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Structural and Electrical Conductivity Study of Prosopis Africana carbon Charcoal based material

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Abstract – This work aims to study the structural and electrical conductivity of the Prosopis Africana carbon material. The characterization of new material from Prosopis carbon-based was conducted in which the following analysis was obtained. The carbon charcoal was locally milled and tested, and then the powder of the carbon material was sieved using a 63-micron sieve and tested, finally, the material was milled into nano size using a milling machine and the test was conducted again and compared. The Electrical conductivity test and thermal conductivity test were carried out at different nano sizes. The electrical conductivity test of the material was conducted in the laboratory using HACH Sension5 Equipment in which the results show a variation of conductivity at different sizes and the result finally gives 386.5/100 = 3.8655µs/m. Also, the thermal conductivity test was conducted two times and the result obtained was 0.7508 (w/km) and 59.50 (w/km). Raman spectroscopy and TDA analysis were also conducted. However, the Scanning Electron Microscopy test (SEM) and Energy Dispersive X-ray test (EDX) test were all carried out to know the elemental and structural properties of the material. The results showed that Carbon Element C has the highest percentage of about 80.72% while the remaining elements like potassium K have 6.36%, calcium Ca has 6.94% and Niobium Nb has 5.98% as presented in the results and discussions.

Keywords – Prosopis Africana, Carbon Material, SEM, EDX.

I. INTRODUCTION

It's becoming interesting to investigate the potential application of using carbon charcoal from (the Prosopis Africana tree) as a potential material. Prosopis Africana is a savannah tree usually found to be 40-60 feet in height and up to 7 feet in girth. Though the common name of Prosopis Africana is mesquite, and its native Nigerian names are: Kirya (Hausa), kohi (Fulani), sam chi latti (nupe), kpaye (Tiv), avan (Yoruba), and ubwa (Ibo) (Ogunshe, 2007). However, many researchers have used this tree for different applications some of which are; some researchers used it as a fermented food and about thirty different foods have been recorded some of them are condiments while some serve as main meals (Ogunshe, 2007). Some have used it as a medicinal plant (Houetchegnon, 2015). Some have used it in poultry research on the growth performance of broiler chickens (Yusuf, 2008). While some used it in charcoal production (Adeniji, 2015). The most important research on this tree is the physical and engineering properties of the Prosopis Africana seed (Raji, 2006). The physical and engineering properties showed that the seed of Prosopis Africana contains steel material which can be used for machine design (Raji, 2006).
Figure 1 (a, b c & d) Shows the Prosopis Africana tree, stem wood, and charcoal.


Figure1a. P. Tree


Figure1b. P. Wood


Figure1c. P. Stem


Figure1d. P. Charcoal

II. MATERIAL AND METHOD

This section presents the characterization of the Prosopis Africana charcoal material which involved milling into nano size, thermal conductivity test, electrical conductivity test, Scanning Electron Microscopy test **(**SEM), and Energy Dispersive X-ray test (EDX).

III. OBTAINING THE CHARCOAL MATERIAL

The charcoal was locally obtained from the Prosopis Africana three, burnt, and processed into charcoal as shown in Fig. 1 (a, b, c & d).

IV. MILLING AND SIEVING OF THE CHARCOAL

The charcoal-based material was milled and sieved into micro size using a 63-micron sieve and then processed into Nano size using a milling machine which ranges from 1 to 100 nano as presented in fig.2.


Figure 2. Milling and sieving experimental setup

V. THERMAL CONDUCTIVITY TEST

The thermal conductivity test of the Prosopis Africana Charcoal material was conducted two times i.e. (before milling and after milling) in the laboratory using thermal conductivity meter model 3750k as presented in the experimental setup in Figure 3.

Figure 3. Thermal conductivity experimental set up.

VI. ELECTRICAL CONDUCTIVITY TEST

The electrical conductivity test of the material was conducted in the laboratory using electrical conductivity test Equipment (HACH Sension 5) about six times at various sizes before milling and after milling into nanosized as presented in Figure 4 (a, b, and c).

Figure 4. (a, b & c) Electrical conductivity experimental set up.

VII. SCANNING ELECTRON MICROSCOPY TEST (SEM)

The Scanning Electron Microscopy test of the charcoal material used in this work was conducted at different sizes (10um, 20um and 100um.) as presented in the result and discussion.

VIII. ENERGY DISPERSIVE X-RAY TEST (EDX)

The energy-dispersive X-ray test of the charcoal material used in this work was presented in the result and discussion. The results showed that the material contains: Carbon Element C, potassium K, Calcium Ca, and Niobium Nb.

IX. RESULTS AND DISCUSSIONS

The result obtained from the characterization of material will be presented.

X. MILLING CHARCOAL MATERIAL INTO NANO SIZE

The results obtained using 63-micron sieve was in micro after sieving and then milled into Nano size using milling machine which ranges from 1 to 100 Nano.

XI. THERMAL CONDUCTIVITY RESULT

From the test conducted before milling and after milling, the result obtained were 0.7508 (w/km-k) and 59.50 (w/km-k) respectively as presented in table 1.

Table 1. Thermal Conductivity result

Thermal Conductivity		
S/N	**Thermal Conductivity test**	**Condition**
1	0.7508 (w/km-k)	Before milling into nano size
2	59.50 (w/km-k)	After milling into nano size

From the above table, the results obtained after milling have the highest thermal conductivity values of 59.50 (w/km-k). And it's in watts/kilometer-kelvin.

XII. ELECTRICAL CONDUCTIVITY RESULT

The test was conducted about six times as presented in table 2.

Table 2. Electrical Conductivity result

Electrical Conductivity test						
Number of Tests	1st test	2nd test	3rd test	4th test	5th test	6th test
Conductivity Result in µs/cm	186.5	355.0	407	397	364	378
Conditions	Before milling	After milling	After milling	After milling	After milling	After milling

The last four results were sum and divided by four in which the average was considered as follows;
407+397+364+378= 15465µs/cm
Therefore, the average is giving by 1546/4 = 386.5µs/cm and the result is then converted in meter which gives 386.5/100 = 3.8655µs/m.
However, based on various test conducted, the electrical conductivity of the Prosopis carbon charcoal is 3.8655µs/m. and it's in micro-Siemen/meter.

XIII. SCANNING ELECTRON MICROSCOPY (SEM) RESULT

The Scanning Electron Microscopy result of the charcoal material used in this work is presented in Figures 6 a, b, and c below.

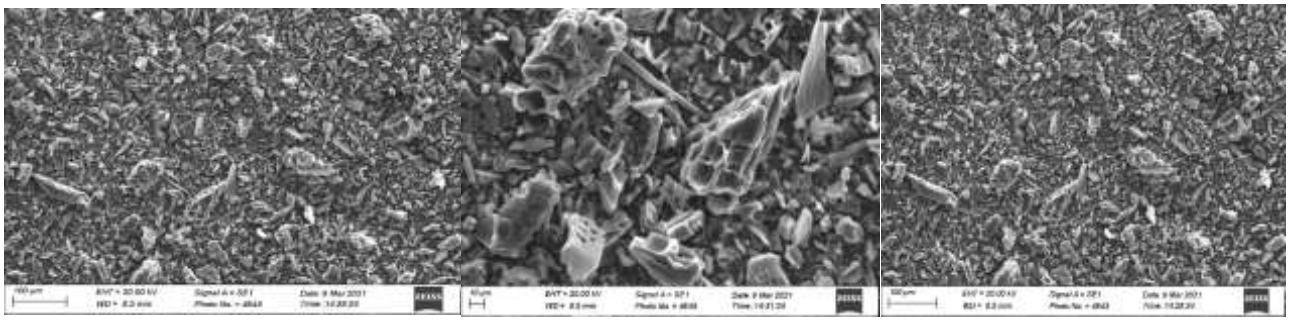

Figure 6. (a) SEM at 10um (b) SEM at 20um (c) SEM at 100um

XIV. ENERGY DISPERSIVE X-RAY TEST (EDX) RESULT

The Energy Dispersive X-ray result of the charcoal material used in this work was presented in the graphical, Bar chart, and numerical result.

The results showed that the Carbon element (C) has the highest percentage of about 80.72% while Potassium (K) has 6.36%, Calcium (Ca) has 6.94% and Niobium (Nb) has 5.98% as shown in the result presented in graphical result, Bar chart representation and result sheet in figure 7 and 8.

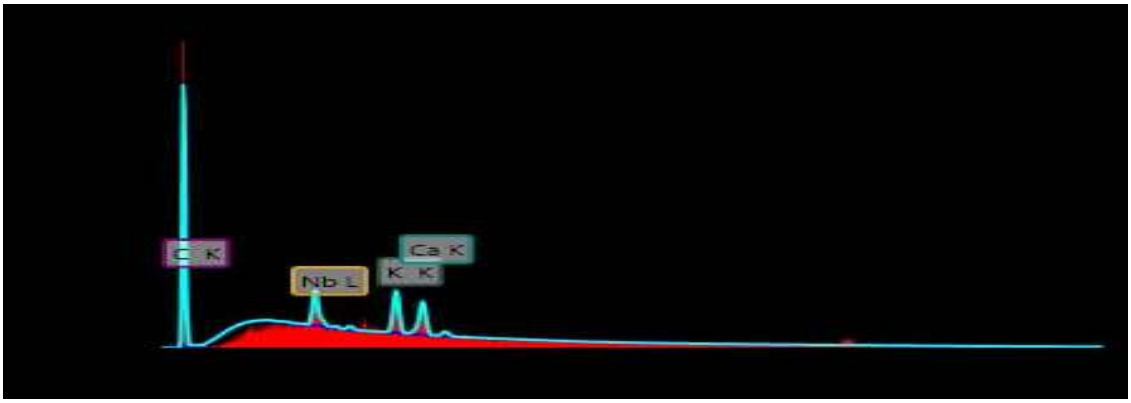

Figure 7. EDX Graphical result of carbon

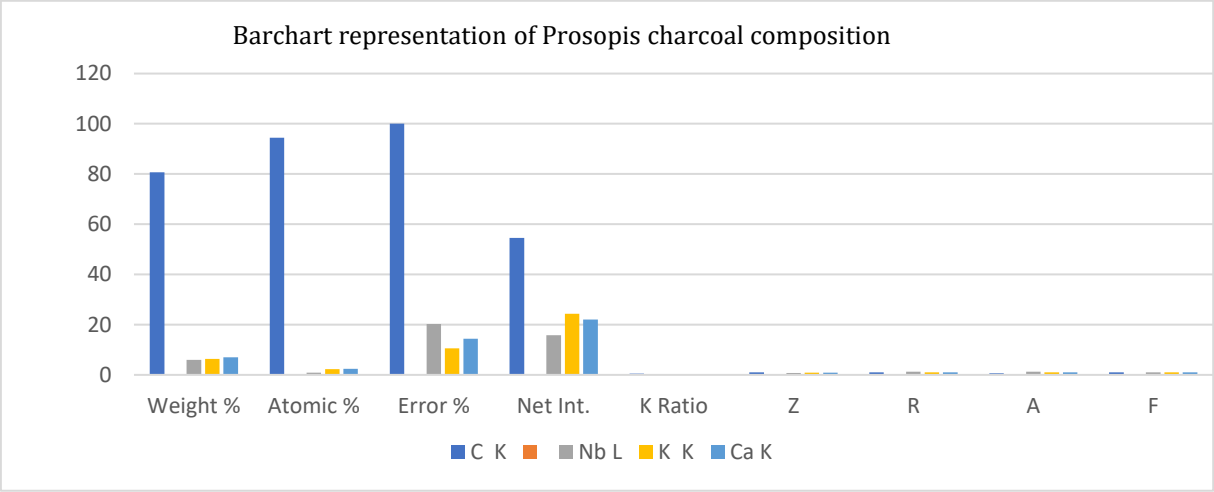

Figure 8. EDX Barchart of Carbon

Table 3. EDX Result Sheet

Element	Weight %	Atomic %	Error %	Net Int.	K Ratio	Z	R	A	F
C K	80.72	94.38	99.99	54.57	0.4895	1.0388	0.9709	0.5838	1
Nb L	5.98	0.9	20.2	15.82	0.0512	0.6993	1.2319	1.218	1.0052
K K	6.36	2.28	10.52	24.36	0.0537	0.8387	1.061	0.9992	1.0075
Ca K	6.94	2.43	14.36	22.01	0.0583	0.8541	1.0651	0.9798	1.0036

XV. CONCLUSION

In this work, the method adopted in carrying out the research was presented, in which the characterization of the material such as electrical conductivity, thermal conductivity test, Nano sizing, SEM, and EDX tests was presented. In which the characterization results show that the material contains high carbon material having the electrical conductivity test of 3.865 x 10^{-6} S/m. The results obtained from thermal conductivity were 0.7508 (w/km-k) and 59.50 (w/km-k) respectively. Also, the EDX result showed that the material contains Carbon element (C) with the highest percentage of 80.72% while Potassium (K) has 6.36%, Calcium (Ca) has 6.94% and Niobium (Nb) has 5.98%. However, based on the outcomes, this

material can serve as a semi-conductive material especially a substrate material in the design of a Microstrip Patch Antenna (MPA).

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