ONLINE ISSN 2069-7430
ISSN-L 1841-4737

PRO LIGNO
www.proligno.ro

Vol. 18 N° 3 2022
pp. 21-25

CHARACTERIZATION OF ACTIVATED CARBON PRODUCED FROM TEAK (*Tectona grandis*) SAWDUST

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Abstract:

Tectona grandis (Teak) is one of the most utilised trees for furniture and other household items leading to the generation of sawdust as waste with no appropriate means of disposal. Clean water is the basis for life sustenance. However, the introduction of wastewater from industries to water bodies poses a potential danger to the environment because of heavy metal contamination amongst other possible contaminants due to its non-degradability and toxicity to humans. This study aimed at determining the adsorptive capacity of Tectona grandis (Teak) sawdust. Raw Tectona grandis sawdust and activated carbon prepared from Teak sawdust using H_3PO_4*, were characterized using Fourier Transform Infrared (FTIR), Scanning Electron Microscopy (SEM), and Energy-dispersive X-ray spectroscopy (EDX) respectively. The FTIR spectrum revealed shifts in, and disappearance of bands of prominent functional groups, SEM showed visibility of pores due to acid modification and EDX revealed increased carbon content by weight (%) to confirm the acid activation. Thus, the influence of acid modification on Tectona grandis there by making it an effective adsorbent for the removal of pollutants from waste water.*

Key words: *SEM; activated carbon; Tectona grandis; sawdust.*

INTRODUCTION

Sawdust, tiny particles of voluminous waste from wood processing industries particularly saw-milling industries in southwest Nigeria are mostly improperly disposed of ensuing in environmental pollution (Adebawo *et al.* 2016). However, it can be valuable as a refrigerator insulator, briquette, and wood cement board.

According to Badejo (1995), the amount of wood waste produced in sawmills is predicted to be 3.87 million m^3, among which saw dust makes up around 20%. Nigeria's sawmill population has increased immensely over the years and because there aren't better ways to handle these wood wastes, they are frequently disposed of carelessly, which has an adverse effect on the environment. Prominent disposal and management include heaping/abandonment at the mills, biomass inceneration, dumping on the side of the road, and disposal in bodies of water. However, it is crucial that measures be made to not only implement effective oversight but also to employ it efficiently, as is the case in industrialized nations (Oluoti *et al*. 2014). Sawdust left unattended at sawmills produces aesthetic concerns, while left unattended by the side of the road results in air pollution since the wind frequently blows and lifts the wood dusts into the atmosphere. With the emission of carbon (IV) oxide (CO_2), smoke, NO_x, and other pollutants into the air as well as the waste of potentially useful energy, this practice could lead to respiratory issues in people.

Given that it is essential for plant and animal life to survive, clean water is the most vital resource on Earth. Heavy metals and other contaminants are produced in large quantities by human industrial activity, expanding populations, and other factors, reaching water bodies both above and below the surface. When these contaminants are present in amounts that exceed a specific threshold, human life is at danger. Water availability and safety are major issues because of water contamination (Yu *et al*. 2000). Our ability to survive depends heavily on water. However, due to rapid urbanization and population growth, this valuable natural resource is becoming contaminated. According to Ogunwusi (2014), sawdust produced by sawmills in Nigeria annually amounts to roughly 1,000,000m^3, which when burned causes environmental harm and poses a risk to human health when left in heaps. However, it is an environmentally friendly method of using

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waste to treat waste and so safeguard the environment when used as activated carbon that serves as an adsorbent in the treatment of waste water. The amount of atoms, ions, and molecules known as adsorbate accumulates largely depends on the adsorbent's surface during the adsorption process. It also aspires to utilize the physiochemical activation method for producing activated carbon from sawdust. Simple, affordable, and non-toxic activated carbon made from sawdust is used to clean waste water. A high surface area of between 500 and 1000m^2/g, which is regarded as an excellent adsorbent for efficiently removing organic molecules, is one of the most desired characteristics of an adsorbent (Javie 2011). The purpose of this investigation is to evaluate the efficacy of activated carbon made from *Tectona grandis* sawdust as heavy metal adsorbent.

MATERIALS AND METHODS

Reagents

All chemicals/reagents that were used in the study of analytical grade and they were used as obtained. Ferric chloride, sodium hydroxide solution and distilled water were acquired from the soil laboratory, Federal College of Forestry, Ibadan, Nigeria The pH meter was carefully calibrated using standard buffer solutions of pH 4.0, 7.0 and 9.2 respectively.

Sawdust pre-treatment

The sawdust (*Tectona grandis*) was collected from the premises of a plank market in Sango, Ibadan, southwest Nigeria whose principal operations included conversion of roundlog into saw timber and production of wood products such as furniture, wooden kitchen utensils, cabinets and solid doors. The sawdust obtained was washed thrice with tap water and once with distilled water, to eliminate the adhering dirts (impurities) and sun-dried for one week. The dried sawdust was then cleaned with deionized water after which it was dried in the oven at 105^{o}C. The dried sample was stored in a container for further use.

Chemical Activation of sawdust

To carbonize *Tectona grandis* (Teak) sawdust, 50.0g of the sample was immersed in 1000ml of 0.3M H_3PO_4 in a 1000ml beaker. The slurry of the mixture achieved after heat was applied with gentle stirring and later carbonized for 1h at 500^{o}C. It is then frequently cleansed with distilled water till pH 7 was attained and oven dried till the weight is constant for another 4 hours at 105^{o}C. Activated sample was sealed in a clean vessel and kept for further use (Ogunleye *et al*. 2014; Bello *et al*. 2020).

Characterization of Adsorbent

Fourier Transform Infrared Spectroscopy

The vibrational frequency variations in the functional groups of all the adsorbents are identified using Fourier transform infrared (FTIR) spectroscopy. The spectra were generated between 350 and 4000cm^{-1} wave number. For the purpose of creating pellets, the samples will first be combined with KBr and then pulverized in an agate mortar at a ratio of roughly 1/100 (weight of 100mg). The mixture will be crushed at 5 tonnes for 5 minutes and cast into a disk prior to FTIR analysis. On Perkin-Elmer Spectrum version 10.03.07, England, all spectra will be plotted with the same scale and percent transmittance.

Scanning Electron Microscopy

Scanning electron microscopy (SEM) is a technique that is used to investigate surface morphology of biosorbent. This technique allows evaluation of the morphological changes of the biomass surface. If SEM is combined with EDX technique, information on the distribution of the contaminants on the surface is valuable. But, it should be noted that SEM provides only a qualitative assessment of the surface structure.

Energy Dispersive X-ray Spectroscopy

EDX is a chemical technique employed in conjunction with SEM and use for the following purpose; to identify elements. Also, in synthesis of composite, to identify the component of each material present and to determine the homogeneity and its elemental distribution in the synthesized structure.

RESULT AND DISCUSSION

Characterization using the scanning electron micrograph (SEM)

The SEM images of raw sawdust and activated sawdust were presented in Fig.1. The surface structure of raw sawdust are uneven while several pores were developed on the activated sawdust due to the acid modification using orthophosphoric acid H_3PO_4. According to Rao *et al*. 2008, the requisite for effective adsorbent is the availability of pores and an internal surface. The volatilization of certain materials in the adsorbent and the complete breaking down of lignocellulosic materials at elevated temperature explains the presence of numerous pores in the activated sawdust.

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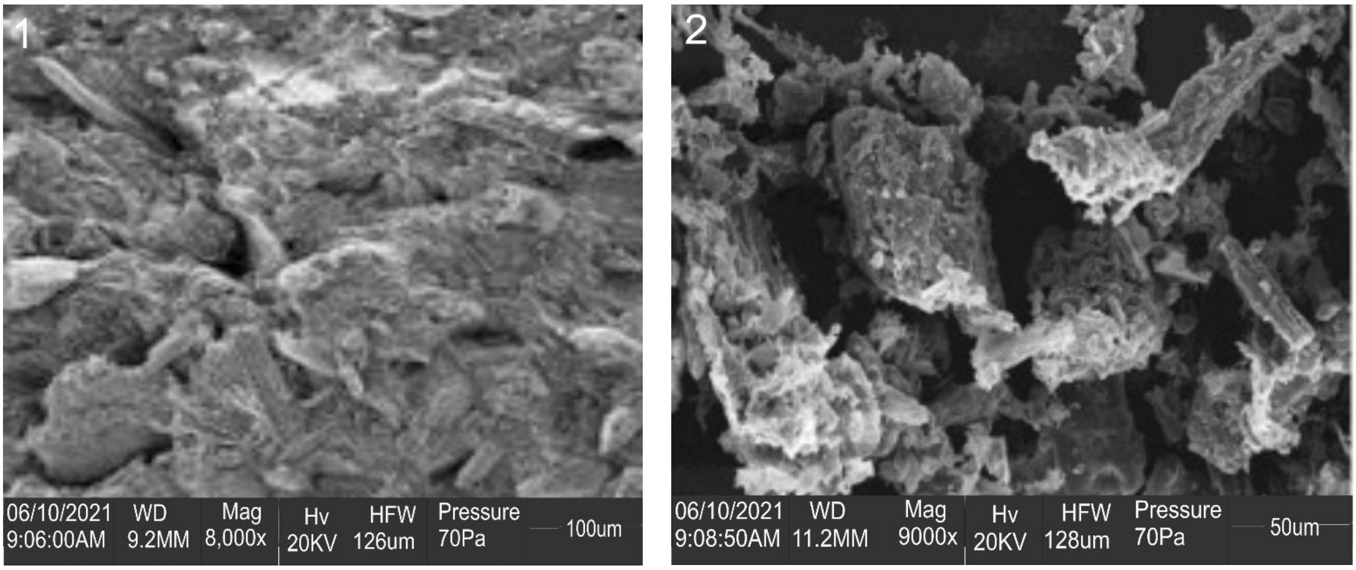

Fig. 1.
SEM image of raw and activated** Tectona grandis **sawdust.

Characterization using the energy dispersive X-Ray (EDX)

EDX analysis was carried out on the raw and prepared adsorbent in order to determine the elemental composition (% weight) and were presented in Fig. 2 and Table 1. The EDX spectra results obtained for raw sawdust revealed the carbon content to be 7.0 (Wt. %) compared to activated sawdust adsorbent as shown indicating significant increase in the bulk percentage of carbon (57%) and oxygen of 10.5 (Wt. %) exposing the influence of acid activation and confirms that rich carbon content as a unique characteristic feature of a good adsorbent for the adsorption of heavy metals, organic pollutants and Endocrine disruptive chemicals (EDCs) from waste water bodies (Sahu *et al.* 2017).

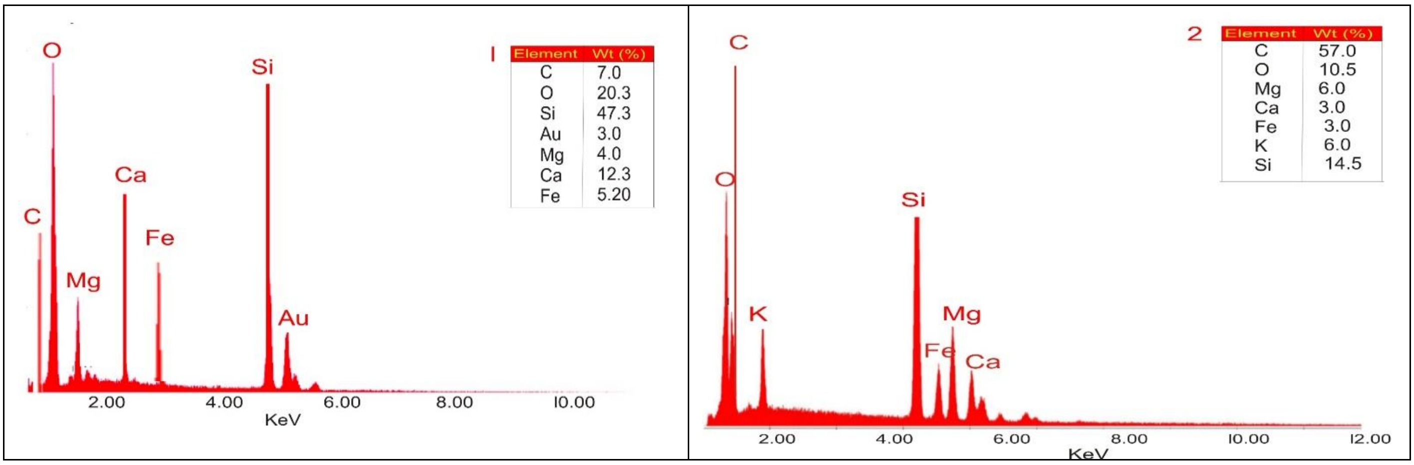

Fig. 2.
EDX spectra image of raw and activated** Tectona grandis **sawdust.

Table 1

Elemental composition (%weight) of raw and activated** Tectona grandis **sawdust

Elements	Raw sawdust	Activated sawdust
C	7.0	57.0
O	20.3	10.5
Si	47.3	14.5
Au	3.0	-
Mg	4.0	6.0
Ca	12.3	3.0
Fe	5.20	3.0
K	-	6.0

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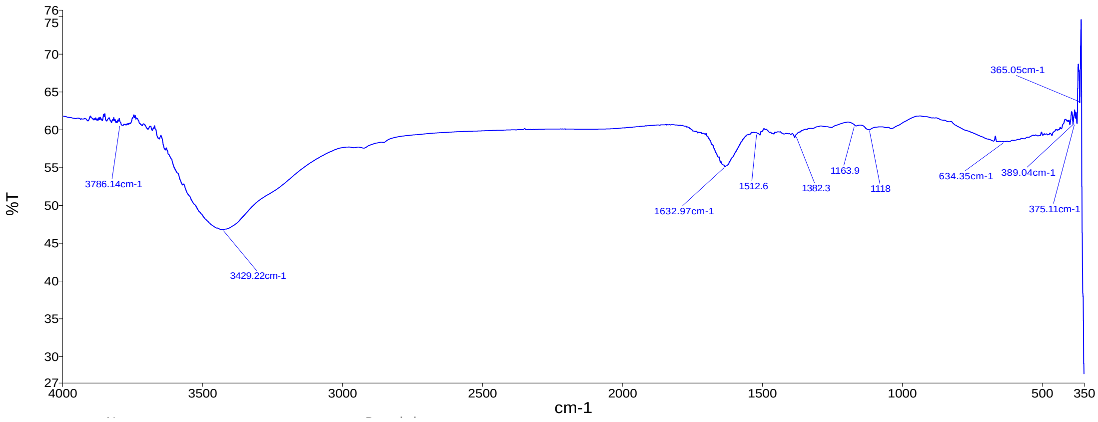

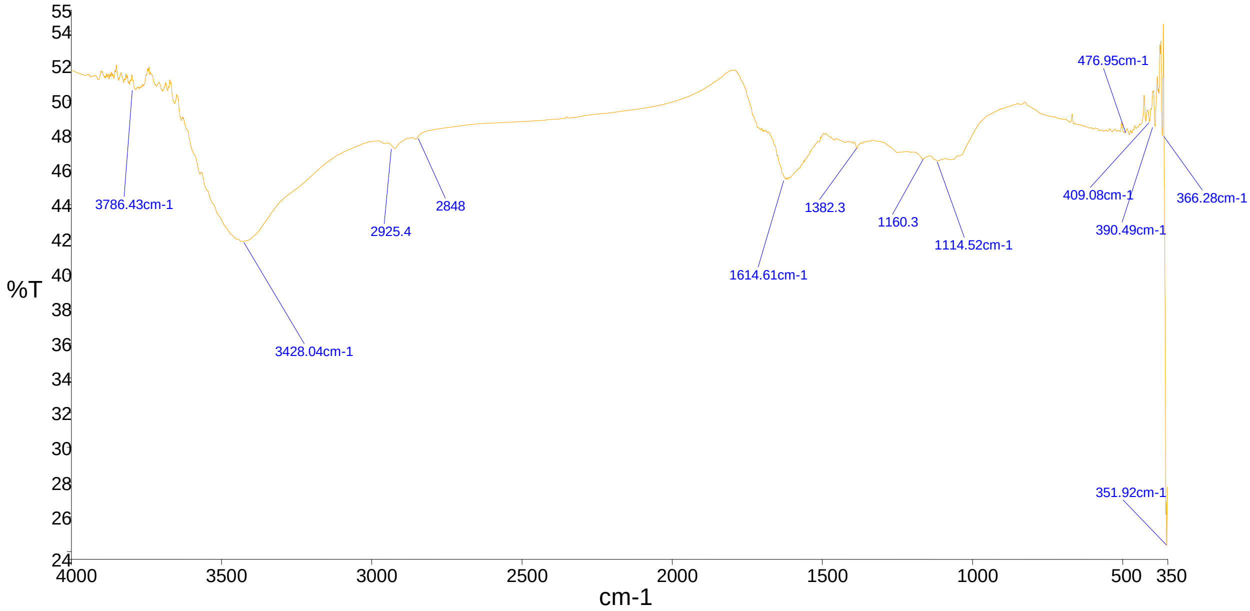

Fig. 3.
Spectra of a raw and activated Tectona grandis sawdust.

FTIR spectra of sawdust

Spectra of *Tectona grandis* sawdust (for raw, activated and after sorption) were taken from 400-4000cm^{-1} to examine the functional groups on the adsorbents. The spectra revealed different adsorption peaks, their corresponding bands were shown in the Fig. 3 above while the corresponding band assignments were presented in Table 2 below.

Spectroscopic analysis revealed a peak band at 3786.14cm^{-1} for raw sawdust, and 3786.43cm^{-1} for activated sawdust, these bands are attributed to O-H bonding of alcohol (Abdulsalam *et al.* 2020 and Abdelhafez and Li 2016). The peak at 2925.4 – 2848cm^{-1} for activated sawdust was assigned to C-H group of aliphatic. Also, the bands at 1632.97cm^{-1} for raw sawdust, and 1614.61cm^{-1} for activated are assigned to C = O stretch of esters and the peak around 1512.6cm^{-1} in raw, and 1614.61cm^{-1} in activated sawdust was assigned to C = C stretch of aromatic groups and C – Br was assigned to 634.35 in raw sawdust. The shifts observed in the FTIR spectra revealed that acid modification of raw teak sawdust resulted in band shifts, which will enhance pollutants (dyes, heavy metals, surfactants, PAHs) adsorption through bond formation between the surface of the adsorbent and the pollutant molecule (Bello *et al.* 2017, Ahmad 2019, Abdulsalam *et al.* 2020).

Table 2

Comparison in the FTIR spectra of raw and acid Activated Sawdust

Raw sawdust	Activated sawdust	Differences	Band Assignment
3786.14	3786.43	+0.29	O-H stretch of alcohol
3429.22	3428.04	-1.18	O-H stretch of alcohol
-----------	2925.4	--------	C=H stretch of alkane
---------	2848		C=H stretch of alkane
1632.97	1614.61	-18.36	C=O stretch of esters
1512.6	--------	---------	C=C stretch of aromatic group
1382.3	1382.3	---------	C-H bending of alkane group
1163.9	1160.3	-3.6	C-O-C stretch
1118	1114.52	-3.48	C-O-C stretch
634.35	--------	--------	C-Br Stretching

CONCLUSION

The results revealed the influence of acid modification on *Tectona grandis* there by making it an effective adsorbent for the removal of pollutants from waste water. Utilization of the prepared adsorbent should be employed in an adsorption process to generate data for the determination of its isotherm models, kinetic models and thermodynamic parameters of the adsorbent and other characterization like boehmn titration, Thermogravimetric analysis should be carried out on the adsorbent to furnish us with additional information while different pollutants should be used as adsorbate e.g dye, endocrine disruptive chemicals, heavy metals, and surfactants.

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