PRODUCTION AND CHARACTERIZATION OF ADHESIVE FROM CAMEL BONE

BY

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DECLARATION

I Muhammed Tijani (2001/11574EH) hereby declare that this project work "Production and Characterization of Adhesive from Carnal Bone" is written by me, carried out under the supervision of Engr. Auta Manase and has not be submitted anywhere for any degree to the best of my knowledge.

20/01/2010

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CERTIFICATION

This is to certify that this project is an original work taken by Muhammed Tijani 2001/11574EH which was signed and approved on behalf of the department by my supervisor. It was submitted for assessment for the award of bachelor of Engineering Degree in the Department of Chemical Engineering Federal University of Technology, Minna.

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DEDICATION

I Muhammed Tijani dedicate this project work to Almighty Allah for his mercy, protection, grace and infinite love upon me and his sustenance throughout my education. To my parents, Alhaji and Hajiya Muhammed who has contributed immensely toward my education.

ACKNOWLEDGMENT

All praise is due to Allah Almighty the protector and the sustainer of the world, who with infinite mercy makes this project work be a successful one, he is the one that give time, knowledge, strength, courage and inspiration to who he pleased. My profound gratitude goes to my supervisor Engr. Auta Manaseh who despite the enormous lecturing work, tight schedules was able to see me through, whose comments and corrections gave this project a sense of direction. Sir I appreciate your concern. My sincere appreciation goes to my parents, Alhaji Usman Muhammed and Hajiya Khadijat Muhammed for their immense contribution, both morals and financial support right from my childhood up till date. May Almighty Allah reward them abundantly (Amen). I also thank my brothers, sister and wife for their support, Usman, Aisha, Umm Hanifah and others for their encouragement.

ABSTRACT

The research work on production and characterization of Adhesive from Camel bone was carried out, aimed at exploring the possibility of producing adhesive from camel bone by extraction process using acidulated water at temperature ranging from 80^0C-90^0C and extraction ranging from difference times using benzene as the degreasing solvent to remove the fats. The extraction time and the glue yield were found to be dependent on temperature of extraction and particles sizes. The highest particles of 1.70mm gave the highest yield of glue from camel bone is 48.86%. The smaller the particle sizes the better the quality of the glue. The time and temperature for the optimum yield of glue was found to be 2½ hours and 90^0C respectively. The glue obtained from camel bone was tested on palm sandals and was found satisfactory.

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CHAPTER ONE

1.0 Introduction

Adhesive or glue is a compound in a liquid or semi liquid state that adheres or bounds items together. Adhesive may come from either natural or synthetic sources. Some modern adhesives are extremely strong, and are becoming increasingly important in modern construction and industry. The types of materials that can be bounded using adhesives are virtually limitless, but they are especially usefully require a controlled temperature to curve or set. They can be electrically and thermally conductive or non conductive. The earliest date for a simple glue is 200,000BC and for a compound glue 70,000BC. (Lau, 2002). The term adhesives in general include among other things glue, cement, mucilage and paste-names which are loosely used interchangeably various description adjectives are used with the term adhesives to indicate specific characteristics with regard to the following,

1. Physical form, i.e liquid adhesives, tape adhesives
2. Chemical form i.e silicate adhesives, resin adhesives
3. Material bounded i.e paper adhesives, metal plastic
4. Condition of use: hot-setting adhesives (Lau, 2002). Local consumption of adhesives in the country has been rising steadily, especially as a result of increase in the country standard of living.

The establishment of many bottling companies, packaging factories, shoe industries etc hence, there is need for high quality and reliable durable material adhesives, this has created a high demand for glue adhesives in our market. For Nigeria to achieve an indigenous technological base, there is need for all goods and finished product to be developed or produced locally from locally available resource. Unfortunately, most of the adhesive from foreign countries, the shift from the use of locally raw material should be of economic importance, Nigeria is blessed with millions of animals, so it was estimated that there are 6.2 millions hard of camels, 13.5 millions hards of cattle, 12.6 millions hards of goats, 11.8 million hards of sheep and 10.7 million hards of hourse (Jubrin, 2000).

The basic raw material for animal glues or adhesives are bones. Albumin glue are derived from either egg or blood, which the casein glue are ferived principally from milk albumin and casein glue are generally not economical to produce for obvious resource. Camels bone glue are those of particular area of interest in this work. It is those a reliable source of raw material for adhesive production especially from camel alone much of those bones are lying wasted. (Jubril, 2000).

1.1 Aims and Objectives

The overall aim of this project work is to explore the possibility of producing adhesive from camel bone and also to ensure the purification of the adhesive, through the following objectives;

1. Determine the glue yield from camel bone
2. Improving the optimum degreasing solvent
3. Determine the optimum condition for the glue production

1.2 Scope

The methods to be employed for the experiment include:-

1. Collection of the bones
2. Cleaning and drying
3. Crushing and degreasing
4. Grinding and screening
5. Accidulation
6. Concentration of glue
7. Gelling and drying

CHAPTER TWO

2.0 Literature Review

The oldest known adhesive, dated to approximately 200,000BC, is from spear stone flaker glued to a wood with birch-bark-tar, which was found in central Italy. The use of compound glues to haft stone spear into wood date back to round 70,000BC. Evidence for this has been found in sibudu care, South Africa and the compound glues used were made from plant gum and redochre. The Tyrolean iceman has weapon fixed together with the aid of glue. 6000 year-old ceramics show evidence of adhesives based upon animal glues made by rendering animal products such as hours teeth. During the times of babylonia, tar like glue was used for gluing statues. The Egyptians made much use of animal glues to adhere furniture, ivory and papprus. The Mongols also used adhesives to make their short bows, and the Native Americans of the eastern united state used a mixture of spruce gum and fat as adhesives to fashion waterproof seams in their birch back canoes. In medieval Europe, egg whites were used as glue to decorate parchments with gold leaf. The first actual glue factory was founded in Holland in the early 1700s. in the 1750s, the English introduced fish glue. As the modern world evolved, several other patented materials, such as bone, starch, fish, and casein, were introduced as alternative materials for glue manufacture. Modern glue have improved flexibility, toughness, curing rate and chemical assistance (Mazza, 2006).

2.1 Previous Study on Adhesive

As said earlier, adhesive have long produced by different industries and using different raw materials. It has been produced from blood album and this involves the use of either slaughter house blood or dried soluble blood power to which water mixture has been added. Addition of alkali to albumin water mixture improve adhesive. Adhesive touch our lives every day, they are never more than aims length away, even though we may not be aware of their present. A description of some of the more common type of adhesives and their use should make you more aware of how adhesive touch your life (Henkel, 2005). Synthetic resin adhesive has also been produced for example urea resin adhesive consist of area of formaldehyde or combined usually with starch based adhesive where some water resistance is desirable. Phenolic resin adhesive are base on phenol or it derivation such as resorcinol, which are cordeased with aldehyde or ketone. Sarch adhesive-a carbohydrate extracted from vegetable plants such as corn price, wheat and potatoes. Probably better known as paste, major use area are in bonding paper and paper products such as book binding. Corrugated boxes, paper bags, wall paper, paste (non-removable), also used as a sizing in textiles. The laundry uses starch on your shirt collars, to so stiffen and give shape to your shirt (Henkel, 2005).

2.2.0 Categories of Adhesives

Adhesive can be categorize or classified in various ways.

2.2.1 Natural adhesive: They are made from inorganic mineral sources, or biological sources such as vegetable matter, starch (dextrin), natural resins or from animal glue. They are often referred to as bioadhesures. One example is a simple paste made by cooking flour in water. Animal glue are traditionally used in booking, wood joining, and many other areas but now are largely replaced by synthetic glues. Casein are used in corrugated board production and paper sack production, paper tube winding, wall paper adhesive. Another form of natural adhesive is blood albuman (made from protein component of blood), which is used in the plywood industry.

2.2.2 Synthesis Adhesive: Elastomers, thermoplastic, emulsion, and thermosetting adhesives base on polyvinyl acetate, epoxy, polyurethane, cynoacrylate polymers are examples of synthetic adhesives (Jordis,2000).

2.2.3 Drying Adhesive: These adhesive are a mixture of ingredients (typically polymers) dissolved in a solvent, white glue and rubber cements are numbers of the drying adhesive family. As the solvent evaporates, the adhesive hardens. Depending on the chemical composition of the adhesive, they will adhere to different materials to greater or lesser degree. These adhesives are typically weak and are used for household applications.

2.2.4 Contact Adhesive: Must be applied to both surfaces and allowed some time to dry before the two surfaces are pushed together. Some contact adhesives requires as long as 24 hours to dry before the surface are to be held together. Once the surfaces are pushed together, the bond forms very quickly. It is usually not necessary to apply pressure for a long time, so there is no need to use clamps. Natural rubber and polychloroprene (neoprene) are commonly used contact adhesives. Both of these elastomers undergo strain crystallization. Contact adhesive are used in strong bonds with high sheer resistance like laminates, such as bounding Formica to a wooden counter, and in footwear, such as attaching an outside to an upper (Jordis,2000).

2.2.5 Hot Adhesive: Also known as hot melt adhesives, are simple thermoplastics applied in molten form (in the 65-180^{0}C range) which solidify on cooling to form strong board between a wide range of materials. These adhesive are popular for crafts because of their case of use and the wide range of common materials they can join. A glue gum is one method of applying hot adhesives. The glue gum melts the solid adhesive, then allows the liquid to pass through its barrel onto the material, where it solidifies.

2.2.6 Pressure Sensitive Adhesive: (PSA) form a bond by the application of light pressure to marry the adhesive with the adhered. They are designed with a balance between flow and resistance to flow. The bond forms because the adhesive is soft enough to flow (if "wet") the adhered. The bond has strength because the adhesive is hard enough to resist flow when stress is applied to the bond. Once the adhesive and the adherend are in close proximity, molecular interactions, such as Vander weals forces, become involved in the bound, contributing significantly to its ultimate strength (PSAs) are designed for either permanent or removable applications. Example of permanent applications include safety labels or power equipment, foil tape for HVAC duct work, automotive interior trim assembly, and sound/vibration damping films some high performance permanent PSAs exhibit high adhesion values and can support kilograms of weight per square centimeter of contact area, even at elevated temperature. Permanent (PSAs) may be initially removable (for example to recover bond after several hours or days. Removable adhesive are designed to form a temporary bond, and ideally can be removed after months or years without leaving residue on the adherend. Removal adhesives are used in applications such as surface protection films, masking tapes, bookmark and note papers, price marking labels, promotional graphics materials, and for skin contact (wound care dressings, EKG electrodes, athletic tape, analgesic and transdermal drug patches, etc). s

2.3.0 Industrial and Commercial use of Adhesives

Under this heading comes adhesives usage in all kinds of industries, small or heavy in small industries like those of food products, toys or stationary items, adhesive play an integral role in processing to packaging. Even the cling wrap around your phone card or the lipstick connected to its box has adhesives playing their roles in heavy industries, adhesive play a central role right from assembling spare parts of any machine, car paint or branding them with lebels, in the construction industry too, for uniform distribution of stree woods are bounded with strong adhesives. Apart from that, for painting and furnishing or home decoration, adhesives are very essential (Jordis, 2000).

2.3.1 Household use

Right from sticking envelopes to rejoining broken toys, we use adhesives very frequently, in form of glue sticks, cellotapes or gums, we use adhesives everyday to mend shoe, to glue postage stamps, repair something or attaching tags to gifts. There are manifold advantages of using adhesives over other adhering processes. Adhesives work faster than other bounding methods though surface preparation takes time as well as material cost, yet it more effective than the tradition process. Unlike thermal or mechanical fastening methods, adhesives offer flexibility of material selection (Jordis, . 2000).

2.3.2 Shoes

Shoes production continous to demand an impressive array adhesives these materials are need to make various shoes components and to attach the soles either permanently or temporarily (Henkel, 2005).

2.3.3 Air craft

This industries does not use large quantities of adhesive, however the product are expensive as they are highly specialized and must meet strict specification the adhesive are utilized for both structural and non structural application.

2.3.4 Construction

Adhesive are utilized in construction for many structure and decorative applications e.g the installing vingl flowing competing, ceramic tile, making doors gluing floor etc. the construction industry is one of the largest outlets for adhesives, requiring some 40 types of adhesives in about 30 difference application (Henkel, 2005).

2.4.0 Selection of Adhesives

Selecting a proper adhesive for a given bonding application can at a time, appear to be an overwhelming task, but it needed root to be. An adhesive should be compatible with the materials it will join. The adhesive be available for bonding (clamps, heater etc) and hare pressure, temperature or curing requirement which are beyond the limits of that equipment. The adhesive must have adequate basic strength for its intended job. In addition to adequate basic strength, of the adhesive must be sufficiently durable to provide adequate load bearing. The physical properties such as colour, density, electricity properties, solid content etc often need to be considered as subjected to screening test too, but often for most in the user's mind, is bonding cost. All though many factors influence the ultimate bonding cost, the price per unit of adhesive is significant and must be considered early in the selection process (Whistler, 2001).

s2.4.1 Advantage of Adhesive

1. Thin films, fibers and small particles that could not be combined or other techniques are readily bonded with adhesives.
2. Stresses are assemblies than could be achieved with mechanical circuits.
3. The glue line provides electrical insolution in capacitors, printed circuits, motor potted resistor etc (Whistler,2001).

2.4.2 Disadvantage of Adhesives

1. Impermeability may deteriorate with the time and temperature.
2. Many adhesives become brittle at low, temperature some adhesives are stronger than substrates and disassembly destroys past (Whistler, 2001).

2.5.0 History of Animal Glue

Animal glue was the most common woodworking glue for thousands of years until the advent of synthetic glues such as polyvinyl acctate (PVA) and other resin glues in the 20^{th} century. Today it is used primarily in specially applications such as lutherie, pipe organ building and antique restoration. Glass artists take advantage of hide glues ability to bond with glass, applying hide glue to glass. As the glue hardens it shrinks, chipping the glass. It has several advantages and disadvantage compassed to ther glues. The glue is applied hot, typically with a brush or spatila, it is kept hot in a glue pot. Most animal glues are soluble in water, useful for joints which may at sometime need to be separated. Alcohol is sometimes applied to such joints to dehydrate the glue, making it more brittle and easier to crack apart. Nearly 5,000 year ago, the Egyptians used hide glue as furniture adhesive. This is proven by hairs found in pharoh's tombs and by stone carvings depicting the process of gluing different woods. Evidence exists that Sumerians also used glue before the Egyptians (Courtnall, 2000).

2.5.1 Categories of Animal Glue

There are two categories or classification of animal glue, they are hide as bone glue. Both strive for grater yield and cost efficient, resulting in optimum test properties including viscosity grain strength, pH, moisture, foam, grease ash, colour, clarity and odour (Skeist, 2000). Hide glue is used in wood working, It may be supplied as granule, flake or lat sheets, which have an indefinite shelf life if kept dry. It is dissolved in water, heated and applied warn, typically around 140^0F (60^0C). Warmer temperatures quickly destroy the strength of the tride glue (Skeist, 2000). Extracted bone glue are derived from collagen product in the structure of bones. It is processed from clean clay bones which have been degreased before processing for glue. As a group, the bone glue, while not a versatile as hide, find wide acceptance where glue of medium and lower strength indicated (Skeist, 2000).

2.5.2 Properties of Animal Glue

The significant disadvantage of hide glue-its thermal limitation, short open time, poor gap filling capability and vulnerability to micro-organism are offset by several advantages. Hide glue joints are reversible and repairable. Recently glued joints will release easily with the application of heat and steam. High glue sticks to itself, so the repairer can apply new hide glue to the joint and reaching it in constract, PVA glue do not adhere to themselves once they are cured, so a successful repair requires removal of the old glue first which usually requires removing some of the material being glued. Hide glue creates a somewhat brittle joint, so a strong shock will often cause a very clean break along the joint. In contrast, a joint glued with (PVA) will usually break the surrounding material, creating an irregular, difficult to repair break (Courtnall, 2000).

2.5.3 Purification of Animal Glue

Warm solution of glue needed to be preserved against bacteria or micro-bacteria spoilage. A preservation is usually added at the thin liquor stage before filiations (to removed extraneous particles) and my usefully be put into the water used for extraction before it meets the collagens raw material. A soluble zinc salt such as $Znso_4$ is widely used usually in conjunction with a phenolic such as 4-chloro-in-aerool (in the ratio of one part zinc and seven part of phenolic or other compound that will not raise unduly the ach content of the glue) (Skeist, 2000).

2.5.4 Production of Animal Glue

Animal hides are soaked in water to produce 'stock' the stock is then treated with lime to break down the hides. The hides are then rinsed to remove the lime, army residue being neutralized with a weak acid solution. The hides are heated in water, to a carefully controlled temperature around 70 degree Celsius. The glue liquor is then drawn off more water added and the process repeated at increasing temperatures. The glue liquor is then derived and chipped into pellets (Courtnall, 2000).

2.5.5 Application of Animal Glue

There are various application of animals glue which includes coated abrasive, presently the largest consume of animal hide glue is the abrasive industries.

2.5.6 Gummed tape: Both hide glue and bone have played an important role in the manufacture of gloomed tape.

2.5.7 Paper: Animal glue has played a very important role in the marking of paper and paper products. It proves the wet strength of paper and can later be insolibilized.

2.5.8 Matches: In the matches industries consumers animal, in the marking of stick, book matches, and wooden safety matches (Skeist, 2000).

2.6.0 Bone

Bones are rigid organs that form part of the endoskeleton of vertebrates. They function to move, support and protect the various organ of the body, produce red and white blood cells and store minerals. Bone tissue is a type of dense connective tissue. Because bones come in a variety of shapes and have a complex internal and external structure they are light weight, yet strong and hard, in addition to fulfilling their many other functions. One of the types of tissue that makes up bone is the mineralized osseous tissue, also called bone tissue, that gives it rigidity and a honey comb-like three-dimensional internal structure. Other types of tissue found in bones includes marrow, endosperm and periosteum, nerves, blood vessels and cartilage (Gerard, 2005).

2.6.1 Function of Bones

Mechanical Functions

1. **Protection:** Bones can serve to protection internal organs, such as the skull protects the brain or the ribs protecting the heart and lungs.

2. **Shape:** Bones provide a frame to keep the body supported.

3. **Movement:** Bones, skeletal muscles, tendons, ligaments and joints function together to generate and transfer forces so that individual body part or the whole body can be manipulated in three dimensional space. The interaction between bone and muscle is studied in biomechanics.

4. **Sound tradition:** Bones are impotent in the mechanical aspect of over shadowed hearing (Gerard, 2005).

Synthetic Functions

1. **Blood production:** The marrow, located within the medullary cavity of long bones and interstics of cancellous bone, produces blood cell in a process called haematopoieses.

Metablic Functions

1. **Mineral storage:** Bones act as reserves of minerals important for the body, most notably calcium and pheshorus.

2. **Fat storage:** They yellow bone marrow acts as a storage reserve of fatty acid (Gerard, 2005).

2.6.2 Characteristics of Bone

They primary tissue of bone, osseous tissue, is a relatively hard and lightweight composite material, formed mostly of calcium phosphate in the chemical arrangement termed calcium hydroxylapatite (this is the osseous tissue that gives bones thin rigidity). It has relaticely high compressive strength but poor tensile strength of 104-121Mpa. Meaning it resists pushing forces well, but not pulling forces. While bone is essentially brittle, it does have a significant degree of elasticity contributed chiefly by collagen. All bones consist of living and dead cells embedded in the mineralized organic matrix that makes up the osseous tissue (Gerard, 2005).

2.6.3 Classification of Bone

Bone varies greatly in size and shape. They may be long, hort or flat, according to their function in each vertebrate in man, the breast bone is a shield like bone together with the attached rib, serves mainly to protect the vital organs in the chest. That also form a flexible below, which can expand and contract during breathing. The bone of the skull which guard the brain against injury, are flat and closely filled and cemented together. Those of the ankle, wrist and other parts of the body that require great flexibility are small and interlocking arm and leg bone which serve as learner for movement are long (Bennet, 2004).

2.7.0 Collagen

This is the major fibrous protein of many animal content, located in the extral cellular connective tissue. It is probably the most abundant animal protein in nature. It is about 30% glycine and 25% protein and hydripoline (Alexander, 2003).

2.7.1 Properties of collegen

These properties account for good quality production

1. Has a characteristic banded or structural appearance
2. Relative resistance to most of the pretealutic enxymes of vertebrate
3. Appearance in electron microscope is unique
4. Insolubility under mild condition (Alexander, 2003).

2.8.0 Gelatinization of Bone

Gelatin is obtained by partial hydrolysis of collagen the chief protein component in skin, bone and white tissues of the animal body. It is also a hydrolysis product obtained by hot water extraction and does not exist in nature. Gelatin is used in the food, pharmaceutical and photographic industries which take advantage of it unique properties such as reversible gel-to-sol transition of ageous solution, viscosity of warm ageous solution, capability and insolubility in cold water but complete solubility in hot water (Alexander, 2003).

2.9.0 Bone Glue

Glue from bone re extracted from collagenous mixture which is the chief organic constituent of all bone. Bone glue fall into two categories, extracted bone and green bone, extracted bone glue are prepared from bones that have been solvent-extracted to removed by product grease. Green bone are processed as received from slaughter house. The bone are crused, washed and processed in mild acid in pressure vessels. A series extractions, alternating steam pressure in the jacket and sparing with hot water, removed the dulute glue laguor, which is the filtered or centrifuged to remove by product grease. The glue is formally concentrated and dried. The residual bone are utilized as an additional by-product to produce bone meal fertilizer, which contain approximately 85% calcum phosphate (Alexander, 2003).

2.9.1 Advantage of Bone Glue

The advantages over other adhesive cannot be over emphasized but prominent amount them are as follows.

1. Bone adhesives have high strength then starch adhesives
2. They equally have high water resistance
3. Animal bone adhesives re uses costly than synthetic resin adhesives (Alexander, 2003).

2.9.2 Disadvantage of bone glue

1. It has some undesirable characteristics like odour, which is not present in that of starch
2. It involves more labour than starch adhesive (Alexander, 2003).

CHAPTER THREE

3.0 Equipment and Experiential Procedure

3.1 Equipments and Materials

Table 3.1: List of instruments and equipment

Instruments	Model/Type/Manufactura
Beakers	Pyrex glass capacity
Measuring cylinder	Pyrex glass capacity
Electric grinder	3PH, 50HZ, 200W machine No. 17834, 4.7A
Standard screen	Mesh flyer
Thermometer	76mm immersion
Viscometer	portable type
pH comparator	Model 5
Hot plates	App No. 8325628
Weighing balance	Maximum capacity
Electric oven	Serial No. 2274
Jaw crusher	3-H, 50HZ, 8.1AMP Machine No. 17769,415v

Table 3.2: List of material

Material	Description
Benzene	Solvent
Borax	Power
Distilled water	Liquid
Hydrochloric	Liquid
Hydrogen peroxide	Liquid
Grinded Camel Bone	Power

3.2.0 Experiment Procedure

3.2.1 Pretreatment

Fresh bones obtained from camel were washed with water until they were free from stone, blood, dark and other foreign body.

The bones were then dried in an electric oven for about 10 hours or more, maintaining a temperate of about 150^0C the drying weights of the bone before and after drying were recorded, and used to calculate the percentage weight lost.

3.2.2 Crushing and Degreasing

The dried bone were crushed using the jaw crusher, having observed, the weight of crushed bones, were degreased manually by putting the crushed bones separately in a container and adding 600ml of benzene already dissolved 1800ml of distilled water (i.e benzene to distilled water ratio 1:3). The socking of material is maintained for 3 days. The solvent with the extraction grease was then decanted to make the bone grease free. The percentage fat yield were calculated and the optimum degreasing solvent was thus determined

3.2.3 Grinding and Screening

The drying of the camel bone took place in an oven for one hour thirty minutes at a constant temperature of 150^0C to ensure complete dryness.

The degreased camel bone were grinded with an electric grinder and screened using tylers's screen into various sizes, in this way.

3.2.4 Acidulation

The contents of the sieves were transferred into separate beakers and two molar solution of HCL was added to each of the mixtures. The mixture were stirred and effervescence occurred with the evolution of carbon dioxide (CO_2). The acidulation lasted for two and half hours when the carbon dioxide gases were noticed to have completely evolved. The weight of the bones before and after acidulation was noted and the percentage declination was calculated.

3.2.5 Extraction of Glue

Extraction of takes place using acidulated water prepared by mixture 10ml of HCL and 50ml of distilled water.the mixture was placed on hot plate. The heating was carried out at a temperature between 70^0C and 90^0C and the extraction was done between one to three hours.

2ml of hydrogen peroxide was added to extract prior to filtration and subsequent concentration.

3.2.6 Concentration of Glue

The extracted glue was poured into pyrex beaker and was mounted to a hot plate. The temperature was maintained between 70^0C and 90^0C. The extract evaporates until it was 40% of the original volume. The residue left is the glue.

3.2.7 Gelling and Drying

Gelling was achieved by means of cooling the samples of the glue prepared and place in sampling bottles, which are meant to put into the refrigerator. After cooling for an hour, the jellies or jells produces were allowed to dryed.,

3.2.8 Stabilization of the Adhesive

0.5g of Borax ($Na_2B_4O_7 10H_2O$) was added to portions of adhesive produced from Camel bone already in sample bottles With string. The stringing continued until the system become sticky.

3.3 Measurement of Adhesive pH

The pH of the stabilized adhesive was measured by the acid pH meter. The sample was collected in a beaker and the pH determined by inserting the pH meter electrode into it. The value was then read from instrument.

3.4 Determination of Specific Gravity

The specific gravity of the adhesive was determined with the acid of a specific gravity instrument. The procedure involved pouring water into the specific gravity cylinder and inserting the instrument until the float is steady and the reading is taking from calibrator. Adhesive is now used in place of water and the value read from the calibrator.

3.5 Viscosity Determination

The standard method of viscosity determination was employed using the viscometer bath. The u-tube viscosity with capillary was inserted into a viscometer bath. A known guaranty of a sample was powered into the u-tube viscometer with capillary and them was carted. The sample was allowed to build up with the temperature of the bath. The temperature of the bath was

28^0C then the cork was removed and the time taken for the content to run up starting from the middle mark to the mark was noted using a stopwatch.

3.6 Testing of Adhesive

Mechanical test was carried out as below small quantity of the glue was applied on the surface of the two slabs of the sole of a palm sandal and the surface were exposed to atmosphere for about five minutes before it was them homebred together the sandal was thus ready for use.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Results

The results obtained from the experiment conducted according to the outlined procedure as shown below.

Table 4.1: Percentage yield of fat from camel bone

Type of bone	Solvent	Percentage fat yield
Camel bone	Benzene	10.50

Table 4.2: The percentage decalcification from camel bone

Particles size (mm)	Percentage decalcification
1.70	111.97
1.18	10.80
0.60	14.37
0.30	4.60

Table 4.3: The percentage glue extracted from camel

Particle size (mm)	weight of particles Initial (g)	Final (g)	Glue yield	Time yield	Time (hours)	Temp ^0c
1.70	95.20	83.80	51.45	48.86	2½	90
1.110	110.220	98.30	33.50	31.81	2	90
0.60	210.20	180.00	11.12	10.56	1½	85
0.30	150.20	143.30	9.223	8.77	1½	80

Table 4.4: The pH, specific gravity and viscosity of glue obtained

Particle size (mm)	pH	Specific gravity	Viscosity kg/ms
1.70	7.70	1.38	11.452×10^{-4}
1.18	7.50	1.35	11.0182×10^{-4}
0.60	7.31	1.25	7.7375×10^{-1}
0:30	7:22	1.20	6.500×10^{-4}

4.2 Discussion of Results

From the results obtained during the experiment, Table 4.1 and 4.2 show the type of bone of interest, solvent used and percentage decalcification of the particles sizes respectively, it shows that the smaller the particles size, the higher percentage decalcification. Table 4.3 and 4.4 shows the glue yield weight of particles at $2\frac{1}{2}$ hour , temperature of 90^0C , pH and Viscosity respectively; the higher the particles size the higher the glue yield, pH and viscosity.from the Percentages decalcification of camel bone tabulated, it can be seen that increase in particles size leads to corresponding increase in percentage decalcification. There is variation in the quantity of adhesive produce between the four grades. The weight of glue extraction increases in order of increasing particle size of camel bone. Also the amount of the glue produced at the end of the extraction process depended on the time of extraction. The temperatures for the extraction were maintained between 80^0C and 90^0C because any temperature above that, the substance may changed or turned to another compound. However, the glue produced from camel link is not pure, it is brownish in nature, nearly odourless but not completely as that of the normal industrial one.

When the glue is stabilized using Borax, it become tack and more sticky and have high quality. The adhesive product from camel bone was stored for some days and it was observed that it has a long life span. the quality of glue produced which is due to the ability of the temperature destroy the gelatin and course low viscosity and low grade of the glue produced.

CHAPTER FIVE

5.0 Conclusion and Recommendation

5.1 Conclusion

Conclusively, adhesive can be extracted from any animal bone such as camel bone, from the result obtained from this work. It can be deduced that the yield and quality of glue is highly qualitative. The higher the level of degreasing, the higher the quality of the glue produced. Hence the quality of glue produced increases in order to increasing particle sizes. Also, the concentration temperature does not exceed 100^0C, which prevents the glue from losing it adhesives properties. Highest amount and quality of glue produced was obtained at 90^0C, 2½ hours duration at 1.70mm.

5.2 Recommendation

1. Equipments for the experiment should be made available as unavailability may cause inaccuracy of the results of the experiment.
2. The experiment should be carried out in a more controlled environmental condition to reduce the effect of internal disturbance.
3. Stronger animal bones e.g. horse, donkey should be used, because the stronger the bone, the stronger the adhesive
4. Suitable solvent extractor can be used for proper degreasing which gives high quality of glue.

5. All necessary safety precaution should be observed during the course of experiment.

6. The residual bone obtained after the extraction process should be used as meal for feeding live stock.

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APPENDIX

Camel bone

Weight of fresh bones = 1500g

Weight of dry bones = 1350g

Weight of crushed bones = 1050g

Weight of degreed bones = 900g

Weight of grinded bones = 810g

Calculation

Weight of fresh bones = 1500g

Weight of dry bones = 1350g

Weight of fresh bones - Weight of dry bones = 1500g – 1350g = 150g

Weight of moisture removed = 150g

Percentage weight of moisture removed $\frac{weight\ of\ moisture\ removed}{weight\ of\ fresh\ bone} \times 100$

$\frac{150g}{1500g} \times 100 = 10\%$

Weight of crushed bones = 1050g

Weight loss after crushing = weight of dry bones – weight of crushed bones

= 1350g – 1050g = 300g

Percentage of degreased bones = 900g

Weight loss after degreasing =

weight of degrease bone – weight dried degreased bone = 900g – 812g = 88g

Percentage weight loss after degreasing = $\frac{weight\ loss\ after\ degreasing}{weight\ of\ degreasing\ bone} \times 100$

$\frac{88g}{900g} \times 100 = 9.78\%$

For 1.70mm

Weight of bone before acidulate 95.2g

Weight of bone after acidulate 83.8g

Calcium loss =

weight of bones before acidulate – weight of bone after acidulate

= 95.2g – 83.8g = 11.4g

Percentage decalcification $\frac{calcium\ loss}{weight\ of\ bones\ before\ accidulate} \times 100$

$\frac{11.4g}{95.2g} \times 100 = 11.97\%$

For 1.18mm

Weight of bones before acidulate = 110.20g

Weight of bones after acidulate = 98.30g

Calcium loss =

weight of bone before acidulate – weight of bones after acidulate

$110.2g - 98.3g = 11.90g$

$$\text{Percentage decalcification} = \frac{Calcium\ loss}{weight\ of\ bone\ before\ acidulate} \times 100$$

$$\frac{11.9g}{110.2g} \times 100 = 10.80\%$$

For 0.60mm≈ $600\mu m$

Weight of bone before acidulate = 210.2g

Weight of bone after acidulate = 180g

Calcium loss =

weight of bone before acidulate – weight of bone after acidulate

$$\frac{30.2g}{210.2g} \times 100 = 14.37\%$$

For 0.30mm≈ $300\mu m$

Weight of bone before acidulate = 150.2g

Weight of bone after acidulate = 143.3g

Calcium loss =

weight of bone before acidulate – weight of bone after acidulate

= 150.2g -143.3g = 6.9g

$$\text{Percentage decalcification} = \frac{Calcium\ loss}{weight\ of\ bone\ before\ acidulate} \times 100$$

$= \frac{6.9g}{150.2g} \times 100\% = 4.60\%$

The percentage glue yield

Total weight of glue yield = 105.3g

For 1.70mm

Glue extracted = 51.45g

Percentage glue extracted = $\frac{51.45g}{105.3g} \times 100\% = 48.86\%$

For 1.18mm

Glue extracted 33.50%

Percentage glue extracted = $\frac{33.50g}{105.3g} \times 31.81\%$

For 600μm

Glue extracted = 11.12g

Percentage glue extracted = $\frac{11.12g}{105.3g} \times 100\% = 10.56\%$

For 300μm

Glue extracted = 9.23g

Percentage glue extracted = $\frac{9.23g}{105.3g} \times 100\% = 8.77\%$

Viscosity (using flow of viscometer)

For 1.70mm

Viscosity o water at 25^0c $= 0.9285 \times 10^{-4}$kg/ms

Time taken for water to flow through flow cup 15 seconds

Time taken by glue to flow through flow cup 18.5 seconds

Viscosity of glue at $25^0c = \frac{0.9285 \times 18.5}{15}$

$= \frac{17.17725}{15} = 1.1452cp$

$= 11.452 \times 10^{-4}\, {}^{kg}/_{ms}$

$= 0.925 \times 10^{-4}\, {}^{kg}/_{ms}$

For 1.18mm

Viscosity of water at 25^0c $= 0.9285 \times 10^{-4}\, {}^{kg}/_{ms}$

Time taken for water fo flow through flows cup 15 seconds

Time taken by glue to flow through flow cup 17.8 seconds

Viscosity of glue at $25^0c = \frac{0.9285 \times 17.8}{15}$

$= \frac{16.5273}{15} = 1.1018cp$

$= 11.0182 \times 10^{-4}\, {}^{kg}/_{ms}$

$= 0.9285 \times 10^{-4}\, {}^{kg}/_{ms}$

For $600\mu m$

Viscosity of water at 25^0c $= 0.9285 \times 10^{-4} \, {}^{kg}/_{ms}$

Time taken for water to flow through cup 15 seconds

Time taken by glue to flow through cup 12.5 second

Viscosity of glue at 25^0c $= \frac{0.9285 \times 12.5}{15}$

$= \frac{11.60625}{15} = 0.77374cp$

$= 7.7375 \times 10^{-4} \, {}^{kg}/_{ms}$

For $300\mu m$

Viscosity of water at 25^0c $= 0.9285 \times 10^{-4} \, {}^{kg}/_{ms}$

Time taken for water to flow through flow cup 15 seconds

Time taken by glue to flow through flow cup 10.5 seconds

Viscosity of glue at 25^0c =

$= {}^{9.74925cp}/_{15}$

$= 6.500 \times 10^{-4} \, {}^{kg}/_{ms}$