ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

PRODUCTION OF GLUES FROM ANIMAL BONES

Akpa Jackson Gunorubon and Uku Misel
Department of Chemical/Petrochemical Engineering, Rivers State University of Science and Technology, Port-Harcourt, Rivers State, Nigeria
E-Mail: jacksonakpa@yahoo.com

ABSTRACT

The environmental and health risks associated with improper handling of waste bones will be greatly reduced if bone wastes generated from the abattoirs are converted to useful products. Waste cattle bones have been successfully used in the production of glue. The quality of the produced glue was ascertained by testing for quality indicators such as moisture content, pH, density, ash content and viscosity. The values of these quality indicators were greatly improved on investigation of the effects of water quantity and ratio of glue volume to polyvinyl volume used. The values of these quality indicators for the final glue produced with the new raw materials mix compared favorably with values of standard glue with maximum deviation of 0.20 for the ash content.

Keywords: bone glue, cattle bones, polyvinyl acetate (PVA).

INTRODUCTION

Rapid industrialization has caused an enormous increase in the amount of wastes generated particularly solid waste in Nigeria and the world in general. Solid wastes include all discarded solid materials from municipal, industrial and agricultural activities (Glynn, 1996). The wastes generated from agricultural activities especially from abattoirs in the processing of edible portions of slaughtered animals for consumption was estimated by Aniebo, *et al*. (2011) as shown in Table-1.

Table-1. Data for estimating abattoir effluent.

S/N	Waste category	Cow	Goat
1	Blood/head (kg)	12.6	0.72
2	Intestinal content/head (kg)	8.0	1.25
3	Waste tissue (kg)	6.4	0.80
4	Bone/head (kg)	11.8	2.06

The solid wastes consists mainly of bones, undigested ingest and occasionally aborted foetuses while the liquids comprise of blood, water, dissolved solids and gut contents.

Table-1 showed that bones constitute the highest quantity of solid waste and total waste generated from abattoir operations. The bone dump of the Trans-Amadi abattoir in Port-Harcourt, Rivers State shown in Figure-1 depicts a typical bone dump of an abattoir.

Figure-1. Bones disposed at the Trans-Amadi abattoir in Port-Harcourt.

Inefficient management of these bones creates a variety of problems that endanger public health and the environment in general. These wastes are disposed in ways that have been reported to cause the pollution of surface and underground waters and air quality (Odoemelan and Ajunwa, 2008); affect the health of residents living within the vicinity of the abattoirs, destroy affected water bodies thus affect fish yield, (Aina and Adedipe, 1991); discharge of blood and animal faeces into streams has been reported by Nwachukwu *et al*., (2011) to cause oxygen-depletion while humans may also be affected through outbreak of water borne diseases and other respiratory and chest diseases (Mohammed and Musa, 2012). Bone wastes are also ideal breeding grounds for disease causing organisms (pathogens). These waste materials are disposed of without regard to sound environmental management practices, (Osibanjo and Adie, 2007); the waste bones are

VOL. 9, NO. 9, SEPTEMBER 2014 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

usually disposed by burning which further pollutes the air and endanger human lives.

This work investigates the production of glue from these waste bones thus provides an efficient method/means of waste abattoir bones disposal that does not pollute the environment and also creates wealth.

Glue is an adhesive substance used for sticking objects or materials together or any substance applied to the surfaces of materials that binds them together and resists separation (Roberts and Etherington, 1982). Adhesives may be found naturally or produced synthetically. Adhesives of "animal" origin have been found (Thorndahl, 2009) to be non-toxic, biodegradable and environmentally friendly. However, difficulty of storage in the wet state, it darkens with age and shrinks as it dry thus can potentially damage what it is applied on are some disadvantages of its use (Ebnesajjad, 2010). Hence this work also seeks the improvement in the quality of glue from this source by utilizing polyvinyl acetate and formaldehyde to improve the gel strength, odor and shelf life that make animal glue not applicable for most applications.

MATERIAL AND METHODS

In the city of Port Harcourt, there are four abattoirs (Trans-Amadi, Ogbunabali, Rumuokoro and Ngboshimini). The activities of the Trans-Amadi abattoir was monitored and used as a basis for this work. The quantity of bones generated from this abattoir was estimated with the assistance of the workers as an average of 14, 850lbs daily over a one month period.

PRODUCTION OF BONE GLUE

The glue production was performed in the unit operations laboratory of the Department of Chemical/Petrochemical Engineering, Rivers State University of Science and Technology, Port-Harcourt. The steps involved in a typical glue production from cattle bones were followed for the laboratory production of the bone glues as follows:

SAMPLE COLLECTION

Samples of cattle bones were collected from the Trans-Amadi abattoir in Port-Harcourt, Rivers State, Nigeria. These samples were properly packed in a polyethylene sack and taken to the laboratory.

SAMPLE TREATMENT

The bone samples were processed as follows:

Size reduction

The bones were reduced to smaller sizes as shown in Figure-2 with the aid of a hammer.

Figure-2. Reduction of bone sample.

Washing and treatment with lime water

The bones were washed thoroughly with warm water to remove fat and dirt. Hydrated lime solution was produced (74g/mol of $Ca(OH)_2$ dissolved in $1000cm^3$ of water), 200g of the bone samples were soaked in the hydrated lime solution for three days to eliminate odor and all traces of hair and flesh attached to the bones as shown in Figure-3.

Figure-3. Treatment of sample with lime water.

The bones were removed and washed with distilled water to rinse off the hydrated lime.

Preheating with dilute acid

The samples were treated with dilute hydrochloric acid (HCL) to control the pH, thus ensure optimum breakdown of the collagen to glue as shown in Figure-4.

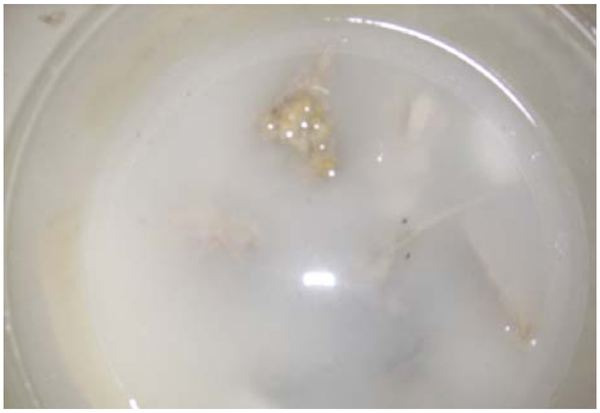

Figure-4. Treatment of bones sample with Hydrochloric Acid (HCL).

Shredding/crushing

The bone samples were dried for two days and crushed in a Jaw crusher to particle size of about 0.015mm (300mesh) as shown in Figure-5.

Figure-5. Crushed bone samples.

Heating/evaporating

75ml of water was added to 100g of fine bone sample. The bone solution was transferred into a beaker and heated at 70^{o}C for three hours to loosen the collagen contained in the bone.

Figure-6. Heating of crushed bone solution.

Gelling/cooling

The resulting bone glue was allowed to stand for 40 minutes. On cooling, a jelly-like material was formed as shown in Figure-7.

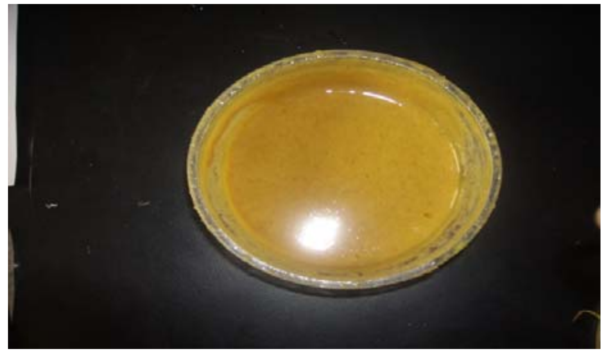

Figure-7. Jelly-like glue formed on cooling.

QUALITY CONTROL/IMPROVEMENT

Polyvinyl acetate (PVA) was added to the glue in the ratio 1:4 (volume) to make the glue formed more jelly. The mixture was stirred vigorously to achieve homogeneity. The ratio can be varied to control the desired degree of flexibility to improve elasticity. 10ml of formaldehyde was added to prevent mold, bacterial growth and improve shelf life.

Drying and pulverization

The glue was dried in a dryer to remove unwanted moisture. This gives hard and brittle sheets of the glue which can be stored. The brittle sheets can be broken into pieces or flakes and ground into fine particles according to the desired particle size or user's specification.

ANALYSIS OF PRODUCED GLUE

The quality of glue produced was ascertained by determining the following quality indicators of the produced glue: moisture content, pH, density, ash content and viscosity. All results were the average of duplicate analysis

Moisture content

5ml of the glue sample was weighed in a crucible and heated in the oven at a temperature of 60^{o}C until no form of moisture was visible. Heating was continued till no water was visible in any part of the apparatus except in the trap and the volume of water in the trap remained constant for five minutes. The sample was cooled to room temperature and weighed. The moisture content was calculated using the formula:

$$\text{Moisture content (\%)} = \frac{\text{Weight of moisture in glue}}{\text{Weight of glue before drying}} \times 100\%$$

Determination of pH

This was determined using a digital pH meter (model HI 8424 with pH buffer 7). The pH meter was inserted into a beaker containing the glue sample and the reading taken.

Determination of density

The densities of the glue were determined by taking the weight of a known volume of the glue in a density bottle (pycnometer) using an analytical balance.

Determination of ash content

100ml of the glue sample was weighed in a beaker. The beaker with its content was heated to 500°C until the glue became very dry and the visible appearance of black spots on the glue sample. The dried glue was cooled to room temperature and weighed. The ash content of the glue was calculated using the expression:

$$\%\text{ Ash content} = \frac{\text{Mass of dry glue sample}}{\text{Mass of original glue sample}} \times 100$$

Determination of viscosity

The Viscosity profile of the glue was obtained using a viscometer (LvDv I+, Brookfield, USA) with the spindle set at 60rpm following the technique proposed by AOAC, (2000).

RESULTS

The results of the laboratory test of some quality indicators performed on the produced glue are shown in Table-2. The values of these quality indicators for standard animal glue as giving by Pizzi and Mittal, (2008) are also shown in Table-2 for comparison.

Table-2. Laboratory results of quality indicators for produced glue.

Parameter	Produced glue	Standard glue	Deviation
pH	5.86	6.06	0.0330
Density (g/cm^3)	1.015	1.270	0.2008
Viscosity (cp)	46.26	80.00	0.4218
Moisture content (%)	17.88	15.00	0.1913
Ash content (%)	3.029	2.000	0.5149

Table-2 shows that the quality indicator ash content had the maximum deviation while pH had the minimum deviation between the values of the quality indicators for standard glue compared with values obtained for the produced glue. The produced glue was more acidic, less dense, had lower viscosity (less resistant to flow), contained more water and had more ash.

PRODUCT OPTIMIZATION

The effect of water and PVA on the quality indicators of glue produced was investigated.

EFFECT OF WATER

The quantity of water used in the production of the glue was varied between 35 to 125 ml. The results of the quality test on the produced glue are as shown in Table-3.

Table-3. Effect of water on quality indicators of produced glue.

Water content (ml)	**Viscosity** (cp)	**pH**	**Density** (g/cm^3)	**Moisture content** (%)	**Ash content** (%)
38	180.20	5.33	1.0449	11.93	4.43
50	106.15	5.64	1.0226	17.71	3.09
75	46.25	5.86	1.0152	17.87	3.03
100	34.10	5.99	1.0103	22.90	1.14
125	24.10	6.22	1.0035	30.20	0.25

pH: pH is the degree of acidity or alkalinity of a substance. Increase in water quantity in the produced glue neutralizes the acidity of the glue. Therefore, the more water in the glue the less acidic the glue. This trend is shown in Table-3 where increase in water increases the pH of the glue.

Density: Density is the mass per unit volume of a substance; increase in water quantity in produced glue increases the volume of the glue thus reduces its density. This trend is shown in Table-3 where increase in water content decreases the density of the glue.

Viscosity: Viscosity is the resistance to flow. The more water added to the glue, the lighter and less sticky it becomes, it flows faster (its resistance to flow reduces). Hence, the viscosity reduces. This trend is shown in Table-3 where increase in water quantity in the glue decreases the viscosity of the glue.

Moisture content: Increase in water increases the water content in the glue. This trend is shown in Table-3.

Ash content: Ash content is the amount of residue obtained when a sample is burnt under controlled condition so that all ignitable mass is removed. The denser the glue, the more the ash obtained (Milligan and Higgins, 2009). Increase in water content of the glue increases the volume of the glue and reduces its density. Therefore increase in water content of the glue makes the glue less dense, hence reduces its ash content. This trend is also shown in Table-3.

EFFECT OF POLYVINYL ACETATE (PVA)

The effect of polyvinyl acetate (PVA) on the quality of the glue produced was investigated. The ratio of glue volume produced to PVA volume was varied from 1:0.125 to 1:1. The results of the quality indicators of the produced glue are shown in Table-4.

Table-4. Effect of polyvinyl Acetate on quality indicators of produced glue.

Ratio of glue to PVA	Viscosity (cp)	pH	Density (g/cm^3)	Moisture content (%)	Ash content (%)
1:1	251.2	5.33	1.3806	15.30	4.7002
1:0.50	104.7	5.52	1.2401	19.00	3.8964
1: 0.40	83.81	5.58	1.2290	19.80	3.2059
1: 0.33	51.75	5.63	1.1452	21.80	3.1420
1: 0.167	3.44	6.20	1.1431	22.70	2.1925
1:0.125	1.72	7.00	1.0176	28.99	2.0024

Poly vinyl acetate is acidic; hence an increase in its quantity in the produced glue makes the glue acidic (decrease in pH value) while a decrease makes the glue less acidic (increase in pH value). Glues with high acidity have been reported (Milligan and Higgins, 2009) to absorb less water; this is seen in Table-4, as the quantity of PVA is increased, the glue became more acidic; it absorbed less water leading to a decrease in glue volume and subsequently an increase in its density. As the density of the glue increases, it becomes thicker, produces more ash (Milligan and Higgins, 2009); flows slower, thus its resistance to flow increases (the viscosity of the glue increases). These trends are shown in Table-4.

The water quantity and glue to polyvinyl volume ratio had minimal effect on the density and pH but had tremendous effect on the viscosity and moisture content of the produced glue. The effect of water content and polyvinyl ratio can be used to determine the optimum values of these raw materials to use in the glue production based on the values of the quality indicators of the produced glue compared with values of the standard glue. A couple of new trial raw material mix (proportions) (water content: 50 - 75ml; PVA: 1:0.40) were used again for the glue production from which a new optimum raw materials mix was obtained; (ratio of glue to PVA of 1: 0.40 and the quantity of water 70 ml) was proposed and used for the production of the last sample of glue.

This glue was subjected to quality test and the results obtained for the quality indicators are shown in Table-5.

Table-5. Comparison between new optimum glue and standard glue.

Parameter	Optimum produced glue	Standard glue	Deviation
pH	5.82	6.06	0.0396
Density (g/cm^3)	1.23	1.27	0.0315
Viscosity (cp)	83.25	80.00	-0.0406
Moisture content (%)	16.57	15.00	-0.1047
Ash content (%)	2.40	2.00	-0.2000

The values of the quality indicators of the new produced glue compared favorably with those of the standard glue with deviations as shown in Table-5. The quality indicator; ash content had the maximum deviation of 0.2000. There were also great improvements in the quality indicators of the glue produced with the 'new mix' in Table-5 compared with the values of the quality indicators of the initial glue produced in Table-2.

CONCLUSIONS

The hazardous effects of inadequate disposal of waste bones are very glaring and cannot be ignored. There is therefore the need for a proper approach to manage waste bones from all sources especially the abattoirs, particularly through Waste to wealth - schemes where wastes are converted to useful products. Cattle bone wastes were successfully used to produced glue, an adhesive. The quality of the produced glue was improved by investigating the effects of two raw material used: quantity of water and polyvinyl acetate used. The final glue produced was tested and the quality indicators compared favorably with those of standard glue.

REFERENCES

AOAC. 2000. Official Methods of Analysis International, Horwitz W, (Editor). Association of Official Analytical Chemists, Gaithersburg Mongland, USA, 17th Ed. 1(41): 1-68.

Aniebo A. O., Wekhe S. N. and Okoli I. C. 2009. Abattoir Blood Waste Generation in River State and its Environmental Implications in the Niger Delta, Toxicol. Environ. Chem. 91: 619-625.

Aina E. O. A. and Adedipe N. O. 1991. Water Quality Monitoring and Environmental status in Nigeria, FEPA Monograph, Lagos. pp. 12-59.

Ebnesajjad S. 2010. History of Adhesives, Handbook of Adhesives and Surface Preparation: Technology, Applications and Manufacturing. Amsterdam: Elsevier. 137. ISBN 9781437744613.

Glynn H. 1996. Environmental Science and Engineering, Prentice - Hall, New Jersey, USA.

Milligan M. and Higgins B. 2009. Hide Glues, Bone Glues and Industrial Gelatins, Johnstown, New York, USA.

Mohammed S and Musa J. J. 2012. Impact of Abattoir Effluent on River Landzu, Bida, Nigeria. J. Chem. Biol. Phys. Sci. 2(1): 132-136.

Nwachukwu M. I., Akinde S. B., Udujih O. S. and Nwachukwu I. O. 2011. Effect of Abattoir Wastes on the Population of Proteolytic and Lipolytic Bacteria in a Recipient Water Body (Otamiri River). Global Res. J. Sci. 1: 40-42.

Odoemelan S. A. and Ajunwa O. 2008. Heavy Metal Status and Physicochemical Properties of Agricultural Soil Amended by Short term Application of Animal Manure. J. Chem. Soc. Niger. 20: 60-63.

Osibanjo O. and Adie G. U. 2007. Impact of Effluent from Bodija Abattoir on the Physico-chemical Parameters of Oshunkaye Stream in Ibadan City, Nigeria. Afr. J. Biotechnol. 6: 1806-1811.

Pizzi A. and Mittal, K. L. 2008. Handbook of Adhesive Technology Available at http//specialchem4 adhesives.com (Accessed 29 April, 2014).

Roberts M. T. and Etherington D. 1982. Book Binding and the conservation of Books. Preservation Department of Stanford University Libraries.

Thorndahl E. 2009. The use of Hide Glue as an Adhesive, Bjorn Industries, Charlotte, North Carolina.