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Production And Characterization Of Activated Carbon From Animal Bone

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ABSTRACT*: The aim of the study is to investigate the method of preparation and characterization of activated carbon from cow bone. The cow bone was carbonized by charging into an automated muffle furnace and heated at temperature of 700 ℃ followed by activation with orthophosphoric acid. The charcoal obtained was characterized by scanning electron microscopy (SEM), and Fourier transform infrared spectroscopy (FT-IR). The bulk density of the produced activated carbon was found to be 1.285g/ml, porosity 5.36, pH 6.6, moisture content 3.5% and iodine number 576.84mg/g and ash content 10.65%.*
KEYWORD: *Animal bone, Activated Carbon, Adsorbent.*

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I. INTRODUCTION

Activated carbon has long been recognized as one of the most versatile adsorbents to be used for the effective removal of contaminants in wastewater treatments. Charcoal is the fore runner of modern activated carbon whose ability to purify water dates back to 2000 BC. (Adie et al., 2014).

It is a tasteless, solid, microcrystalline, non-graphitic form of black carbonaceous material with a porous structure and has been regarded as a unique and versatile adsorbent because of its extended surface area, microporous structure, high adsorption capacity, and high degree of surface reactivity (Sugumaran et al., 2012). Activated carbon, also widely known as activated charcoal or activated coal is a form of carbon which has been processed to make it extremely porous and thus to have a very large surface area available for adsorption or chemical reactions (Madu and Lajide, 2013;Shendkar et al., 2013;Hesas et al., 2013). It is a unique material because of the way it is filled with holes (voids, spaces, sites and pores,) of zero electron density, these pores possess intense vander Waals forces (from the near proximity of carbon atoms) and these are responsible for the adsorption process (Adie et al, 2014).It can be made from hard woods, coconut shell, animal bones, fruit stones, coals and synthetic macromolecular systems (Harry and Francisco, 2006). The abundance and availability of agricultural by-products makes them good sources of raw materials for activated carbon production (Malik et al., 2007). Activated carbon are carbonaceous material that can be distinguished from elemental carbon by the oxidation of the carbon atoms found on the outer and inner surfaces. The surface oxygen functional groups can be easily introduced to the carbon by different activation methods including dry and wet oxidizing agents. Activated carbon are used for wastewater treatment, drinking water purification and liquid phase adsorption (Heijman and Hopman, 1999) and have wide applications in domestic, commercial and industrial settings (Mendez et al., 2006). In the food industry, activated carbon is used in de-colourization, deodorization and taste removal. It is used to remove heavy metals and organic contaminants from liquids. Activated carbon is used in water de-chlorination and processing of foods. It is also used in medicine for adsorption of harmful chemicals and drugs. In gas cleaning applications, activated carbon is extensively used in air filters at industrial level as well as in general air conditioning application (Yusufu et al., 2012). Animal charcoal also known as bone black, bone char or abaiser, is a granular material produced by charring animal bones. Animal bones are part of the composite that form the body of animals; it basically gives shape and support to animals (Skeletal systems). It contains about 10 % carbon, the remainder being calcium and magnesium (80 %) and other inorganic materials present in the bones (Mohammed et al., 2012). Adie et al.(2014) in his work used Parkiabiglobosa pod to reduce

chemical oxygen demand, nitrogen and phosphorus that may cause eutrophication.The results obtained were as follows COD was reduced from 250mg/l to 6.2mg/l, (which is 97.52%), nitrate had 87.5% while phosphorus was reduced by51.2%. Maruf and Sina(2012) also used activated carbon in treating industrial wastewater effluents and was able to achieve 47.68% and 34.20% removal efficiency for TDSand BOD. Tansengco et al.(2015) used activated carbon for post treatment of abattoir wastewater after treating with anaerobic sequence batch reactor and recorded 94%, 93%, 54%, 58% and 53% for COD, BOD, TSS, Turbidity and colour removal respectively.

The knowledge of physical and activity of characterization of activated carbon made of cow bone will help in determining the suitability of absorbent made from cow bone. The aim of the study is to investigate the method of preparation and characterization of activated carbon from Cow bone

II. MATERIALS AND METHODS

2.3.1 Carbonization

The animal bone sample was collected from Kwata Abattoir located close to Udoka Housing estate and washed with deionized water to remove sand, dirt and flesh before being sundried. The sample was carbonized at Scientific Equipment Development Institute located at Enugu by charging into an automated muffle furnace and heated at temperature of 700 ℃ for 2hours in the absence of air before it was transferred into a desiccator.

2.3.2 Activation

The carbonized bone was activated at Chemical Engineering Laboratory Nnamdi Azikwe University, Awka by crushing in a mortar. It was thereafter washed and soaked with orthophosphoric acid for 24hours for purification and enhancement of surface area. The acid was filtered off and the crushed carbon washed several times with distilled water until pH 6-7 was achieved on the surface of the sample and the product was sundried and stored in an air tight polythene bag.

2.3.3 Physical and chemical characterization of activated carbon

2.3.4 Determination of moisture contents

The determination of moisture content of crushed bone was done by weighing out approx. 5–10 g of previously ground sample of crushed bone. The sample of crushed bone was placed in drying oven at 105°C for at least 12 h and was allowed to cool in dryer. The sample was weighed again, taking care not to expose the sample to the atmosphere. The difference in the mass constitute the amount of moisture adsorbed (Dada et al 2012).

$$moisture\ content\ (\%) = \frac{(B-A)-(C-A)}{(B-A)} \qquad (1)$$

Where

A = weight of clean, dry scale pan (g)
B = weight of scale pan + wet sample (g)
C = weight of scale pan + dry sample (g)

2.3.5 Determination of bulk density

The bulk density of crushed bone was determined by weighing a cylinder and an aluminum plate each. The sample of crushed bone activated carbon was put into the cylinder, reweighed and transferred into the aluminum plate before it was put into an oven so as to dry it to constant weight at a temperature of 105°C for one hour. The weight of the dried samples was taken again after drying. A clean dry well corked density bottle was weighed. The bottle was filled with water, corked and reweighed, small quantities of samples of activated carbons were taken and grounded to powder, sieved using 106μm and was gradually put into the bottles with little amount of water and weighed again. The bulk density was calculated using the following expressions

$$Bulk\ Density = \frac{mass\ of\ the\ weigh\ sample}{mass\ of\ the\ Volume} \qquad (2)$$

2.3.6 Adsorbent pH

Measuring of adsorbent pH was executed by the standard test method for determination of activated carbon pH ASTMD3838-80. 1.0g of crushed bone activated carbon (CBAC) was weighed and transferred into a beaker. 100mL of distilled water was measured, added and stirred for one hour. The samples were allowed to stabilize before the pH was measured using a pH meter.

2.3.7 Total ash content

2.5 to 5 g of dry crushed bone sample was placed in a crucible previously calcined and brought to constant weight.The crucible was placed in a furnace and heated at 550°C for 12 hours and was allowed to cool before it was transferred to a dryer. The crucible was carefully weighed again with the ash.

$$Ash\ Content = 100\ \frac{A - B}{C} \quad (4)$$

Where A= weight of crucible sample (g)
B = weight of crucible with ash (g).
C= weight of sample (g).

2.3.8 Fourier transform infrared spectroscopy (FTIR) analysis

1 mg of sample were grinded and milled with 100mg KBr to form a fine powder. This powder will then be compressed into a thin peller under 7 tons for 5 minutes. The sample was analyzed using Shimadzu 8300 spectrometer and the spectrum was recorded in the mid-IR range from 4000 to 400 cm^{-1} with a resolution of 1 cm^{-1}.

2.3.9 Scanning electron microscopy (SEM)

To study the effect of activation on porosity and observe the surface physical morphology of the bone char activated carbon, Scanning Electron Microscopy was employed (Aji et al., 2015). The scanning electron micrographs enable the direct observation of the surface microstructures of the adsorbent (Ahmed et al., 2013).

2.4.1 Liquid Adsorption Studies

For liquid adsorption studies iodine number determination was performed

2.4.2 Iodine number determination

Iodine number determination was performed by measuring 0.5ml of sample into a conical flask; 15ml of chloroform was added and shaken vigorously. Aliquot solution was also added and stirred; it was kept in dark place for 30 minutes. After which the iodine was being added. 3 drops of starch solution was added to the mixture which serves as an indicator and was then titrated with sodium thiosulphate until a colourless solution was observed.

$$Iodine\ I_2 = \frac{(B - S)\ \times\ VM}{B\ \times\ W}\ X\ 253.81 \quad (5)$$

Where,B = Volume of Sodium thiosulphate required for Blank (ml)
S= Volume of Sodium thiosulphate required for Sample (ml)
V= Volume of aliquot solution used (ml) = 10ml
M= Concentration of iodine solution used (mol/l) = 0.1M
W= Mass of activated carbon used (g)

III. RESULTS AND DISCUSSION.

3.1 Characterization of cow bone activated carbon

Table 1: Characterization of cow bone activated carbon.

Bulk Density	1.285 g/ml
Porosity (Π)	5.36%
pH	6.6
Moisture Content	3.50%
Ash Content	10.65%
Iodine Number Determination	576.84 mg/g

The proximate analysis was presented in Table 1 below. The bulk density is an important physical parameter, this is because it determines the mass of carbon that can be contained in a filter of given solids capacity and the amount of treated liquid that can be retained by the filter cake. The bulk density of cow bone was found to be 1.285g/ml against 2.56g/ml, 2.24g/ml, 2.32g/ml and 2.32g/ml for cow bone, dog bone, goat bone and chicken bone conducted in a research work by Mohammed, et al., (2012). Porosity describes the

number of pores present in a sample, it enhances adsorption capacity of the adsorbent, the proximate analysis for cow bone shows that the porosity and pH of CBAC as 5.36 and 6.6 respectively. The pH falls within the range of pH of mostby products, adsorbents with pH of 6-8 are acceptable in most applications (Martinez *et al* 2003).The proximate analysis also shows a low amount of moisture and ash content indicating that the particle density is relatively small and that the biomaterial should be an excellent raw material for adsorbent to be used in a column or a fixed bed reactor. Ash content can also affect activated carbon, it reduces the overall activity of activated carbon and reduces the efficiency of reactivation, the lower the ash value the better the activated carbon for use as adsorbent. The moisture and ash content as presented are found to be 3.5% and 10.65%. against 3.9% and 10.75% for cow bone, 4.5% and 19% for dog bone, 5.4% and 26.75% for goat bone and 97% and 23.75% for chicken bone conducted by Mohammed, et al., 2012 Iodine number is a fundamental parameter used to characterize activated carbon performance. It is a measure of the micropore content of the activated carbon and is obtained by the adsorption of iodine from solution by the activated carbon sample. The micropores are responsible for the large surface area of activated carbon particles and are created during the activation process. It is in the micropores that adsorption largely takes place, the iodine number of CBAC as presented in Table 4.17 is 576.84mg/g.

3.2 Scanning electron microscopy (SEM)

The Scanning electron microscope (SEM) was applied to investigate the surface morphology of the physical sample (Untreated and Treated). Plate 1 and Plate 2 shows the SEM image of the microstructures of the Untreated and Treated activated carbon. The surface of the untreated carbon in Plate 1 is fairly smooth with few cracks and voids while the SEM image in Plate 2 (treated) shows the chemical activation produce extensive external surface with irregular cavities and pores due to evaporation of chemical reagent (H_2PO_4) during drying leaving empty spaces (pores) for adsorption of material unto them.

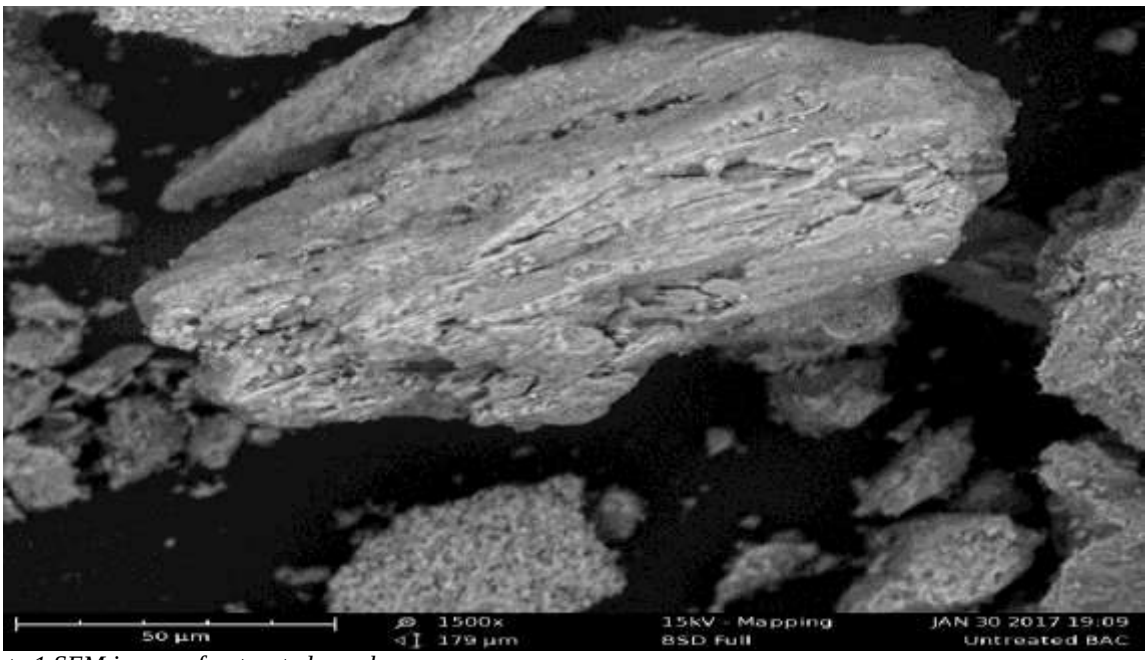

Plate 1 SEM image of untreated cow bone

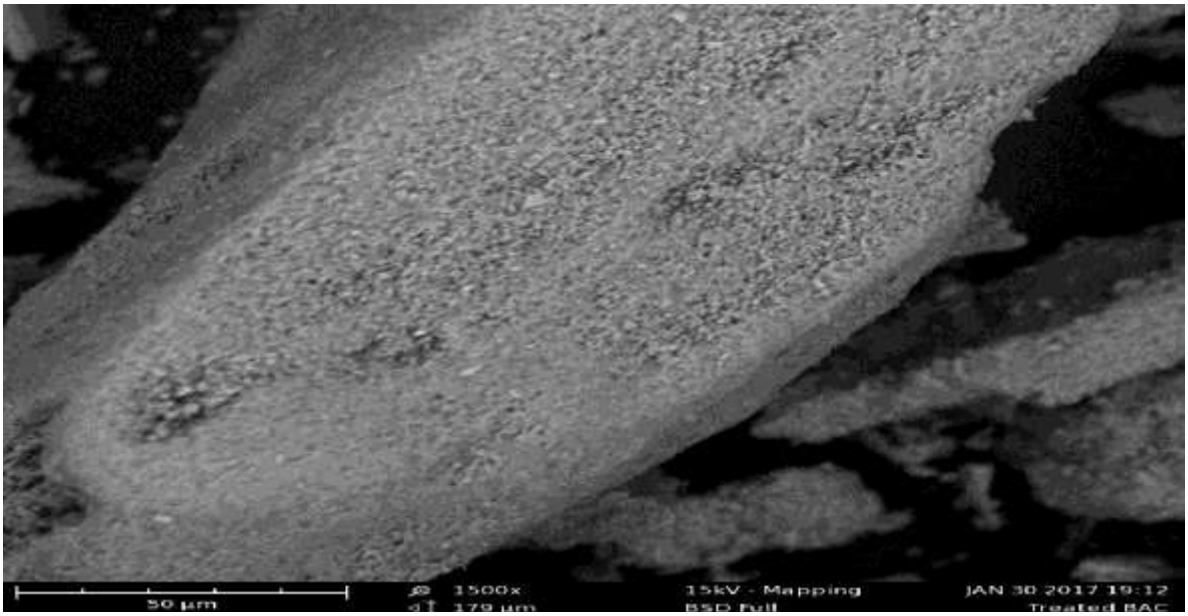

Plate 2: SEM image of treated cow bone

3.3 Fourier transform infrared spectroscopyof treated and untreated cow bone

Fourier Transform Infrared Spectroscopy was carried out in order to identify the functional groups present in activated carbon. Figures 1 and2, Table 2 shows the functional group and surface properties of the adsorbent by FTIR spectra. Functional groups of adsorbents not only affect the adsorption behavior but also dominate the adsorption mechanism (Hesas et al, 2013). The spectra of adsorbent were measured in the range of 4000cm^{-1} to 650cm^{-1}wave number. The FT-IR spectrum reveals the complex nature of the adsorbent as evidence by the presence of a large number of peaks. The peaks obtained at 872cm^{-1} to 875cm^{-1} indicates C=C stretching, the stretching adsorption band observed at 1017cm^{-1} to 1025cm^{-1} ascribed to C-O in carboxylic acid, the band at 1408 cm^{-1} to 1416cm^{-1} correspond to C-H asymmetric bending, the band at 1446cm^{-1} to 1467cm^{-1} attributed to C-H deformation, the peak 1617cm^{-1} to 1651cm^{-1} ascribed to C=C stretching, the peak at 1982cm^{-1} to 2012cm^{-1} corresponds to C=C=C stretching vibration, the peak 2068cm^{-1} to 2113cm^{-1} was due to C=C stretching, the peak 2109cm^{-1} to 2143cm^{-1} was attributed to C=C stretching, the peak obtained from 3749cm^{-1} to 3693cm^{-1} O=H indicates the presence of free and intermolecular bonded hydroxyl groups and the peak around 3875cm^{-1} to 3902cm^{-1} indicates the C=C stretching present in the carbon.

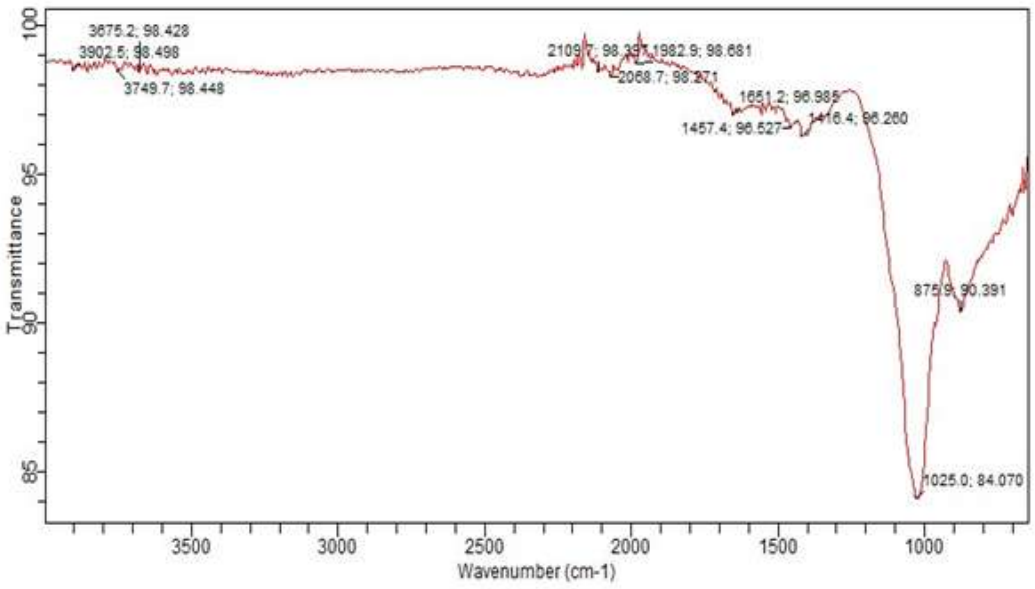

Fig. 1 Fourier infrared spectroscopy of untreated cow bone.

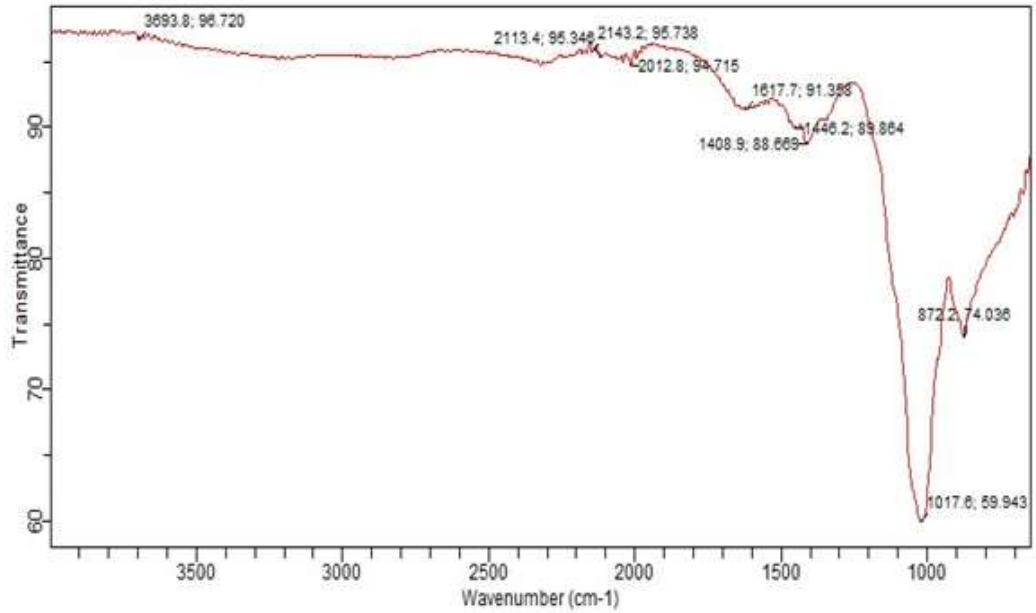

Fig. 2 Fourier infrared spectroscopy of treated cow bone

Table.2:Fourier transform infrared spectroscopy (FTIR) of crushed Bone

S/N	Peaks (cm^{-1})	Untreated Cow Bone AC	Treated Cow Bone AC	Functional group
1	872 - 875	*	*	C-C Stretching
2	1017 - 1025	*	*	C-O in Carboxylic acid
3	1408 - 1416	*	*	C-H Asymmetric bending
4	1446 - 1457	*	*	C-H deformation
5	1617 - 1651	*	*	C=C Stretching
6	1982 - 2012	*	*	C=C=C Stretching Vibration
7	2068 - 2113	*	*	C=C Stretching
8	2109 - 2143	*	*	C=C Stretching
9	3749 - 3693	*	*	O-H
10	3875 - 3902	*	*	C-C Stretching

IV. CONCLUSION

Activated carbon was prepared from animal cow bone at 700 °Cby chemical activation with orthophosphoric acid. The results obtained from the research conducted into the production, characteristics and analysis of absorbents made from cow bone shows that the bulk density was 1.285mg/g, porosity, moisture content and ash content were 5.36%, 3.5% and 10.65% while the pH and iodine number were 6.6 and 576.84. These are all in range with agricultural waste activated carbon and can be used for commercial absorbent.

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