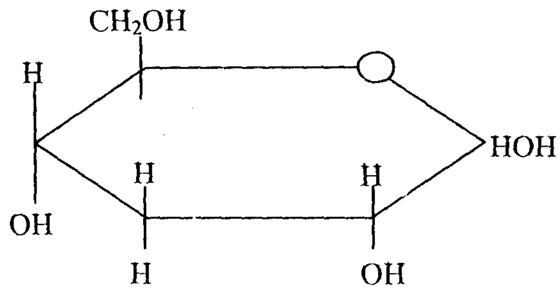
2.5.2. STRUCTURE

Polysaccharides are normally insulted from their natural environments for study. When monosaccharides come together to form polysaccharides, numerous hydroxyl group other than that of the former. The few mannoses, which occur as components of polysaccharide, are D-galactosamine, D-glucose, D-fructose, D-xylose, L-arabinose and D-glucuronic acid. These mannoses are shown in figure below.

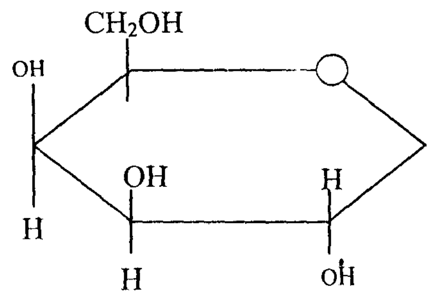
Structure and Composition of Cashew Gum

Hydrolysis of cashew gum yields L-arabinose, L-rhamnose, D-galactose and glucuronic acid (Glicksman and Sand, 1973). Auto hydrolysis of cashew gum yields 34.4% arabinose, 14.2% L-rhamose plus 3-OB-D-galactopyransoyl-L-arabinose, on further hydrolysis with degraded acide produces 42.1% of D-galactose, 15.5% lucuronic acid and some 6-O-B-D glucupyranosyluronic acid.

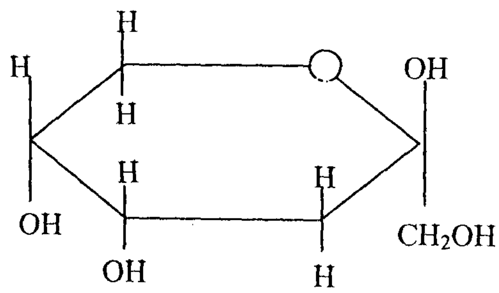
Mild hydrolysis of the gum yiels L-arabinose,L-rhamnose, 3-B-D-galactopyranosyl-L-arabinose shown in figure below.



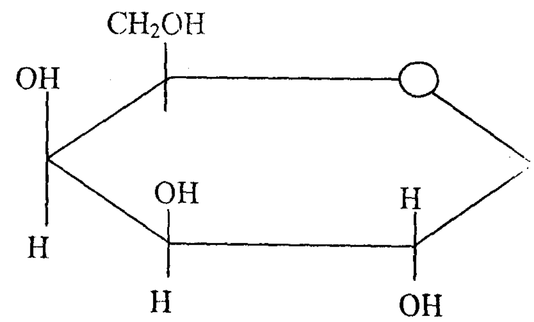
D-glucose



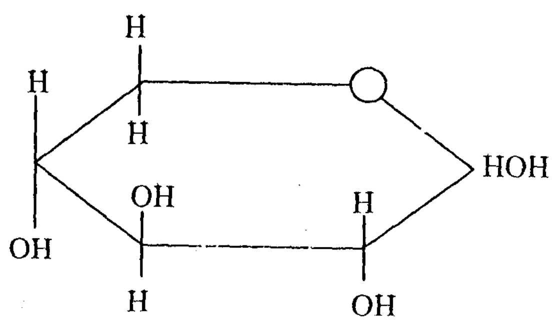
D-mannose



D-fructose

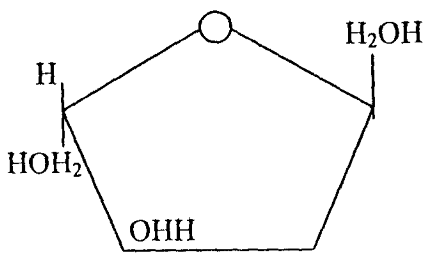


D-galactose

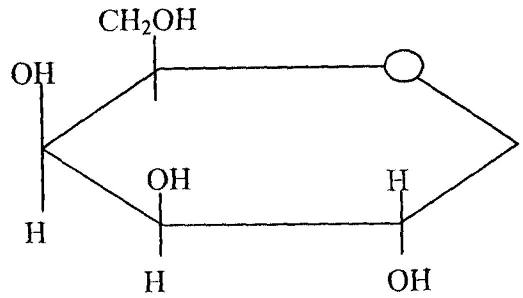


D-xylose

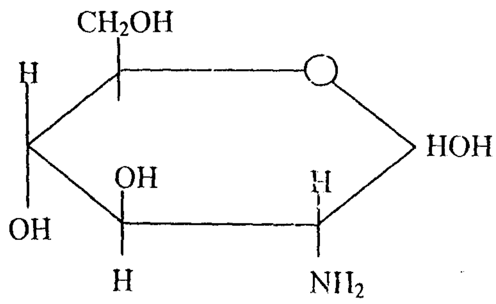
Fig. 2.0: Structures of Simple Sugar



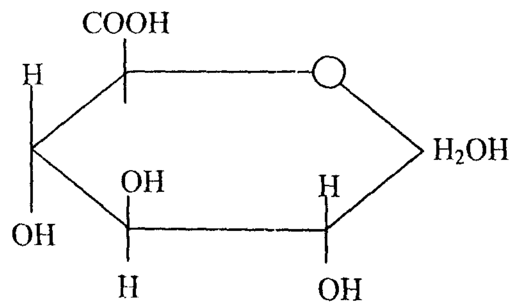
L-arabinose



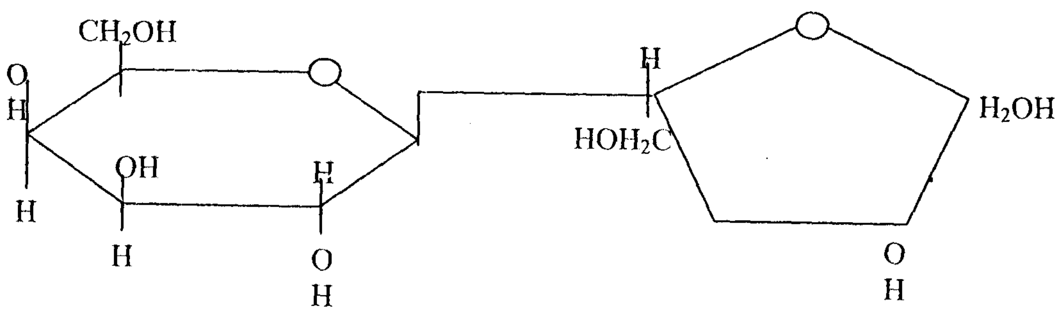
GLucosamine



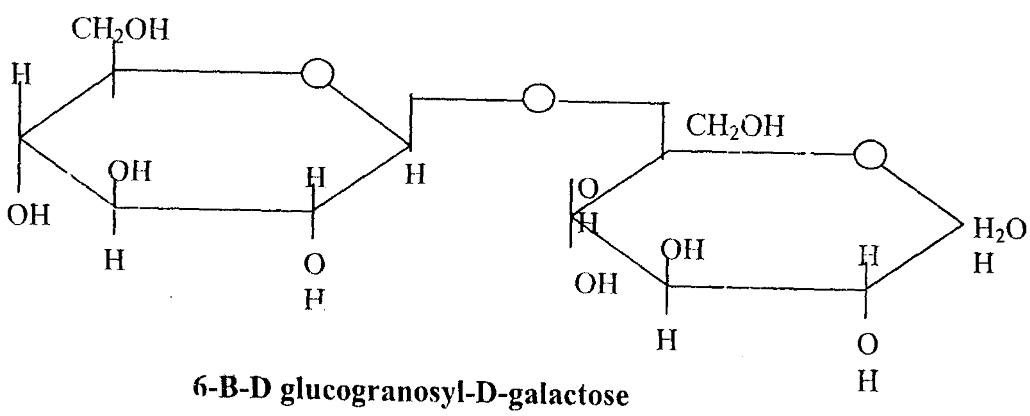
Galactosamine



Glucuronic acid



3-B-Dgalactopyranosyl-L-arabinose



6-B-D glucogranosyl-D-galactose

g. 2.1: Stuctures of complex sugar

ADDITIVES USED IN STABILIZING THE GUM

2.5.3. GLYCERIN

Glycerin a polyhydric alcohol liquid with a distinctively sweet taste at room temperature above its melting point. It mixes with water in all proportions, as a plasticizer it makes brittle material flexible by replacing polymer - polymer bonds with polymer glycerin bonds thus allowing easy slippage of polymer molecules past one another.

It gives firm but smooth texture and toughness as such, it is completely compactable with the base material used and is absorbed by then and does not crystallize or volatilize appreciable, it also prevent spoilage by formation of salts.

2.5.4. STARCH

Starch consist of two polysaccharides amylose andamylopetin the linear branded molecular components.

Ungelatinized starch incapable of binding anything together because the molecules are tightly bounded to one another. Heating to a temperature range of between 60-70°C the molecules become separated and act as an adhesive.

The temperature at which this occurs is called gelatinization temperature. The starch makes the back of the envelope and stamp to be glossy and sticky when wet because of the linear molecule amylose.

2.5.5. ZINC OXIDE

In aqueous suspension most filters develop negative surface charge, which prevents confloculation.

They neutralizers the negative charges on fines and act as wat... orrecting agents, also controls acidity of the gum.

2.6.0 PROPERTIES OF GUM

Physical Properties

i. Taste and smell

Generally gums generally ha no odor and may be tasteless but some are slightly sweet because of the presence of glycerin.

ii. Solubility.

Most gums yield amount of insoluble residue when mixed with water.

iii. Viscosity

This is thickness of a gum; this is an important factor in the quality of the gum the higher the viscosity the better the gum.

iv. colour and firm:

The colour of gums varies due to the presence of impurities and the age of the part of the tree that is tapped.

Chemical properties

The plant gums are composed of carbon, hydrogen, oxygen and small quantities of mineral matter or ash constituents and little nitrogen.

Gums are simply carbohydrates substances similar to sugar, starch and cellulose with the formular $C_{12}H_{22}O_{11} - (C_6H_{10}O_5)_n$ assigned to them. But some gums are not carbohydrates but complex acids built up of nucleus combines with several of the less common sugar.

Among the acids is Arabic acids (gum Arabic) edible gum (Gedda gum).

On hydrolysis with dilute mineral acids, the gum from various sugar largely lose their characteristics.

These properties lead to the use of gum as stabilizers and as lubricants friction reducers.

2.7.0 CHARACTERISTICS/ COMPONENTS OF ADHESIVES

2.7.1 MODIFIERS

Includes materials that are added to adhesive material primarily to improve the permanent of the resultant bond.

2.7.2 EXTENDERS

They generally have adhesive atom added to an adhesive to reduce the amount of primary binder required per unit area and thus the cost of the actual joint.

Adhesives are used to reduce the cost in hardwood and plywood manufacture.

2.7.3 FILTERS

They are relatively substance added to adhesive material for its working properties, performance, strength as well as reduce cost of surface task.

Others include binder, runners, stabilizer and placticisers.

CHAPTER THREE

3.0 EXPERIMENTAL WORK

The cashew gum exudates were collected from paiko cashew plantation.

The exudates gum was semi-dry when collected; it was then dried and used.

3.1.0 EXPERIMENT PROCEDURE

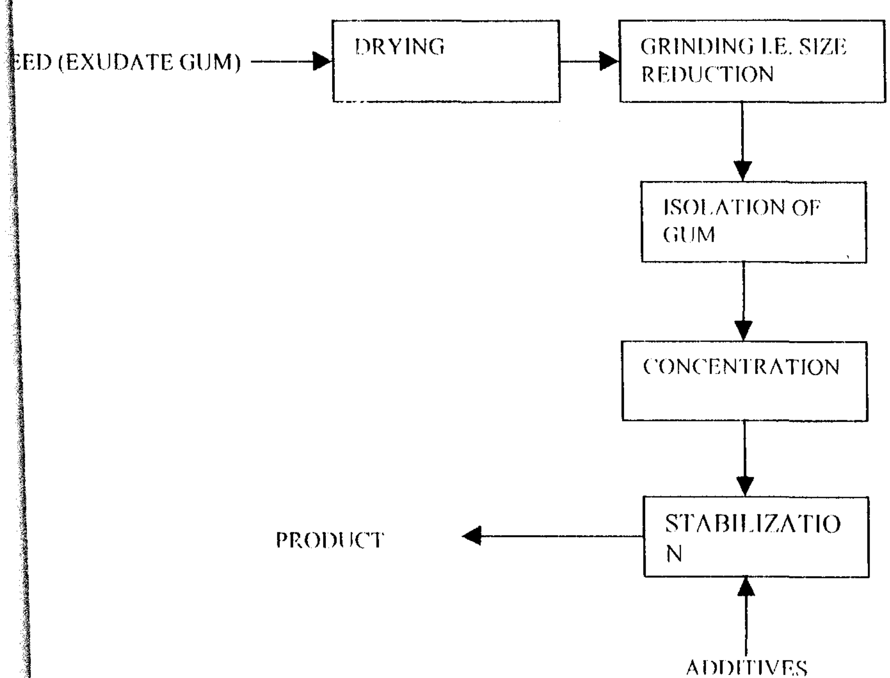
500g of exudates gum sample was collected and dried to reduce the moisture content. The dried sample was grind to pass through 2.5mm size mesh sieve.

The gum was isolated that is the separation of the polysaccharides present in the raw gum, and this is done by stirring of the gum sample in distilled water for 6-8hrs at room temperature.

The sample was` centrifuged to remove the impurities and concentrated by heating to a temperature of 10^0c.

The sample was stabilized by addition of additives and the property of gum was measured i.e. gum viscosity. PH and density.

3.1.1 BLOCK DIAGRAM OF PROCESS



3.1.2 PROCESS DESCRIPTION

- Collection of exudates gum.
- Drying f the sample to reduce the moisture contact.
- Grinding of the sample to pass through 2.5mm size mesh sieve.
- Isolation of gum (i.e. stirring of sample distilled water for 6-8hrs at room temperature for the separation of polysaccharides present in the raw gum).
- Certifying to remove the impurities.
- Concentration of the sample.
- Stabilization of the process (i.e. addition of the additives).

3.1.2 CHARACTERIZATION

Analysis for gum.

- Gum viscosity
- Gum PH.
- Gum density.

3.1.3 INSTRUMENT AND EQUIPMENT

- Grinder
- 2.5mm mesh size sieve.
- Beakers
- Conical flask 250ml
- Electronic stirrer.
- Test tube

- Measuring cylinder 500ml.
- Filter paper
- Oven
- Petri-dish
- PH meter.
- Viscosimeter
- Density bottle.

3.2 MATERIAL AND REAGENT

- Exudates gum
- Distilled water.
- Starch
- Glycerin
- Zinc oxide.

3.3 CASHEW GUM ADHESIVE

Cashew gum adhesive was prepared by the addition of the following additives into the gum sample;

i. Starch

ii glycerin

ii. Zinc oxide

3.4 PREPARATIONS OF ADDITIVES

- 3%, 5%, and 10%, concentration of zinc oxide was prepared,
- 3%., 5%, 7%, and 10%, concentration of starch was prepared.
- 3%., 5%, 7%, and 10%, ml of glycerin was prepared.

Process Description

Sample 1: (Various concentration of Zinc oxide solution was prepared).

Sample vii: 3grms of zinc oxide was dissolved in 100ml of distilled water at room temperature, and 5ml of this zinc oxide solution was added to 25ml of the gum solution.

Sample V_{12}: 5grmsa of zinc oxide was dissolved in 100ml of distilled water and 5ml of this zinc oxide solution was added to 25ml of the gum solution.

SampV_{13}: 7grms of zinc oxide was dissolved in 100ml of distilled water and 5ml of this zinc oxide was added to 25ml of the gum solution.

Sample V_{14}:

10grms of zinc oxide was dissolved in 100ml of distilled water and 5ml of this zinc oxide solution was added to 25ml of the gum solution at room temperature.

Sample 2: (various concentration of starch solution was prepared).

Sample V_{21}:

3grams of starch was dissolved in 100ml of distilled water and was heated to a temperature of 60-70% with a hot plate. 5ml of this starch solution was added to 25ml a magnetic stirrer.

Sample V_{22}:

5grms of starch dissolved in 100ml of distilled water and was heated with a hot plate to a temperature of 60-70^{0}c, 5ml of this starch solution was added to 25ml of gum solution and the mixture property stirred with a magnetic stirrer.

Sample V_{23}:

7grms of starch was dissolved in100ml of distilled water and was heated with a hot plate to temperature of 60-70^{0}c, 5ml of this starch solution was added to 25ml of gum solution and the mixture properly stirred with a magnetic.

Sample V_{24}:

10grms of starch was dissolved in 100ml of distilled water and was heated with a hot plate to a temperature of 60-70^{0}c, 5ml of this starch solution was added to 25of gum solution and the mixture was properly stirred with a magnetic stirrer.

Sample 3 (various ml of glycerin was prepared).

Sample V_{31}:

3ml of glycerin was added to 25ml of gum solution and stirred properly with a magnetic stirrer at room temperature.

Sample V_{32}:

5ml glycerin was added to 25ml of gum 25ml of gum solution and stirred properly with a magnetic stirrer at room temperature.

Sample V_{33}:

7ml of glycerin was added to 25ml of gum solution and stirred properly with a magnetic stirrer at room temperature.

Sample V_{34}:

10ml of glycerin was added to 25ml of gum solution and stirred with a magnetic stirrer at room temperature

3.5 PROCEDURES FOR pH DETERMINATION

Using buffer tablet standardizes the PH meter. The PH of each sample was determined and recorded. PH of 7 is neutral, below 7 is acidic and above 7 is alkaline.

3.6 PROCEDURES FOR VISCOSITY DETERMINATION

Each sample was filled with the test tube and inserted into the viscometer, there viscosities was determined from viscosity of running water and temperature of running water.

3.7 PROCEDURES FOR MOISTURE CONTENT DETERMINATION

The exudates gum sample collected was weighed and then dried. The weight of the dried sample was also taken, the difference in weight of the two sample that is the initial sample before been dried and the moisture content.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION OF RESULT

4.1 EXPERIMENTAL RESULTS

Table 1: V – 25ml of raw gum solution

SAMPLE	VALUE
PH	4.74
Density (g/ml)	1.047
Viscosity (Ns/m^2)	4.82

Table 2: Raw gum and variation of different composition of zinc oxide

SAMPLE	VOLUME OF SAMPLE (ml)	PERCENTAGE ADDITIVE ZNO (%)	PH	DENSITY (g/ml)	VISCOSITY (Ns/m^2)
V_{11}	25	3	6.32	1.024	5.07
V_{12}	25	5	6.54	1.040	5.37
V_{13}	25	7	6.68	1.040	5.54
V_{14}	25	10	6.72	1.040	8.01

Table 3:Raw gum and variation of different composition of starch

SAMPLE	VOLUME OF SAMPLE (ml)	PERCENTAGE ADDITIVE STARCH (%)	PH	DENSITY (g/ml)	VISCOSITY (Ns/m^2)
V_{21}	25	3	4.53	1.032	4.67
V_{22}	25	5	4.54	1.032	5.02
V_{23}	25	7	4.56	1,032	7.38
V_{24}	25	10	4.72	1.032	9.56

Table 4: Raw gum and variation of composition of glycerin

SAMPLE	VOLUME OF SAMPLE (ml)	ADDITIVE GLYCERIN (ml)	PH	DENSITY (g/ml)	VISCOSITY (Ns/m^2)
V_{31}	25	3	4,20	1.056	5.26
V_{32}	25	5	4.38	1.064	[illegible].68
V_{33}	25	7	4.47	1.080	8.44
V_{34}	25	10	4.54	1.092	10.21

However, when glycerin was added i.e. from table 4, the pH of the gum dropped within the range of 4.20-4.54.

But the viscosity of the gum was at its highest between the range of 5.26-10.21 (Ns/m^2)

It was observed that when glycerin was added, the nature of the gum became slippery which shows that glycerin is use for easy spread of the gum.

The variation of the additive (zinc oxide, starch glycerin) as shown in table 5, showed that the PH of the gum was in the range of 4.20- 5.30 and the viscosity within the range of 4. 52-6.78 (Ns/m^2). But the best sample were that of V_{41} and V_{42} with pH and viscosity of 4.20 and 4.52 Ns/m^2, 4.50 and 4.73Ns/m^2 respectively, this is because the pH of these samples falls within the range of pH of Acacia Senegal. i.e. 3.9-4.9 (Anderson et. al, 1990).

The entire result shows that increase in pH of gum leads to an increase in the viscosity of the gum and vice versa.

And the higher the percentage of the additives, the higher the PH and viscosity of the gum.

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APPENDIX

Sample calculations:

(1) Density

$$\text{Density} = \frac{mass}{volume}$$

Where;

Mass = mass of gum solution and density bottle mass of empty density bottle.

For gum before the addition of additives;

Mass of gum solution and density bottle = 33.33g

Mass of gum density bottle = 7.15g

Mass of gum solution = 33.33g − 7.15g

= 26.18g.

But volume of density bottle = $25cm^3$

$$\text{Density} = \frac{26.18}{25}$$

$= 1.047g/cm^3$

For sample V_{11}:

Mass of gum solution + Density bottle = 32.75g

Mass of density bottle = 7.15g

Mass of gum solution = 32.75 − 7.15g

Mass of gum solution = 32.75g − 7.15g

= 25.6g

$$\text{Density of gum solution} = \frac{25.6}{25.0}$$

$= 1.024g/cm^3$

For sample V_{12}

Mass of solution + mass of density bottle = 33.15g

Mass of density bottle = 7.15g

Mass of gum solution = 33.15g – 7.15g

= 26.0g

Density of gum solution = $\frac{26.0g}{25.0}$

= $1.04g/cm^3$

For sample V_{13}:

Mass of gum solution + mass of density bottle = 33. 15g

Mass of density bottle= 7.15g

Mass of gum solution = 33.15g

= 26.0g

Density of gum solution = $\frac{26}{25}$

= $1.04g/cm^3$

(2) Viscosity

Viscosity of gum = $\frac{\mu_{cG}}{\mu_{H_2O}}$

Temperature of water ion viscometer bath = 29^0C

Running time of water at 29^0C = 14. 23 Secs.

Viscosity of water at 29^0C = $0.8138 Ns/m^2$

Where;

t_{cG} = running time for cashew gum

t_{H_2O} = running time for water.

μ_{cG} = viscosity of cashew gum solution.

μ_{H_2O} = viscosity of water.

For raw gum;

$$\frac{t_{cG}}{t_{H_2O}} = \frac{\mu_{cG}}{\mu_{H_2O}}$$

$$\mu_{cG} = \frac{84.28x0.8138}{14.23}$$

$$= 4.82 \ Ns/m^2$$

For sample V_{11}:

Running time for cashew gum solution = 88.66

$$\mu_{cG} = \frac{88.66x0.8138}{14.23}$$

$$= 5.07Ns/m^2$$

For sample V_{12}:

running time for gum solution = 93.90s

$$\mu_{cG} = \frac{93.90x0.8138}{14.23}$$

for sample V_{13}:

running time fort gum solution = 96.87s

$$\mu_{rG} = \frac{96.87x0.8138}{14.23}$$

$$= 5.54 \text{ Ns/m}^2$$

(3) Percentage concentration

For 3% concentration of zinc oxide.

Weigh 3g of ZnO in 100ml of distilled water.

For 5% concentration of zinc oxide

Weigh 5g of ZnO in 100ml of distilled water.

For 7% concentration of Zinc oxide.

Weigh 7g ZnO in 100ml of distilled water.

For 10% concentration of Zinc oxide.

Weigh 10g of ZnO in 100ml of distilled water.