RODUCTION AND CHARACTERIZATION OF CHEMICAL ACTIVITED CARBON FROM ANIMAL SOURCES (I.E BONES) AND PLANT SOURCES (I.E SAW DUST).

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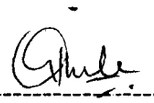
A RESEARCH PROJECT SUMITTED TO THE DEPARTMENT OF CHEMICAL ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR, OF ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE, NIGERIA

DECLARATION

I, ISA MUSA YAKASAI (98/7010EH), declare that this research project was carried out under the supervision of Dr, F. Aberuagba and presented in partial fulfillment of the requirement of the award of B.ENG. Degree in Chemical Engineering. All sources on information and quotation are duly acknowledged.



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STUDENT SIGNATURE DATE

CERTIFICATION

This is to certify that this project, production of activated carbon from animal source (bones) and plant source (saw dust) had been presented by Isa Musa Yakasai of the department of chemical engineering, school of engineering and engineering technology, federal university of technology Minna.

DR, F, ABERUAGBA
ROJECT SUPERVISOR

19/11/2014
DATE

DR, F ABERUAGBA
HEAD OF DEPARTMENT

19/11/2014
DATE

EXTERNAL EXAMINAR

DATE

DEDICATION

This project report is heartily without reservation of thoughts dedicated to my beloved father, Alh. Yaro Isa, my beloved mother, Hajiya Bintu Yaro, and my beloved brother Alh. Sani Isa Yaro.

AKNOWLEDEGEMENT

All praises are due into Allah, the creator of heavens, and the earth and all between, the giver and the sustainer of life; the one on whom I have depended on for all these ages and my hope in the years to come. My gratitude goes to the holy prophet for teaching me the path leading to a faithful life.

My heart felt appreciation to my able supervisor DR, F. Aberuagba for his guidance and fatherly assistance during the course this project work. My appreciation also goes to the head of department, staff and students of chemical engineering department, federal university of technology Minna. To my course mates; the storm is over. Thank you so much.

My deepest appreciation goes to my parent Alh. And Hajiya Yaro Isa for nursing and supporting me to this stage of my life, I shall always be there for you. To all my brothers and sisters, you are wonderful;I love you all.

My warmest appreciation also goes to my cousin brother, Alhaji Ismaila Isa thank you so much for giving me a strong footing and for your solid support and for the encouragement given to me; your efforts shall not be in vain.

To the one and only Monsurat Hassan, who also had been there for me big time, you are simply the best, I am indebted to you. Thank you so much only God can reward you. I am speechless.

Finally, I wish to express my sincere appreciation to the following individuals and families for their contribution to my life in one way or the other, Hajiya Amina Amadu, Garba, Hajara, Saratul, Mohd, Yarinya, Iyabo, Mallama Azimi Baba Sule, may Allah reward you all. Thank you.

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ABSTRACT

Activated carbons were produced from cow bone, chicken bone and saw dust by chemical activation method. The activated carbons produced were carbonized by determining the surface area, pore volume, moisture content and ash content. The performance efficiencies of the activated carbons were tested using methyl orange color adsorption.

Of the three activated carbon produced, it was discovered that, the activated carbon produce from the chicken bone seemed to be most effective than those produced from cow bone and saw dust because, it produced: the largest value of surface area (i.e. 2.829cm$10^{-5}m^2$), the largest value pore volume (i.e. 0.0081cm^3g^{-1}) and also the largest value of ash content (i.e 96.79%), the percentage methyl orange color removal was also calculated to be the largest value (i.e. 76.23%).

CHAPTER ONE

1.10 INTRODUCTION

Activated carbon is an amorphous of carbon with large internal surfaces and pores, which are as a result of the choice of raw materials and the method of production.

Almost any carbonaceous raw material can be used for the production of activated carbon. Wood is commonly used for the production of activated carbon for decolorization while bones chars made by calcing bones are used in large quantity for sugar refining.

Bones and woods are some of the few solids that can produce high surface area per unit weight at relatively low cost. The high surface area per weight enhances its adsorption capabilities. Typical composition of activated carbon includes; high percentage carbon. Ash, hydrogen, sulphur and nitrogen (Fasami 1994).

Whatever the starting materials, bones, palm kernel shell, wood, corn curbs etc. the basic steps in the production of activated carbon are:

- Carbonization or burning to eliminate the bulk of the volatile matters.
- Grinding to give a desired particle size
- Activating using chemical or oxidizing with heated gas steam, etc all these are done to develop a proper pre-structure for adsorption.

Activated carbon and its use for desulphurisation processes was produced from oil palm shell by Ekpong, Josephat Okara (PGD February); activated carbon and its use for flue gas cleaning was also produced from palm kernel shell and coconut shell by Nwanko Uchenna (PGD March 2001). But as far as I am concern little or nothing as been produced from local raw materials (i.e. bones and saw dust) particularly in Niger state.

1.20 AIMS AND OBJECTIVES

The aim and objectives of this work is to look at the possibility of utilizing waste products from agricultural and animal products into more productive form.

In this work, however, Agricultural and animal waste products such as bones and sawdust were investigated.

1.30 SCOPE OF WORK

The scope of this work is on the production of activated carbon from plant and animal sources, the determination of the factors that influences the performance of the activated carbon produced such as: the temperature of carbonization, sources of activation, also the activated carbon produced were also characterized, the performance efficiencies of the activated carbon were also tested and finally the use of the activated carbon.

CHAPTER TWO

LITERATURE REVIEW

2.10 CHEMISTRY OF BONE

Bone is a rigid tissue consisting of cells embedded in an abundant, hard intercellular material. The two principal components of this material, collagen and calcium phosphate, distinguish bone from such other hard tissue as chitin, enamel and shell.

The major minerals are calcium and phosphate. When first deposited, mineral is crystallogragphically amorphous but with maturation become typical of the appetite mineral. Carbonate is also present in varying quantity and occurs in two distinct phases; calcium carbonate and carbonate appetite.

2.20 CARBON

A chemical element C with an atomic number of 6 and an atomic weight, of 12.01, carbon is unique in chemistry because it forms a vast number of compounds, larger than the sum total of all other element combined. Carbon is a typical non-metal although an allotrope of carbon graphite conduct electricity. Carbon exists in two allotropic forms graphite and diamond. Carbon also has the ability to form multiple with it and with other non-metals. (Ababio.O.Y, 1998).

2.30 ALLOTROPY OF CARBON

If an element can exist without changing it s state in two or more different forms, the element is said to exhibits allotropy or polymorphism. The forms of the elements are known as allotropes of it. They exhibit different physical properties and the same or may have different chemical properties. (Ababio.O.Y, 1998).

2.40 ACTIVATION

It is the process of treating the carbon to open an enormous number of pores in the sizes of 1.2-to 2.0-nanometer diameter range. (Gas-adsorbent carbon). Or up to 100-nanometer range (decolourization carbon). After activation, the carbon has a large surface area for the adsorption phenomona. Carbons that have not been subjected previously to high temperature are easier to activate. Selective oxidation of the base carbon with steam, carbon dioxide, structure. Other methods required the mixing of chemical such as metal chlorides (particularly with the carbonaceous matter, followed by calcining and washing the residue. The economic of the latter process require the recovery of the chemical agent. (Sheffer, 1969).

2.50 ACTIVATED CARBON:

It is powdered granular or pelleted form of amorphous carbon characterized by very large surface area per unit volume, because of an enormous number of fine pores. Activated carbon is capable of collecting gases, liquids or dissolved substances on the surface of the pores. Activated carbon has a board spectrum of adsorption activity,

excellent physical and chemical stability and ease of production from richly available, waste materials.

Activated carbon came into prominence through its use as an adsorbent in gas mask in world war I. however, the knowledge that, carbon produced by the decomposition of wood can remove coloring matter from solution dates back to the fifteenth century. The first commercial application of this property, however, was not made until 1974, when charcoal filters were used in a British sugar refinery. About 1812, bone char was discovered by Fguer. The market continues to be dominated by the USA and Japan which together account for around 60% of the world consumption. The importance of major gold mining in the activated carbon market is growing rapidly following the spread in the use of carbon in pulp and carbon in leading technology. (Chilow, F.W 1972)

2.51 TYPES OF ACTIVATED CARBON ACCORDING TO PHASE

There are two types of activated carbon, which are commercially recognized under this heading, they are

- Gas adsorbed carbon that are used for purification purposes in the vapor or gas phase such as solvent recovery, gas separation. These are hard dense granules or pellets
- Liquid-phase carbon, which are used to decolorized or purify liquids, solution of liquefiable materials like waxes. These are light fluffy powders. The main different between them lies in the pore-size distribution.

2.52 PRODUCTION OF ACTIVATED CARBON

Activated carbon can be produced from any carbonaceous materials. The choice between raw materials depends on the properties needed at the end product, the processing technology available and the cost of the raw material. By far the most commonly used raw materials are coconut shell and coal based materials. Other materials used for liquid phase adsorbent are lignite's, bones, wood. Activated carbon has also been made from sawdust, and rice husk.

These are two basic manufacturing processes for activated carbons. Steam is generally used for coal-based coconut shell; palm kernel shell raw materials etc. chemical activation is used for the production of activated carbon from saw dust, wood shaving, or bones. The choice of processing method depends on the raw material used and on whether a low or high density powdered or granular activated carbon is required. Both processes involved the control oxidation of the raw material at high temperatures.

In the selective activation process, the carbonaceous raw material is first carbonized at 500^{O}C to 600 ^{O}C to drive off the volatile materials. However, a coke is produced with pores too small to act as a useful adsorbent. To enlarge the pore size and increase the surface area the carbon is activated with either steam or chemical activation method. (Shaffer, 1969).

2.53 PROPERTIES OF ACTIVATED CARBON

Activated carbon, in powder, granule, pellet fibre are extruded form, are used for their adsorption properties to purify a liquid or gas, to concentrate a chemical from liquid or gas, or to separate a chemical from a gas stream. Commercial grades of activated carbon are designed as liquid-phase or gas phase adsorbents.

Liquid-phase carbon can be powdered or granular in form, gas phase carbon is generally hard granules or hard relatively dust-free pellet. A large specific surface area characterizes all activated carbons.

Selective oxidation or chemical or steam activation can be used to produce both liquid or gas-phase carbon. In both cases, the raw material is activated in the granular form. Some gas adsorber carbons are made from hard, dense materials like fruit pips and nutshells. They are crush to sizes and activated directly to give hard dense granules of carbon.

Important chemical properties of activated carbon are its ash content, the ash composition and the Ph of the carbon. The ash content increases in direct proportion to the degree of activation. It can be used to determine the raw material used to produce and activated carbon. Carbon. Can inhibit adsorption. The ph of the carbon affects the material ammonic or catic ic adsorption preference. (Sheffler, 1969).

TABLE 2.54 A AND B: PHYSICAL PROPERTIES OF TYPICAL ACTIVATED CARBON.

LIQUID-PHASE ACTIVATED CARBON

Property	Lignite base	World base	Bituminous
Diameter (mm)	0.15	0.15	0.59-2.38
Mesh (tyler)	-100	-100	8-30
Carbon tetrachloride activity (mm)	30	40	50
Iodine no. (mm)	500	700	950
Bulk density mm(g/ml)	0.48	0.25	0.50
Ash content (mash %)	-18	7	8

GAS- PHAS ACTIVATED CARBON

Property	Granular coal	Pelleted coal	Bituminous
Diameter (mm)	4.75-1.70	3.36- 2.38	3.36-1.18
Mesh (tyler)	-4, + 4.10	-6,+8	-6, + 14
CCl_4 activity (mm)	60	60	60
Iodine no. (mm)	1000	1000	1000
Bulk density mm(g/ml)	0.50	0.52	.53
Ash content (mash %)	8	2	4

2.55 USES OF ACTIVATED CARBON

1) Activated charcoal, the vapor- adsorbent type was first used in gas mask because of its ability to adsorb certain poisonous gases, and it is now widely employed in both military and industrial gas masks.
2) Activated carbon is used in air conditioning systems to control odors in large restaurant, auditoriums and airport
3) Specially impregnated grade are used in cigarette filters.
4) Activated charcoal is used on large scale in Germany for the removal of hydrogen sulphide from town's gas.
5) Activated charcoal has also been used in Germany for dephenolizing effluent gas-work liquor.
6) In the purification of drinking water activated charcoal has in recent years been used. Its use is confined to the find states of purification for the removal of excess chloride remaining after chlorination and of traces of phenol introduced through contamination of the water with factory effluent, this purification is done by means of filtration through beds of active charcoal.
7) It is used for the recovery of gasoline from natural gas. It able to adsorb practically any organic solvent at about $35^{O}C$ and release it when heated to $12^{O}C$ or higher for solvent recovery.
8) Other uses include solution purification such as the clean up of cane, beet, and corn sugar solution and for the removal of testes and odors from vegetable and animal fats and oil, alcohol beverage chemical and pharmaceuticals.

2.56 ADVANTAGES OF ACTIVATED CARBON OVER OTHER ADSORBENTS

Other forms of adsorbents include activated aluminas, molecular sieve and silicate gel. Activated carbon are less polar than other adsorbents but it is incorrect to call them non polar because the surface oxides render then slightly polar. The polarity generally increases with aging of the carbon in humid air. Compared with other commercial adsorbent, activated carbon has a broad spectrum of adsorptive activity's excellent physical readily available frequently waste materials. Adsorption on activated carbon is selective, favoring non-polar over polar substances. (Clifford And Gensner, 1973)

2.60 ADSORPTION

It is defined as a process in which fluid molecules are concentrated on the surface of an adsorbent by chemical or physical forces or both. It is a solid substance to condense and retain on its surface layer of a gaseous or liquid substances. A well known equation relating quantity adsorbed is as follows

$$\frac{X}{m} = Kp^{\frac{1}{n}}$$

where

x = weight of the adsorbed material

m = weight of the adsorbing material

c = concentration n equilibrium with adsorbed material or p = pressure

k and n = constant to be determined experimentally for each temperature.

The adsorption of a gas on a solid takes place in several stages, which include:

- The movement of the gas molecules to the external surface of the solid, and this is the same as the diffusion of the gas molecules through a stationary layer
- The penetration of the molecules into the pores of the solid
- The actual adsorption of the molecular on the site in the pore. (Philip G and K, Watson 1979).

2.61 TYPES OF ADSORPTION

When any gas brought into contact with any solid under the right condition of temperature and pressure it is attracted to and partially covers the surface of the solid by a process known as adsorption. The solid is called the adsorbent while the adsorbed substance is called the adsorbate. Actually either liquid or solid can act as adsorbent. Also adsorbate can be gas or liquids. The adsorption of gases on solids has being found to fall the convenient classification known as physical and chemical adsorption respectively. Physical adsorption occurs through vander waals forces between adsorbent and the adsorbate molecule but Chemical adsorption differs from physical adsorption in that it depends on chemical bond formation between the adsorbent and adsorbate. Chemical adsorption is therefore highly specific. (Kirk O. 1983).

CHAPTER THREE

3.0 EXPERIMENTALS

3.1 RAW MATERIALS,EQUIPMENTS AND UTILITIES

3.1.1 RAW MATERIALS:

The major raw materials for the production of these activated carbons are bones from animals and saw dust from plant sources.

3.12 EQUIPMENTS

- Digital analytical balance (brain weigh B 300) from London.
- Laboratory electric furnace (digital) mechanical instrument corporative
- Hungary model- TYP:OH 85TR
- Encrete brass sieve mesh size 2mm made steel manufactured from Endicott's limited London England.
- Tray drier made in Hampshire England
- Colorimeter corning 253 model
- Funnel
- Filter paper

3.13 APPARATUS

- Beaker
- Conical flask
- Measuring cylinder
- Crucible
- Mortal and pestle made of clay manufacture from pascal engineering company limited England.

UTILITIES

- $Mgcl_2$ (reagent) percentage purity 95.3 made by M and B England
- Methyl orange
- Distilled water from the laboratory

3.20 SOURCE OF MATERIALS AND EQUIPMENTS

The basic raw materials, which are: bones from animal source were obtained from abattoir in Minna and the sawdust from plant source was obtained from a sawmill in Minna also. All other equipments and apparatus were obtained from chemical engineering department laboratory.

3.30 ACTIVATED CARBON: METHOD OF PREPARATION

In the manufacture of activated carbon, a carbonaceous raw materials are subjected to a four stage processes

i. **DEHYDRATION:** the materials were first heated to a temperature of about 170°C in an electric oven to remove water or any moisture; sometimes a dehydrating agent such as zinc chloride or phosphoric acid is used.

ii. **CARBONAZATION:** This is carried out at varying temperatures in an electric furnace.

iii. **PULVERIZATION:** the carbonized bones and the saw dust were then crushed into smaller sizes using mortals and pestle or any other method of pulverization

iv. **ACTIVATION:** in the final stage, the charcoal were treated with an activating agents such as magnesium chloride ($MgCl_2$),$CaCl_2$. in the course of activation, the decomposition product are burned off, exposing pore openings. The pores then increase in size and a macro porous structure develops.

3.40 METHOD OF PRODUCTION OF ACTIVATED CHARCOAL FROM ANIMAL BONES AND SAW DUST.

The animal bones (cow and chicken), obtained from abattoir within Niger state were collected and washed in distilled water to remove dirt and any adhering substance, then the bones were sun dried for one day.

Therefore 100g each of these samples was placed into a dried crucible and placed into an electric oven at 170°C for 30minutes to facilitate dehydration. More so 14.00g of each of these samples were placed into 4 different crucible each at varying temperatures (i.e. 500, °C 530 °C, 560 °C, and 600 °C,) and carbonized in an electric muffler furnace for 45 minutes after which it was put off and the sample were allowed to cool for 1 hour.

The carbonized charcoal from cow and chicken bone were pulverized and impregnated with ($MgCl_2$) solution for a period of 24 hours the next day it was drained and place on a tray for air-drying. And therefore ready for use. (Fasanmi F.O 1994).

Activation of charcoal from saw dust.

The weight of a beaker and 10ml solution of ($MgCl_2$) was weighed at different temperatures and the weight of a beaker, 10ml solution of ($MgCl_2$), and that of the sample were weighed and subtracted from the first measurement.

At 600°C: a) 1st beaker + 10ml ($MgCl_2$), = 9.36g

b) Beaker + 10ml ($MgCl_2$), + charcoal = 9.70g

Therefore actual weight of activated charcoal after activation is = 9.70g- 9.36g

= 0.34g

At 560 °C: a) 1st beaker + 10 ml ($MgCl_2$), = 9.57g

b) Beaker + 10ml ($MgCl_2$), + charcoal = 9.97g

Therefore the actual weight of activated charcoal is = 9.97-9.57

0.40g

At 530 °C: a) beaker + 10 ml of ($MgCl_2$), = 9.30g

b) Beaker + 10 ml of ($MgCl_2$), + charcoal = 9.76g

Therefore actual weight of activated charcoal is = 9.77- 9.30g

=0.47g

At 500°C: a) beaker + 10 ml of ($MgCl_2$), = 9.22g

b) Beaker + 10 ml of ($MgCl_2$), + charcoal = 9.73g

Therefore actual weight of activated charcoal is = 9.73- 9.22g

=0.51g

(Shefiler, G.H 1969)

3.50 CHARACTERIZATION OF ACTIVATED CHARCOAL

This involves the determination of some parameters contained in the charcoal which include: ash content, moisture content, charcoal yield, fixed carbon, bulk density (apparent density), particle size, pore volume and surface area, volatile contents etc.

1) **Ash Content:** this gives the total ash present in the charcoal. In specific end uses, the amount and composition of the ash may influence the desired properties of activated charcoa .

It is calculated as follows:

$$\text{Total ash} = \frac{D-I}{C-I} x100 \text{ ---------- } 3(a)$$

Where B = weight of the crucible (g)

C = weight of the crucible + original sample (g)

D = weight of the crucible + ash sample (g)

(ASTM) (1987)

2) **Moisture content**: this determines the moisture content of the charcoal. The moisture content of charcoal is often required to define and express its properties in relation to the net weight of the carbon. The calculation is as follows:

$$\text{Moisture content} = \frac{\text{weight of the original sample – the weight of the ash}}{\text{Weight of the original sample}} \times 100$$

(American society for testing and materials (ASTM) 1987).

3) YIELD OF CHARCOAL

It is obtained from the calculation:

$$\text{Yield} = \frac{Q - A.C + M.C}{Q} \times 100$$

Where,

Q = original mass of activated charcoal.

A.C = ash content.

M.C = Moisture content. [Ekeneme E.J, 1996]

4) FIXED CARBON

This was obtained from calculation,

$$F.C = \frac{Y - M.C - A.C}{Y} \times 100 \quad \text{----------3(d)}$$

F.C = fixed carbon

Y = Yield of charcoal

M.C = Moisture content

A.C = Ash content (British standard institution (BSI) 1997)

5) PARTICLE SIZING.

The smaller the particles size the bigger the porosity. The granules are usually most effective with the size of granular activated carbon in order to provide proper content of gases or liquid in a packed bed of the material. Changes in particle size distribution can affect the pressure drop and the rate of adsorption.

6) PORE VOLUME

15g of activated carbon were soaked in 100ml of distilled water for three hours and the activated carbon was strained. The values obtained are as follows:

$$\text{Pore volume} = \frac{W_f - W_o}{W_o} \times \text{density of } H_2O \quad \text{----------3 (f)}$$

Where

W_f = final weight of activated charcoal and beaker (W_f)

W_o = initial weight of activated charcoal and beaker (W_o)

7) VOLATILE CONTENT:

A mass (Q) of the charcoal was activated at 900Oc for 10minutes in a closed crucible inside a muffle furnace. The content are then removed and cooled in a desiccators. The changes in weight (Y) are noted and the difference is given as the volatile content.

The volatile content (VC) is determined from:

$$V.C = \frac{Q - Y}{Q} \times 100$$

Where VC => Volatile content

Q => Original mass of the charcoal

Y => Change in the weight of the charcoal.

8) PORE VOLUME

15g of activated carbon (i.e. cow bone) was soaked in 100ml of distilled water for two hours and the activated carbon was strained and weighed to be: 17.70g.

The values obtained are as follows

Initial weight of activated charcoal and beaker (W_o) = 105.60g

Final weight of activated charcoal and beaker (W_f) = 108.3g

$$\text{Pore volume} = \frac{W_f - W_o}{W_o} \times \text{density of } H_2O$$

$$= \frac{108.30 - 105.60}{105.60} \times 1$$

$$= 0.026\ cm^3g^{-1}$$

15g of activated carbon (i.e. chicken bone) was soaked in 100ml of distilled water for two hours and the activated carbon was strained and weighed to be: 23.50g.

The values obtained are as follows

Initial weight of activated charcoal and beaker (W_o) = 105.60g

Final weight of activated charcoal and beaker (W_f) = 114.10g

Pore volume = $\frac{W_f - W_o}{}$ x density of H_2O

W_o

$$= \frac{114.0 - 105.60}{105.60} \times 1$$

$$= 0.08 \ cm^3g^{-1}$$

15g of activated carbon produced from saw dust was dissolved in 100ml of distilled water for two hours and the activated carbon was recovered with the aid of a beaker, funnel and a filter paper and the weight of the residue was weighed to be : 16.10g.

The values obtained are as follows

Initial weight of activated charcoal and beaker (W_o) = 105.60g

Final weight of activated charcoal and beaker (W_f) = 106.70g

$$\text{Pore volume} = \frac{W_f - W_o}{W_o} \times \text{density of } H_2O$$

$$= \frac{106.70 - 105.60}{105.60} \times 1$$

$$= 0.010 \ cm^3g^{-1}$$

3.60 TESTING FOR THE PERFORMANCE OF THE ACTIVATED CARBON PRODUCED

The following test was carried out on the activated carbon produced:

METHYL ORANGE COLOUR ADSORPTION

0.1g methyl orange was prepared by dissolving 1.0g of the dye in water, 50ml was taking from the sample and diluted to 1 litre.

For methyl orange color adsorption 1.0g activated carbon of each sample was vigorously stirred in 40ml of the dilute solution for ten minutes. The solution was filtered and the colour units of the filterate as well as the original solution after it has also filtered were compared on a photoelectric colorimeter.

CHAPTER FOUR

4.1 Results

1. Weight of the crucible = 22.10g
2. Weight of the original sample = 14.00g

A. WEIGHT OF COW BONE AT DIFFERENT TEMP. AFTER CARBONNIZATION [i.e. CHARCOAL]

AT 600^{O}C = 8.80g

AT 560^{O}C = 8.93g

AT 530^{O}C = 9.52g

AT 500^{O}C = 9.57g

B. WEIGHT OF COW BONE AT DIFFERENT TEMP. AFTER CARBONNIZATION

AT 600^{O}C = 6.10g

AT 560^{O}C = 6.39g

AT 530^{O}C = 6.53g

AT 500^{O}C = 6.99g

C. WEIGHT OF CHARCOAL FROM SAWDUST AT DIFFERENT TEMP.

AT 600^{O}C = 0.50g

AT 560^{O}C = 0.54g

AT 530^{O}C = 0.56g

AT 500^{O}C = 0.58g

A. WEIGHT OF CHARCOAL FROM COW BONE AT DIFFERENT TEMPERATURES FOR 900 ^{O}C. IN 20 MIN. FOR VOLATILE CONTENTS

AT 600^{O}C = 15.09g

AT 560^{O}C = 15.20g

AT 530^{O}C = 15.30g

AT 500^{O}C = 15.40g

B. WEIGHT OF CHARCOAL FROM CHICKEN AT DIFFERENT TEMPERATURES FOR 900 ^{O}C. IN 20 MIN. FOR VOLATILE CONTENTS

AT 600^{O}C = 15.25g

AT 560^{O}C = 15.30g

AT 530^{O}C = 15.45g

AT 500^{O}C = 15.54g

C. WEIGHT OF CHARCOAL FROM SAW DUST AT DIFFERENT TEMPERATURES FOR 900 ^{O}C. IN 20 MIN. FOR VOLATILE CONTENTS

AT 600^{O}C = 0.48g

AT 560^{O}C = 0.45g

AT 530^{O}C = 0.40g

AT 500^{O}C = 0.36g

A. WEIGHT OF ACTIVATED CHARCOAL FROM CHICKEN BONE

AT 600^{O}C = 10.85g

AT 560^{O}C = 12.10g

AT 530^{O}C = 13.00g

AT 500^{O}C = 13.55g

B. WEIGHT OF ACTIVATED CHARCOAL FROM COW BONE

AT 600^{O}C = 8.40g

AT 560^{O}C = 9.22g

AT 530^{O}C = 9.95g

AT 500^{O}C = 10.57g

C. WEIGHT OF ACTIVATED CHARCOAL FROM SAW DUST.

AT 600^{O}C = 0.34g

AT 560^{O}C = 0.40g

AT 530^{O}C = 0.47g

AT 500^{O}C = 0.51g

TABLE 1. CHARACTERIZATION OF CHARCOAL FROM COW BONE AT VARYING TEMPERATURES

Temp (^{O}C)	Mass (g)	Moisture content (%)	Ash content (%)	Charcoal yield (%)	Volatile content (%)	Fixed carbon (%)	
500	14.00	31.66	68.34	97.38	0.00	0.00	
530	14.00	32.00	68.00	97.43	0.00	0.00	
560	14.00	36.2	63.79	98.03	0.00	0.00	
600	14.00	37.14	62.16	98.60	0.00	0.00	

TABLE 2 CHARACTERIZATION OF ACTIVATED CHARCOAL FROM COW BONE AT VARYING TEMPERATURES:

Temp (^{O}C)	Mass (g)	Ash content (%)	Moisture content (%)
500	15.00	75.50	24.50
530	15.00	71.07	28.93
560	15.00	65.86	34.14
600	15.00	60.00	40.00

TABLE 3. CHARACTERIZATION OF CHARCOAL FROM CHICKEN BONE AT VARYING TEMPERATURES

Temp (^{O}C)	Mass (g)	Moisture content (%)	Ash content (%)	Charcoal yield (%)	Fixed carbon (%)	Volatile content (%)	
500	14.00	50.07	49.93	100.01	0.01	0.00	
530	14.00	53.36	46.64	100.50	0.50	0.00	
560	14.00	54.36	45.64	100.60	0.60	0.00	
600	14.00	56.43	43.57	100.90	0.89	0.00	

TABLE 4 CHARACTERIZATION OF THE ACTIVATED CHARCOAL FROM CHICKEN BONE AT VARYING TEMPERATURES:

Temp (^{O}C)	Mass (g)	Ash content (%)	Moisture content (%)
500	15.00	96.79	03.21
530	15.00	92.86	07.14
560	15.00	86.43	13.57
600	15.00	77.50	22.50

TABLE 5. CHARACTERIZATION OF CHARCOAL FROM SAW DUST AT VARYING TEMPERATURES

Temp (^{O}C)	Mass (g)	Moisture content (%)	Ash content (%)	Charcoal yield (%)	Fixed carbon (%)	Volatile content (%)
500	14.00	95.85	4.14	106.55	6.14	37.93
530	14.00	96.00	4.00	106.57	6.16	28.57
560	14.00	96.14	3.86	106.59	6.18	16.67
600	14.00	96.43	3.57	106.63	6.54	4.00

TABLE 6 CHARACTERIZATION OF THE ACTIVATED CHARCOAL FROM SAW DUST AT VARYING TEMPERATURES:

Temp (^{O}C)	Mass (g)	Ash content (%)	Moisture content (%)
500	15.00	03.64	96.36
530	15.00	03.36	96.64
560	15.00	02.86	97.14
600	15.00	02.43	97.57

PERFORMANCE OF THE ACTIVATED CARBONS PRODUCED ON METHYL COLOR ADSORPTION. TABLE 7

Samples	Methyl orange color unit original (ABS) final (ABS)	
Activated carbon from cow bone	0.610	0.420
Activated carbon from chicken bone	0.610	0.145
Activated carbon from saw dust	0.610	0.450

4.20 DISCUSSION OF RESULTS

This topic is focused on the production of activated carbon from plant and animal sources. In which the level of adsorption depends strictly on how well the charcoals were activated, the particle size, moisture content, fixed carbon etc.

In table 1. For the charcoal from cow bone at 500°C, the moisture content was found to be 31.64%, ash content was 68.34% charcoal yield was 97.38% volatile content was 0.00% and fixed carbon was also 0.00%. Also in table 3, the charcoal from chicken bone at 500°C, the moisture content was found to be 50.07%, ash content was 49.93%, charcoal yield was 100.01%, fixed carbon was 0.01% and volatile content was 0.00%. While in table 5, the charcoal from saw dust at 500 °C the moisture content was found to be 95.86%, ash content 4.14%, charcoal yield was 106.55% fixed carbon was 6.14% and volatile content was 37.93% .

In table 2. For the activated carbon from cow bone, at 500 °C the ash content was found to be 75.50% and the moisture content was 24.50%. In table 4, the activated carbon from chicken bone at 500 °C the ash content was found to be 96.79% and the moisture content was 03.21%. While in table 6, for the activated carbon from saw dust, at 500 °C, the ash content was found to be 03.64% and the moisture content was 96.36%.

Further more, the surface area for activated charcoal from cow bone, chicken bone and saw dust were found to be $1.2572 \times 10^{-5}m^2$, $2.829 \times 10^{-5}m^2$, and $1.767 \times 10^{-6}m^2$, respectively. While, their pore volume were also found to be $0.026cm^3g^{-1}$, $0.081cm^3g^{-1}$ and $0.010cm^3g^{-1}$ respectively.

The percentage methyl orange colour removal by 1.0g of each of the activated carbons produced from cow bone, chicken bone and saw dust were calculated to be 31.15%, 76.23% and 26.23 % respectively.

Therefore, from the result obtained above, it was discovered that, the activated carbon produced from the chicken bone was found to be most effective than those produced from cow bone and saw dust.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMEDATION

5.10 CONCLUSION:

The activated carbon produced from the chicken bone seemed to be of many advantages, some of which include: its high surface area, pore, volume and also most effective for colour removal. It could also provide an avenue of large animal waste recycle and a means of obtaining cheap and abundant activated charcoal for use in gas mask, odour removal especially from hospitals. Household smells etc because of its high adsorption capacities (Fasanmi F.O 1994).

5.20 RECOMMENDATION

Sheffler, (G.H 1990) had shown that, the performance of activated carbons produced can be improved, if the following facts are looked into in further studies on this topic.

i. The optimum carbonization and activation time should be determined.

ii. A size reduction lesser than 2.0mm particle size should be tried to determine the optimum particle size for the activated carbon.

iii. The material samples should be cleaned as much as possible to ensure that, the final product contain as less as possible impurities.

iv. Steam activation should be used in order to determine to optimum temperature of activation.

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APPENDIX

Characterization of charcoal from cow bone of varying temperatures

At 600^{O}C: Weight of the crucible = 22.10g

Weight of the original = 14.00g

Weight after carbonization = 8.80g

1 Ash content $= \frac{30.90 - 22.10}{36.10 - 22.10} x100 = 62.14\%$

2. moisture content $= \frac{14.00 - 8.80}{14.00} = x100 = 37.14\%$

3. Yield of the charcoal $= \frac{14.00 - 0.62386 + 0.3714}{14.00} x100 = 98.16\%$

4 fixed carbone $= \frac{0.9816 - 0.3714 - 0.6286}{0.9816} x100 = -1.87\%$

5. Volatile content $= \frac{8.80 - 15.09}{8.80} x100 = -71.40\%$

At 560^{O}C: Weight after carbonization = 8.93g

$1.Ash, content = \frac{31.03 - 22.10}{36.10 - 22.10} x100 = 63.79\%$

$2.Moisture, content = \frac{14.00 - 8.93}{14.00} x100 = 36.21\%$

3. Yield of the charcoal $= \frac{14.00 - 0.6379 + 0.3621}{14.00} x100 = 98.03\%$

4. Fixed carbon

$$= \frac{0.9803 - 0.3621 - 0.6379}{0.9803} x100 = -1.55\%$$

$$4.Volatile,content = \frac{8.93 - 15.20}{8.93} x100 = -70.21\%$$

At 530°C: Weight after carbonization = 9.52g

1. Ash content = $\frac{31.62-22.10}{36.10-22.10}$ x 100 = 68%

2. Moisture content = $\frac{14.00-9.52}{14.00}$ x 100 = 32.%

3. Yield of the charcoal = $\frac{14.00-0.68+0.32}{14.00}$ x 100 = 97.43%

4. Fixed carbon = $\frac{0.9743-0.32-0.68}{0.9743}$ x 100 = -2.64%

5. Volatile content = $\frac{9.52-15.36}{9.52}$ x 100 = -61.35%

At 500°C: Weight after carbonization = 9.57g

1. Ash content = $\frac{31.67-22.10}{36.10-22.10}$ x 100 = 68.34%

2. Moisture content = $\frac{14.00-9.57}{14.00}$ x 100 = 31.64%

3. Yield of the charcoal = $\frac{14.00-0.6834+0.3164}{14.00}$ x 100 = 97.38%

4. Fixed carbon = $\frac{0.9738-0.3164-0.6834}{0.9743}$ x 100 = -2.67%

5. Volatile content = $\frac{9.57-15.40}{9.57}$ x 100 = -60.92%

Characterization of charcoal from chicken bone at varying temperatures

Weight of the crucible = 22.10g

Weight of the original sample = 14.00g

At 600°C: Weight after carbonization = 6.10g

1. Ash content = $\frac{28.20-22.10}{36.10-22.10}$ x 100 = 43.57%

2. Moisture content = $\frac{14.00-6.10}{14.00}$ x 100 = 56.43%

3. Yield of the charcoal = $\frac{14.00-0.4357+0.5643}{14.00}$ x 100 = 100.9%

4. Fixed carbon = $\frac{1.009-0.5643-0.4357}{1.009}$ x 100 = 0.891%

5. Volatile content = $\frac{6.10-15.25}{6.10}$ x 100 = -1.50%

At 560°C: Weight after carbonization = 6.39g

1. Ash content = $\frac{28.49-22.10}{36.10-22.10}$ x 100 = 45.64%

2. Moisture content = $\frac{14.00-6.39}{14.00}$ x 100 = 54.36%

3. Yield of the charcoal = $\frac{14.00-0.4564+0.5636}{14.00}$ x 100 = 100.6%

4. Fixed carbon = $\frac{1.006-0.5636-0.4564}{1.006}$ x 100 = 0.60%

5. Volatile content = $\frac{6.39-14.30}{6.39}$ x 100 = -139.44%

At 530°C: Weight after carbonization = 6.53g

1. Ash content = $\frac{28.63-22.10}{36.10-22.10}$ x 100 = 46.64%

2. Moisture content = $\frac{14.00-6.53}{14.00}$ x 100 = 53.36%

3. Yield of the charcoal = $\frac{14.00-0.4664+0.5336}{14.00}$ x 100 = 100.5%

4. Fixed carbon = $\frac{1.005-0.5336-0.4664}{1.005}$ x 100 = 0.50%

5. Volatile content = $\frac{6.53-15.45}{6.53}$ x 100 = 136.60%

At 500°C: Weight after carbonization = 6.99g

1. Ash content = $\frac{29.09-22.10}{36.10-22.10}$ x 100 = 49.93%

2. Moisture content = $\frac{14.00-6.99}{14.00}$ x 100 = 50.07%

3. Yield of the charcoal = $\frac{14.00-0.4993+0.5007}{14.00}$ x 100 = 100.01%

4. Fixed carbon = $\frac{1.001-0.5007-0.4993}{1.001}$ x 100 = 0.01%

5. Volatile content = $\frac{6.99-15.54}{6.99}$ x 100 = -122.32%

Characterization of charcoal from saw dust at varying temperatures

Weight of the crucible sample = 22.10g

Weight of the original sample = 14.00g

At 600°C: Weight after carbonization = 0.50g

1. Ash content = $\frac{22.60-22.0}{36.10-22.10} \times 100 = 3.57\%$

2. Moisture content = $\frac{14.00-0.50}{14.00} \times 100 = 96.43\%$

3. Yield of the charcoal = $\frac{14.00-0.0357+0.9643}{14.00} \times 100 = 106.63\%$

4. Fixed carbon = $\frac{1.07-0.9643-0.0357}{1.07} \times 100 = 6.54\%$

5. Volatile content = $\frac{0.50-0.18}{0.50} \times 100 = 4.00\%$

At 560°C: Weight after carbonization = 0.54g

1. Ash content = $\frac{22.64-22.10}{36.10-22.10} \times 100 = 3.86\%$

2. Moisture content = $\frac{14.00-0.54}{14.00} \times 100 = 96.14\%$

3. Yield of the charcoal = $\frac{14.00+0.9614-0.0386}{14.00} \times 100 = 106.59\%$

4. Fixed carbon = $\frac{1.0659-0.9614-0.0386}{1.0659} \times 100 = 6.18\%$

5. Volatile content = $\frac{0.54-0.45}{0.54} \times 100 = 16.67\%$

At 530°C: Weight after carbonization = 0.56g

1. Ash content = $\frac{22.66-22.10}{36.10-22.10} \times 100 = 4.00\%$

2. Moisture content = $\frac{14.00-0.56}{14.00} \times 100 = 96.00\%$

14.00

3. Yield of the charcoal = $\frac{14.00+0.9600-0.04}{14.00} \times 100 = 106.57\%$

4. Fixed carbon = $\frac{1.0657-0.96-0.04}{1.0657} \times 100 = 6.16\%$

5. Volatile content = $\frac{0.56-0.40}{0.56} \times 100 = 28.57\%$

Characterization of activated charcoal from cow at varying temperatures.

At 600°C: Weight after carbonization = 8.40g

1. Ash content = $\frac{30.40-22.10}{36.10-22.10} \times 100 = 60\%$

2. Moisture content = $\frac{14.00-8.40}{14.00} \times 100 = 40\%$

At 560°C: Weight after activation = 9.22g

1. Ash content = $\frac{31.32-22.10}{36.10-22.10} \times 100 = 65.86\%$

2. Moisture content = $\frac{14.00-9.22}{14.00} \times 100 = 34.14\%$

At 600°C: Weight after activation = 8.40g

1. Ash content = $\frac{30.40-22.10}{36.10-22.10} \times 100 = 60\%$

2. Moisture content = $\frac{14.00-8.40}{14.00} \times 100 = 40\%$

At 560°C: Weight after activation = 9.22g

1. Ash content = $\frac{31.32-22.10}{} \times 100 = 65.86\%$

36.10-22.10

2. Moisture content = 14.00-9.22 x 100 = 34.14
14.00

At 530°C: Weight after activation = 9.95g

1. Ash content = 32.05-22.10 x 100 = 71.07%
36.10-22.10

2. Moisture content = 14.00-9.95 x 100 = 28.93%
14.00

At 500°C: Weight after activation = 10.57g

1. Ash content = 32.67-22.10 x 100 = 75.50%
36.10-22.10

2. Moisture content = 14.00-10.57 x 100 = 24.50%
14.00

Characterization of activated charcoal from chicken bone at varying temperatures

At 600°C: Weight after activation = 10.85g

1. Ash content = 32.95-22.10 x 100 = 77.50%
36.10-22.10

2. Moisture content = 14.00-10.85 x 100 = 22.50%
14.00

At 560°C: Weight after activation = 12.10g

1. Ash content = 32.42-22.10 x 100 = 86.43%
36.10-22.10

2. Moisture content = 14.00-12.10 x 100 = 14.29%
14.00

At 530°C: Weight after activation = 13.00g

1. Ash content = 35.10-22.10 x 100 = 92.86%
36.10-22.10

2. Moisture content = $\frac{14.00-13.00}{14.00} \times 100$ = 7.14%

At 500°C: Weight after activation = 13.55g

1. Ash content = $\frac{35.66-22.10}{36.10-22.10} \times 100$ = 96.79%

2. Moisture content = $\frac{14.00-13.55}{14.00} \times 100$ = 3.21%

Characterization of activated charcoal from saw dust at varying temperatures

At 600°C: Weight after activation = 0.34g

1. Ash content = $\frac{22.44-22.10}{36.10-22.10} \times 100$ = 2.43%

2. Moisture content = $\frac{14.00-0.34}{14.00} \times 100$ =97.57%

At 560°C: Weight after activation = 0.40g

1. Ash content = $\frac{22.50-22.10}{36.10-22.10} \times 100$ = 2.86%

2. Moisture content = $\frac{14.00-0.40}{14.00} \times 100$ =97.14%

At 530°C: Weight after activation = 0.47g

1. Ash content = $\frac{22.57-22.10}{36.10-22.10} \times 100$ = 3.36%

2. Moisture content = $\frac{14.00-0.47}{14.00} \times 100$ =96.64%

At 500°C: Weight after activation = 0.51g

1. Ash content = $\frac{22.61-22.10}{36.10-22.10} \times 100$ = 3.64%

2. Moisture content = $\frac{14.00-0.51}{14.00} \times 100$ =96.36%

TO CALCULATE SURFACE AREA OF THE SAMPLES

1. The diameter of the activated charcoal from cow bone was 2.00mm sieve size (i.e 0.002m)

   To get the radius is = $\frac{0.002}{2}$ = 0.001m

Therefore the surface area = $4\Pi r^2 = 4 \times 3.143 \times (0.001m)^2$

$= 1.2572 \times 10^{-5}m^2$

2. The surface area for the activated charcoal from the chicken bone.

   The diameter = 3.00mm = 0.003m

   The radius = $\frac{0.003}{2}$ = 0.0015m

Therefore the surface area = $4\Pi r^2 = 4 \times 3.143 \times (0.0015m)^2$

$= 2.829 \times 10^{-5}m^2$

3. The surface area for activated carbon from the saw dust the diameter of the activated carbon = 750mm = (750×10^{-6})

   The radius = $\frac{750 \times 10^{-6}}{2}$

   0.000375m.

Therefore the surface area = $4\Pi r^2 = 4 \times 3.143 \times (0.000375m)^2$

$= 1.767 \times 10^{-6}m^2$

CALCULATION FOR PERCENTAGE COLOUR REMOVAL

$$\% \text{ Color removal} = \frac{ABso - Absf}{ABso} \times 100$$

Where ABso – Original solution adsorbance

Absf- Final solution adsorbance

1. For activated carbon from cow bone:

$$= \frac{0.610 - 0.420}{0.610} \times 100$$

$$= 31.1506$$

2. For activated carbon from chicken bone:

$$= \frac{0.610 - 0.1425}{0.610} \times 100$$

$$= 76.23\%$$

3. For the activated carbon from saw dust:

$$= \frac{0.610 - 0.450}{0.610} \times 100$$

$$= 26.23\%$$