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Short Communication

Preparation and Characterization of Activated Carbon Derived From the Bark of *Annona senegalensis*

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Abstract

The work aimed to prepare and characterize activated carbon from the back of Annona senegalensis. Chemical activation with phosphoric was done. The activated carbon prepared was characterized by pH, bulk density, moisture content, ash content, surface area, pore volume and volatile organic matter. FT-IR was also carried out in order to identify the functional groups present in the activated carbon prepared. The result of the proximate analysis carried out on the activated carbon was given as follows: moisture content was 4.85%, ash content was 6.35%. The surface area of the activated carbon was 843 m^2/g, pore volume was 0.91 cm^3 and bulk density was 0.78 g/cm^3.

Keywords: Characterization, ***Annona senegalensis,*** activated carbon, FT-IR, moisture.

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Introduction

Activated carbon is broadly defined to include a wide range of amorphous-based materials prepare in such a way that they exhibit a high degree of porosity and an extended surface area (Bansal and Goyal, 2005). They usually have small amounts of chemically bonded oxygen and hydrogen and can contain up to 20 % of mineral matter, which usually consists of ash or residue as a result of ignition. The nature of this mineral material depends on the raw materials used and can consist of silica and compounds of alkali and alkaline-earth metals.

Activated carbons form a large and important class of porous solids which have found a wide range of technological applications. The characteristics of activated

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carbon depend on the physical and chemical properties of the precursor as well as on the method of activation. In addition to the starting material and the oxidizing agent, action time and temperature affect the structural properties of the resulting activated carbon. There are two different ways of preparing activated carbon: Physical and chemical activation. The physical activation method involves: carbonization of raw materials and activation at high temperature in carbon dioxide or water vapor (Petrov, 1999). Chemical activation is a well- known method for the preparation of activated carbon, which has been the objective of numerous studies within the last few years (Karim *et al*., 2006; Wu *et al*., 2006; Yang *et al*., 2006; Haimour and Emeish, 2006; Shalaby *et al*., 2006; Pèrez *et al*., 2006) as it presents several advantages compared to the physical activation. The advantage of chemical activation over physical activation is that it is performed in one step and at relatively low temperatures. The most important and commonly used activating agents are phosphoric acid, Zinc chloride and alkaline metal compounds, such as KOH (Serrano-Gomez *et al*., 2005; Dabrowski *et al*., 2005; Li *et al*., 2008).

A wide range of carbonaceous materials can be used as carbon precursors such as coal, peat, wood and various agricultural by-products. Recently, agricultural by-products have received an increasing attention for the production of activated carbon due to their low-cost, environmental friendliness and wide prevalence (Yang and Lua, 2006; Ahmedna *et al*., 2004; Zhang *et al*., 2004; Cox *et al*., 2000; Kadirvelu *et al*., 2004; Gurses *et al*., 2006; Mohanty *et al*., 2005). The production of value-added products such as activated carbon will enlarge its application, reduce waste materials and generate income to the rural communities as the demand for activated carbon has increased over the years and the market growth has been estimated at 4.6 % per annum (Jabit, 2007).

This study aims to produce and characterize activated carbon from *Annona senegalensis* bark.

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Materials and Method

Sample Collection
The bark of *Annona senegalensis* which was used in the production of activated carbon was obtained from bushes around Maikunkele in Minna, Niger State, Nigeria.

Sample preparation
The bark of *Annona senegalensis* obtained was thoroughly cleaned, dried in the sun and reduced to small sizes of approximately 1.5 to 2.0 cm by hand.

Carbonization
Carbonization was carried out in the pre-heated muffle furnace (make/model) at 600˚C for 45 minutes using the method described by Gimba *et al* (2001).

Chemical Activation
The carbon obtained was soaked in 500 ml of 10 % phosphoric acid and was left to stand for 24 hours. The carbon was then filtered off the acid solution and thoroughly washed using distilled water until the pH of 6.86 was achieved. This was then dried in the Oven (make/model) at 105˚C. The activated carbon was then charged in the muffle furnace at 600˚C for 10 minutes, cooled to room temperature and stored in the dessicator.

Characterization of the carbon
The activated carbon was characterized according to Pore volume, Bulk density, Moisture content, Ash content, Volatile organic matter.

Pore volume
Five grams (5 g) of the activated carbon was weighed into a measuring cylinder. Twenty five centimeter cube (25 cm^3) of distilled water was introduced into the cylinder containing the sample and heated for 15 minutes to displace the air in the pore. The sample was then filtered and placed in the porcelain bag and left to dry in the pre-heated muffle furnace at 900˚C for 1 hour, cooled and reweighed. The resulting changes in mass divided by the density of water gives pore volume (Nurul'ain, 2007).

Bulk density
5 g of the sample was weighed into a measuring cylinder containing 25 cm^3 of distilled water and the volume displaced was noted. The bulk density was

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determined by dividing the mass of the sample by the volume occupied by the mass (Cigdem, 2005).

Moisture content

Five grams (5 g) of activated carbon was weighed into a crucible and placed in an oven at 105˚C to dry to constant weight. Moisture content was determined by the weight before drying minus weight after drying divide by weight of sample (Nurul'ain, 2007).

Ash content

Five grams (5 g) of the sample was weighed (W_1) in a pre-weighed empty crucible (W_0) and placed in a pre-heated muffle furnace set at a temperature of 900 ˚C. The crucible with the sample was left in the furnace is left for 1 hour after which it was transferred into the desiccators and allowed to cool and weighed (W_2). The weight of the ash was determined by the difference between the powdered dried sample, pre-weighed and the ash in the crucible. Percentage ash was obtained using equation (1) below (Bhole and Ramteke, 2011).

$$\text{Ash (\%)} = \frac{W_2 - W_0}{W_1 - W_0} \text{ X } 100 \quad (1)$$

Where:
W_0 = Weight of empty crucible (g)
W_1 = Weight of crucible + powdered sample (g)
W_2 = Weight of crucible + ash sample (g)

Volatile organic matter

Five grams (5 g) of the carbon sample was heated to about 900 ˚C for 10 minutes in a crucible placed in a muffle furnace, then retrieved and cooled in the desiccator. The difference in weight gives the volatile organic matter (Bhole and Ramteke, 2011).

Fourier-Transform Infrared Spectroscopy

FT-IR (Thermo SCIENTIFIC, NICOLET iS5) was used to determine the functional groups present on the surface of the carbon.

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Results and Discussion

Table 1: Physicochemical properties of phosphoric acid activated carbon derived from the bark of *Annona senegalensis* compared with that prepared from groundnut shell Aji (2017).

Parameters	*Annona senegalensis* bark	*Arachis hypogaea* shell
pH	6.90	6.80
Pore volume (cm^3)	0.91	-
Bulk density (g/cm^3)	0.78	0.42 (g/cm^3)
Moisture content (%)	4.85	15.00 (%)
Ash content (%)	6.35	6.00 (%)
Volatile organic matter (%)	5.92	11.00 (%)
Surface Area (m^2/g)	843.00	975.00 (m^2/g)

The result of physicochemical properties of phosphoric acid activated carbon is presented in Table 1 above. From the table, the surface area was given to be 843.00m^2/g. This is comparable with results obtained for activated carbon produced from groundnut shell reported by Aji (2017). The larger the surface area, the greater the number of active sites available for adsorption. The pore volume was given to be 0.91cm^3. The pore volume developed during the carbonization and activation processes is a consideration for quality requirement of the activated carbon since they influence the adsorption capacity. The surface chemistry of activated carbon is another important characteristic that plays a vital role in influencing their adsorption behavior. Heteroatoms such as oxygen, hydrogen, sulphur or phosphorus present in the active carbon network can be in a form of surface functional groups and have a strong influence on the adsorption process. For example, carbon can chemisorp oxygen and hydrogen to form carbon-oxygen and carbon-hydrogen structures, and the acid and base character of a carbon depends on the surface oxidation (Bansal et al., 1988). Therefore, the FT-IR was carried out to identify groups present in activated carbon. The biosorption capacity depends upon the chemical reactivity of the functional groups at the surface.

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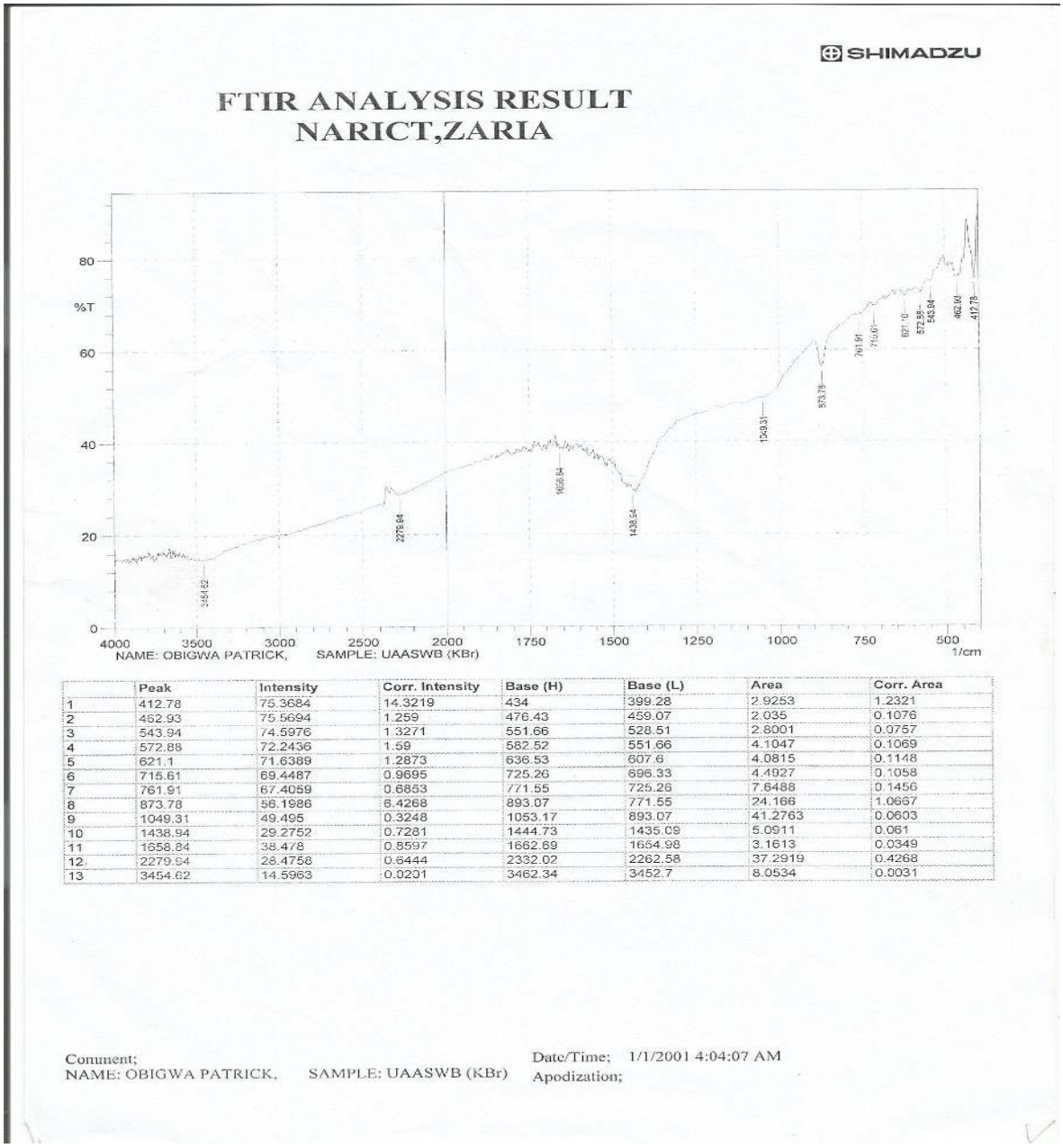

	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area
1	412.78	75.3684	14.3219	434	399.28	2.9253	1.2321
2	462.93	75.5694	1.259	476.43	459.07	2.035	0.1076
3	543.94	74.5976	1.3271	551.66	528.51	2.8001	0.0757
4	572.88	72.2436	1.59	582.52	551.66	4.1047	0.1069
5	621.1	71.6389	1.2873	636.53	607.6	4.0815	0.1148
6	715.61	69.4487	0.9695	725.26	696.33	4.4927	0.1058
7	761.91	67.4059	0.6853	771.55	725.26	7.6488	0.1456
8	873.78	56.1986	6.4268	893.07	771.55	24.166	1.0667
9	1049.31	49.495	0.3248	1053.17	893.07	41.2763	0.0603
10	1438.94	29.2752	0.7281	1444.73	1435.09	5.0911	0.061
11	1658.84	38.478	0.8597	1662.69	1654.98	3.1613	0.0349
12	2279.94	28.4758	0.6444	2332.02	2262.58	37.2919	0.4268
13	3454.62	14.5963	0.0201	3462.34	3452.7	8.0534	0.0031

Conument;
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Date/Time; 1/1/2001 4:04:07 AM
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Figure 1: FT-IR spectra of activated carbon prepared from the bark of *Annona senegalensis.*

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Conclusion

The physicochemical parameters of the activated carbon are very well comparable with those prepared from similar agricultural materials reported in the literature. This is an indication that the bark of *Annona senegalensis* could be an excellent precursor for the preparation of activated carbon.

References

Ahmedna, M., Marshal, W. E., Husseiny, A. A., Rao, R. M., Goktepe, I. (2004). The use of nutshell carbons in drinking water filters for removal of trace metals. *Water Res*., 38: 1062 – 1068.

Aji, M. M., Gutti, B. and Highina, B. K. (2017). Production and Characterization of Activated Carbon (AC) From Groundnut Shell and its Application in Water Treatment. Faculty of Engineering Seminar Series, Vol. 8.

Bansal, R. C., Donnet, J. and Stoeckli, F. (1988). 'Active Carbon', Marcel Dekker inc. pp 27 – 35.

Bansal, R. P. and Goyal, M. (2005). Activated Carbon Adsorption, Taylor and Francis Group, 6000 Broken Sound Parkway NW, Suite 300 Boca Raton, USA.

Bhole, V. and Ramteke, D. S. (2011). Preferential Adsorption of Heavy Metals on Activated Carbon. *Bangladesh Journal of Science & Industrial Research*, 46(2), 211-218.

Cigdem C. (2005). *Production And Characterization Of Activated Carbon From Hazelnut Shell And Hazelnut Husk.* Thesis Submitted to the Graduate School of Natural and Applied Sciences of Middle East Technical University.

Cox, M., El-shafey, E., Pichugin, A. A., Appleton, Q. (2000). Removal of Mercury (II) from Aqueous Solution on a Carbonaceous Sorbent Prepared from *Flax shive*, *J. Chem. Technol. Biotechnol.*, 75: 427-435.

Dabrowski, A., Podkoscielny, p., Hubicki, Z. and Barczak, M. (2005). Adsorption of phenolic compounds by activated carbon- a critical review. Chemosphere, 58: 1049 – 1070.

ISSN: 1597 – 9928.

Science and Education Development Inst., Nigeria

Gimba, C. C., Olayemi, J. Y. and Siyaka Z. M. (2001). Comparative studies on the Adsorption of Dyes Using Activated Carbon Derived from *Arachis hypogaea* and *Cocos nucifera* Shells. *Proc. Chem. Soc. Niger*.

Gurses, A., Dogar, C., Karaca, S., Ikyildiz, A. C. and Bayrak, M. R. (2006). Production of Granular Activated Carbon from Waste Rosa canina sp Seeds and its Adsorption Characteristics for Dye. *J. Hazard*.
Mater. 131 (1 -3): 254 – 259.

Haimour, N. M. and Emeish, S. (2006). Utilization of date stones for the production of activated carbon Using phosphoric acid. *Waste Manage*., 26: 651-660.

Jabit, N. B. (2007). Production and characterization of activated carbon using local agricultural waste through chemical activation process. *Industrial crops and products*, 23: 23-28.

Kadirvelu, K., Kavipriya, M., Karthika, C., Vennilamani, N., Pattabhi, S. (2004). Mercury (II) adsorption by Activated carbon made from sago waste, *Carbon*, 42: 745-752.

Karim, M. M. and Das AK Lee SH (2006). Treatment of colored effluent of the textile industry in Bangladesh Using Zinc Chloride treated indigenous activated carbons, J. *power sources*, 1056-1066.

Li, W., Zhang, L. B., Peng, J. H., Li, N., Zhu, X. Y. (2008). Production of high surface area activated carbons from tobacco stems with K_2CO_3 activation using microwave activation radiation. *Ind. Crops*
Prod. 27: 341-347.

Mohanty, K., Jha, M., Meikap, B. C., Biswas, M. N. (2005). Removal of Chromium (VI) from dilute Aqueous solution developed from *Terminalia arjuna* nuts activated with Zinc chloride. *Chem. Eng. Sci*., 60: 3049-3059.

Nurul'ain B. J. (2007). *The production and characterization of Activated carbon using local agricultural Waste through chemical activation process*. A thesis submitted in fulfillment of the requirements for the degree of Master of Science, University of Technology, Malaysia.

ISSN: 1597 – 9928.

Perez, R. U., Marin, F. C., Jimenez, D. F., Castilla, C. M. (2006). Granular monolithic activated carbons from KOH-activation of olive stones, D.F. Microporous *Mesoporous Mater*. 92: 64-70.

Petrov, N. (1999). Preparation of activated carbons from cherry stones, apricot stones and grape seeds for the removal of metal ions from water, in: Proceedings of the 2nd Olle Indstorm Symposium on renewable energy-Bioenergy Stockholm, Sweden, pp. 9-11.

Serrano-Gomez, V., Correa-Cuerda M. E., Gonzalez-Fernandez C. M., Franco-Alexandre, F. M., Garcia-Macias, A. (2005). Preparation of activated carbons from chestnut wood by phosphoric acid-chemical activation. Study of microporosity and fractal dimension. *Mater. Lett*, 59: 846-853.

Shalaby, C. S., Mine, G., Ucat-Astarlioglu, Levent, A. and Cigdem, S. (2006). Preparation and characterization of activation carbons by onestep steam pyrolysis/activation from apricot stones, Microporous *Mesoporous Mater*., 88: 126-134.

Wu, F. C., Tseng, R. L., Hu, C. C., Wang, C.C. (2006). The capacitive characteristics of activated carbons comparisons of the activated methods on the pore structure and the effects of the pore structure and electrolyte on the capacitive performance, *J. power sources*, 159: 1532-1542.

Yang, T. and Lua, A. C. (2006). Textural and Chemical properties of Zinc chloride activated carbons prepared from pistachio-nut shells, *Mater. Chem. Phys*., 100: 438-444.

Zhang, T., Walawenda, W. P., Fan, L. T., Fan, M., Daugaard, D., Brown, R. C. (2004). Preparation of activated carbon from forest and agricultural residues through CO_2 activation. *Chem. Eng. J*., 105: 53-59.

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