Synthesis and Characterization of a Bio Waste Material as an Effective Low-cost Adsorbent

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***Abstract* — Activated carbons are carbonaceous materials characterized by their large internal surface area, well-developed porous structure, and tunable surface-containing functional groups. Adsorption onto activated carbon has been found to be one of the most widely used methods for removing organic and inorganic contaminants from water due to its high adsorption capacity. Activated carbon has been synthesized from bio-waste materials of the plant Bambusa vulgaris. Physical activation was done by a thermal treatment which was followed by chemical activation using HNO_3 and H_3PO_4 respectively. This is done in order to allow contaminants to be adsorbed on the surface area which depends upon the functional group and ions present on the surface of the activated carbon. Characterization includes pH, apparent density, Boehm titration, iodine number, proximate analysis, SEM studies, and FTIR studies. The synthesized adsorbent acts effectively thus proving that this activated carbon can be considered a good adsorbent for the removal of impurities from water.**

***Keywords* — Activated carbon, Boehm titration, Iodine number, Surface area.**

I. Introduction[1]

Activated carbons are unique and versatile adsorbents because of their extended inter-particulate large surface area, microporous structure, high adsorption capacity and high degree of surface reactivity. Depending on the functional group and ions present on the surface of the activated carbon, its adsorption quality varies [1]. Their important applications are the adsorptive removal of colour, odour, taste and other undesirable organic and inorganic pollutants from drinking water. Activated carbon is also used in the treatment of industrial waste water, air purification, food processing, chemical industries, and pharmaceutical products [1]-[4]. Activated carbon is obtained from a carefully controlled process of dehydration, carbonization, and oxidation of organic substances [5]. It can be prepared for research in the laboratory from a large number of materials. However, the most commonly used ones in commercial practices are primarily industrial and agricultural by products, forest wastes such as coconut shell [6], sugar beet bagasse [7], rice straw [8], bamboo [9], rattan sawdust [10], molasses [11], rubber wood sawdust [12], oil palm fiber [13], waste apricot [14], and coconut husk [15].

Carbonization is a heat treatment at 400-800 °C which converts raw materials to carbon by minimizing the content of volatile matter and increasing the carbon content of the material. This increases the material's strength and creates an initial porous structure which is necessary if the carbon is to be activated. Adjusting the conditions of carbonization can affect the final product significantly. An increased carbonization temperature increases reactivity, but at the same time decreases the volume of pores present. This decreased volume of pores is due to an increase in the condensation of the material at higher temperatures of carbonization which yields an increase in mechanical strength [2]. Therefore, it becomes important to choose the correct process temperature based on the desired product of carbonization [1]. After the initial porous structure has been created by carbonization, this pore structure in carbonized char is further developed which enhances more activation. This activation converts the carbonized raw material into a form that contains the greatest possible number of randomly distributed pores of various sizes and shapes, producing an extended and extremely high surface area of the product [5]. Activation can be carried out by oxidizing gases or a chemical activation. In activation by oxidizing gases, carbon reacts with the oxidizing agent producing oxides of carbon [1]-[3]. These oxides diffuse out of the carbon resulting in a partial gasification which opens pores that were previously closed and further develops the carbons internal porous structure. In chemical activation, the carbon is reacted at high temperatures with a dehydrating agent that eliminates the majority of hydrogen and oxygen from the carbon structure [2].

The objective of this present study is to produce activated carbon from locally available biowaste materials. The synthesized activated carbons are characterized and then finally examined for the adsorption capacity by oxidation of activated carbons of similar porosity with nitric acid and phosphoric acid.

A. Raw Sources of Activated Carbons:

The stem and leaves of common bamboo which are locally available were taken as raw materials for the preparation of activated carbons.

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B. Carbon from Bambusa vulgaris (BVC)

Kingdom: Plantae
Clade: Tracheophytes
Clade: Angiosperms
Clade: Monocots
Clade: Commelinids
Order: Poales
Family: Poaceae
Genus: Bambusa
Species: B. vulgaris
Botanical Name: Bambusa vulgaris
Common Name: Bamboo
Distribution: Cultivated throughout India.

Average Chemical composition is cellulose 41-44%, pentosans 21-23%, lignin 26-28% ash 1.7-1.9% and silica 0.6-0.7%.



Fig. 1. Bamboo plant.



Fig. 2. Bamboo culm.

The origin of the species is unknown [16] although it is believed to have originated in tropical Asia, southern China, or Madagascar [17], [18] Common bamboo is the most widely grown bamboo throughout the tropics and subtropics.

C. Brief Description of the Plant

Bambusa vulgaris forms moderately loose clumps and has no thorns [19]. It has lemon-yellow culms (stems) with green stripes and dark green leaves [20]. Stems are not straight, not easy to split, inflexible, thick-walled, and initially strong [21]. The densely tufted culms grow 10–20 meters high and 4–10 cm thick [16], [17]. Culms are basally straight or flexuous (bent alternately in different directions), drooping at the tips. Culm walls are slightly thick [22]. Nodes are slightly inflated. Internodes are 20–45 cm. Several branches develop from mid-Culm nodes and above. Culm leaves are deciduous with dense pubescence [19]. Leaf blades are narrowly lanceolate [22].

D. Uses

Bambusa vulgaris has a wide variety of uses. The bamboo Culm is used widely as a building material in construction and for various domestic products like furniture, utensils, mats, etc. The bamboo shoot is an important food source in many Asian countries and the leaves are used as fodder [18], [23]. The worldwide production and trade of *B. vulgaris* is considerable, though no statistics is available. Bamboo is abundantly available in the state of Nagaland. It is fast-growing and a highly renewable resource; unlike timber, it can be harvested every year. Bamboo makes excellent charcoal. It has excellent potential for charcoal production to meet rural energy needs for heating and cooking, as industrial fuel, and to make products such as activated carbon.

II. Materials and Methods

A. Preparation of Activated Carbon

Activated carbon in powder form is prepared by the pyrolysis of *Bambusa vulgaris*. Stem and leaves of BVC were collected, washed, dried, and crushed before carbonizing in a uniform nitrogen flow in a horizontal tube furnace electrically heated at 600 °C for 4 hours. Then the activated carbon was cooled to room and ground to 45 mesh. These powdered carbons were subjected to liquid phase oxidation with 0.1N HNO_3 and 0.1 N H_3PO_4. After that, the carbons were washed with double-distilled water to remove the excess acid and dried at 150 ^oC for 12 hours. All the activated carbons (BVC) are chemically activated with 0.1N solution HNO_3 and 0.1 N H_3PO_4. The powdered activated carbon obtained after HNO_3 and H_3PO_4 treatment has a particle size in the range of 40-50 μm mesh.

B. Methods for Physical Characterization of Activated Carbons

The physical characterization of carbon is important in determining which form is best suited for a specific application. For instance, densities vary with the raw materials. Iodine value is an important characteristic of activated carbon. The iodine value gives a measure of the micro pore volume of carbon and it approximates the total internal surface of the carbon. The ash level reflects the purity of the carbon. The ash content can be important in water filtration applications. The performance of activated carbon is indicated by its adsorptive characteristics, which are derived from the specific surface area and porosity of the carbon [1]. Below the details are given about the characterization of the synthesized activated carbon.

C. Determination of pH

In order to determine pH of BVC, the standard test method ASTM (American Society for Testing and Materials) D3838-80 was used [24]. 1.0 gram of activated carbon BVC was transferred into 100 ml distilled water taken in a beaker and kept in a magnetic stirrer for one hour at 120 rpm. pH was then measured by pH meter (Systronics digital pH meter-335). The samples were tested in triplicates.

D. Conductivity

0.1 gram of BVC was mixed with 50 ml water (pH 6.96; conductivity, 0.024 ms/cm) and equilibrated for 1 hour by agitating at 120 rpm. The supernatant was analyzed for conductivity, using conductivity meter (model CM-180).

E. Apparent Density

In order to determine the apparent density, the standard test method ASTM (American Society for Testing and Materials) D 2854-96 was used [25]. A specific gravity bottle of 25 ml capacity was filled with the adsorbent and packed in a rubber stopper. The weight of the adsorbent was determined. The weight (g) divided by the volume (ml) gives the apparent density (g/ml) of the adsorbent.

F. Matter Soluble in Acid

The activated carbon (0.5 g) was placed in an evaporating dish, and mixed with distilled water to a thin slurry 5–10 ml of concentrated HCl was added and digested by warming until sample is nearly dry. The digestion was repeated three times with 5 ml of the acid. Then it was diluted with 100 ml water, filtered using a previously weighed sintered crucible and the weight of the insoluble matter was calculated after drying for a constant weight at 103 °C [26].

Calculation:

$$\text{Matter soluble in acid (\%)} = [(C - D)/(C - B)] \times 100 \rightarrow [31]$$

where
B = weight of crucible (g);
C = weight of crucible with original sample (g);
D = weight of crucible with cover plus dried sample (g).

G. Matter Soluble in Water

1 gm of activated carbon was added to 100 ml of distilled water and shaken thoroughly for about 30 minutes and filtered. The residue i.e., the adsorbent was dried, cooled, and weighed [27].

Calculation:

$$\text{Matter soluble in water (\%)} = [(C - D)/(C - B)] \times 100$$

where
B = weight of crucible (g);
C = weight of crucible with original sample (g);
D = weight of crucible with cover plus dried sample (g).

H. Iodine Number

Iodine number is the mass (mg) of iodine adsorbed from a standard 0.1 N (0.05 M) iodine solutions when the iodine concentration at equilibrium is exactly 0.02 N (0.01 M). According to the procedure [28] defined by ASTM (American Society for Testing and Materials) D4607-94(2006), for the determination of iodine number 0.7–2 g of activated carbon was added with 10 ml of 5% HCl and swirled in a conical flask until the entire activated carbon was wetted. The wetted solution was then boiled for exactly 30 seconds and the solution was cooled to room temperature. Then 100 ml of 0.1N iodine solution was added to the contents of the conical flask. This solution was filtered using a Whatman 2 V filter paper. Later 50 ml of this filtrate was then titrated against 0.10 N sodium thiosulphate solution until the yellow colour had almost disappeared. 1 ml starch indicator was added and the titration was continued until the blue colour just disappears. The equilibrium concentration was determined by calculation using the amount of sodium thiosulphate used in the titration.

I. Calculation of Iodine Number

$$X/M = A-(DF \times B \times S)/ M$$

where X/M = iodine number (mg/g);
A = 12693N2, B = 126.93N1, C = N1/ (50 × S), C = residual iodine (N);
S = sodium thiosulfate (ml);
M = carbon used (g);
N1 = concentration of sodium thiosulfate (N);
N2 = concentration of iodine (N);
DF = dilution factor.

$$DF = (I + H)/F$$

I = initial iodine (ml);
H = 5% hydrochloric acid used (ml);
F = filtrate (ml).

J. Surface Functional Groups (Boehm's Titration)

The presence of surface functional groups in the activated carbons was quantified by Boehm titration method [29], [30]. About 1.0 g of activated carbon was mixed with 50 ml solution (0.1 M) of NaOH, $NaHCO_3$, and Na_2CO_3 respectively, for 24 hours with continuous stirring. Then, the solid phase was separated from the aqueous solution by vacuum filtration. 10 ml of each filtrate was used for the excess acid titration by 0.1 M HCl (hydrochloric acid). The phenolic group content on the carbon surface was determined as the amount of 0.1 M $NaHCO_3$ consumed by the sample. Lactonic group content was calculated as the difference between the amounts of 0.1 M Na_2CO_3 and 0.1 M $NaHCO_3$ consumed by the activated carbon sample. Carboxylic group is contained by subtracting the amount of 0.1 M Na_2CO_3 consumed by the activated carbon from the amount of 0.1 M NaOH consumed. This method was used to calculate the concentration of acid groups on activated carbon surface under the following assumptions. Sodium hydroxide (NaOH) neutralizes carboxylic, phenolic and lactonic groups. Sodium carbonate (Na_2CO_3) neutralizes only carboxylic and phenolic groups. Sodium bicarbonate ($NaHCO_3$) only neutralizes carboxylic groups.

K. Determination of Surface Area (BET Method)

BET-N_2 adsorption experiments were carried out manometrically using an Autosorb (Quanta Chrome Crop). Prior to gas adsorption measurements, the carbon samples were degassed at 200 °C in a vacuum condition for a period of at least 24 hours. Nitrogen adsorption isotherms were measured at a series of different pressures at -196 °C. And the BET surface area was determined by means of the standard BET equation [31].

$$\frac{P}{V(P-P_0)} = \frac{1}{V_m - C} + \frac{C-1}{V_m C}\frac{P}{P_0} \quad (1)$$

The surface area is determined by the following equation:

$$S_{BET} = \frac{N_A A_M V_m 10^{-20}}{m_s V_M} \quad (2)$$

where
S BET → is the BET surface area (m^2/g);
NA → is Avogadro's number (6.023×1023 molecules/mole);
AM → is the area occupied by an adsorbate molecule (16.2 Å2 for nitrogen);
Vm → the quantity of gas adsorbed for monolayer coverage of surface (cm^3);
m_s → is the mass of the solid analyzed (g);
V_M → is the molar volume of gas (22,414 cm^3/mol).

For nitrogen as adsorptive gas, equation (2) becomes:

$$S_{BET} = \frac{4.35 V_m}{m_s}$$

L. Proximate Analysis

The proximate analysis of activated carbon was developed as a simple means of determining the distribution of products obtained when the carbon sample is heated under specific conditions. Proximate analysis, as defined by ASTM (American Society for Testing and Materials) is the determination by prescribed methods of moisture, volatile matter, fixed carbon (by difference), and ash. It separates the products into four groups: (1) moisture, (2) volatile matter, consisting of gases and vapours driven off during pyrolysis, (3) fixed carbon, the non-volatile fraction of coal, and (4) ash content the inorganic residue remaining after combustion [32].

M. Moisture Content

The moisture content of activated carbon samples was determined using standard test method [33]. The sample was put into a pre-dried crucible with lid, and the weight was taken to the nearest 0.5 mg. The lid was removed, which was followed by the heating of the crucible and the lid in a ventilated drying oven at 150 °C for 3 hours. After heating, the plate was quickly covered, cooled in desiccators, and weighed. The loss in weight of the adsorbent represents the moisture content.

The moisture content was calculated as follows:

$$\text{Moisture (weight \%)} = [(C - D)/(C - B)] \times 100$$

where
B = weight of crucible with cover (g);
C = weight of crucible with cover plus original sample (g);
D = weight of crucible with cover plus dried sample (g).

N. Volatile Matter Content

The volatile matter content of the activated carbons was determined using the standard test method [34]. For which, 1 gram of activated carbon was taken in a pre-dried crucible which was covered with the lid and heated in a muffle furnace regulated at 950 °C for 30 min. After heating, the plate was quickly covered, cooled in a desiccator, and weighed.

The volatile matter content was calculated as follows:

$$\text{Volatile matter (\%)} = [(C - D)/(C - B)] \times 100$$

where
B = mass of crucible with cover (g);
C = mass of crucible with cover plus original sample (g);
D = mass of crucible with cover plus de-volatilized sample (g).

O. Ash Content

The ash content of the activated carbon samples were determined using the standard test method [35]. The crucible was ignited in the muffle furnace at 650 °C for 1 hour. After heating, the crucible was placed in desiccators and cooled at room temperature.1 gram of activated carbon pre-heated at 150 °C for 3 hours was taken in the crucible and heated in the furnace at 630 °C for 3 hours. The crucible was kept in a desiccator and cooled at room temperature and the weight was taken.

The ash content was calculated as follows:

$$\text{Total ash (\%)} = [(D - B)/(C - B)] \times 100$$

where
B = weight of crucible (g);
C = weight of crucible plus original sample (g);
D = weight of crucible plus ash sample (g).

P. Fixed Carbon

The fixed carbon content was determined by subtracting the sum of percentage compositions of moisture content, volatile matter content, and ash content from 100. The value obtained was the amount of fixed carbon present in the sample expressed in percentage. The fixed carbon of activated carbon samples was calculated from the following equation.

$$\text{\% fixed carbon} = 100 - (\text{\% ash content} + \text{\% volatile matter content})$$

The higher the percentage of fixed carbon, the greater was the carbon content found in the material which was left after volatile materials are driven off. Hence better activated carbon was produced when a percentage of fixed carbon was higher.

Q. Scanning Electron Microscope (SEM) Analysis

Scanning electron microscope (SEM – JEOL, JSM 6360 LV) was used to know the surface texture and porosity of the sample at the microscopic level. These images are primarily used to determine the structure and distribution of the pores that are present on the surface of the activated carbon. The Scanning Electron Microscope images of powder activated carbon are shown in Fig. 3 and 4.

R. Fourier Transform Infra-red Spectroscopy (FT-IR)

The FT-IR spectroscopy provides information about the presence of the different functional groups in the activated carbon samples. The IR spectra were recorded using Perkin–Elmer SPECTRUM-2000 spectrometer. The spectra were taken in the range between 4000 and 400 cm^{-1}(100 scans). The Background spectrum of air was subtracted from the spectra of the samples.

III. Results and Discussion

A. Determination of pH and conductivity

pH of activated carbon is defined as the pH of a suspension of carbon in distilled water. The results of pH and electrical conductivity of the activated carbons are presented in Table I. The results show that, for both carbon samples, there is an increase in pH. This increase in pH from 7.16 to about 7.28 indicates that these carbon samples may contain some water soluble alkaline substances. In all the cases, the pH increases to the same extent. Conductivity measures the electrical current, which is proportional to the mineral matter present in water. Thus, conductivity depends on the total dissolved solids (TDS) in water. Present results indicate that there is an increase in EC for all the adsorbents. Among the different carbon samples, higher EC value is shown by BVC samples.

B. Apparent Density

The results of apparent densities of the two different carbons activated show that all the carbons synthesized have higher apparent densities. If the density of activated carbon is high, then it provides greater volume activity and hence better quality of activated carbon. Among the samples, higher density was observed in BVC (HNO_3).

C. Matter Soluble in Acid

The amount of acid soluble matter in the adsorbents indicates that the amount of acid soluble matter in the four samples is relatively less. Especially in the case of BVC (H_3PO_4), the value was the lowest. These low values indicate that the carbons are almost insoluble in acid; hence these may be used in treating water with acidic nature [36].

D. Matter Soluble in Water

The water-soluble matters of samples were determined, and the results are given in Table I. The results show that water-soluble matter in all the samples was low. Among the four samples taken, BVC (HNO_3) samples have the lowest solubility in water. These low values indicate that the prepared activated carbon adsorbents are well suited for ground and surface water analysis as it may not alter the physical properties of water.

E. Iodine Number

The iodine number is a relative indicator of porosity in activated carbon. The results for iodine number of the two different activated carbons activated with HNO_3 and H_3PO_4 are presented in the table below. A higher value of iodine number for BVC may be due to a higher degree of activation which enables more adsorption of iodine molecules on the surface.

TABLE I: Values of Different Physical Parameters of the Synthesized Activated Carbon

Samples	BVC (HNO_3)	BVC (H_3PO_4)
pH	7.16	7.28
Conductivity(μʊ)	85.6	82.5
Apparent density(g/ml)	0.544	0.603
Matter soluble in acid %	4.2	2.8
Matter soluble in water %	0.15	0.45
Iodine number (mg/g)	976.19	846.03

F. Surface Functional Groups (Boehm's Titration)

Surface functional groups had been determined by Boehm titration method and are presented in Table II. It is clear that the total basic groups are slightly greater than the total acid groups. Boehm states that the chemisorptions of oxygen suggest the basicity pyrone-type structures on the edges of the poly-aromatic layers. Support for the hypothesis of pyrone-type structures came from theoretical calculations, which showed that the base strength increases strongly when the carbonyl group and the ring oxygen of a pyrone-type structure are distributed on polycyclic aromatic compounds [29].

TABLE II: Surface Functional Groups of the Activated Carbons

Samples	BVC (HNO_3)	BVC (H_3PO_4)
Carboxylic acid (meq/g)	7.16	7.28
Lactonic (meq/g)	85.6	82.5
Phenolic(meq/g)	0.544	0.603
Total basic groups (meq/g)	4.2	2.8

G. Determination of Surface Area (BET Method)

The BET specific surface area of the resulting activated carbons varied in the range 570-530 m^2/g. BVC (HNO_3) sample shows the highest surface area (570 m^2/g) as compared to other activated carbons under the present study. The decreasing order of the surface area of the particles among the two carbons was found to be BVC (HNO_3) > BVC (H_3PO_4). This is a very important parameter because the particle size and surface area play an important role in adsorption. The adsorption capacity of the adsorbent increases with decreasing particle size due to an increase in the availability of active sites for adsorption [37], [38].

TABLE III: Surface Area of the Activated Carbons

Samples	BVC (HNO_3)	BVC (H_3PO_4)
Surface area m^2/g	570	530

H. Moisture Content

The results of moisture content of the two different carbons activated indicate that moisture content in all the samples is less.

I. Volatile Matter Content

The volatile matter content results of the samples are presented in Table IV. The volatile matter content of BVC (HNO_3) is found to be the least. The present results indicate that these carbons contain more volatile materials. These may be due to the extremely high surface area and high adsorption capacity of the activated carbon samples towards various volatile matters.

J. Ash Content

A good, activated carbon must have low ash content [39], [40]. A small increase in ash content causes a decrease in adsorptive properties of activated carbon. With carbonization temperature increase, ash contents of the samples increase. [41]. Ash content can lead to increase hydrophilicity and can have catalytic effects, causing a restructuring process during the regeneration of used activated carbon [42]. The result in Table IV shows that ash content in all the samples is less,

suggesting the fact that the raw material used can be a good source of activated carbon.

K. Fixed Carbon

The fixed carbon of two different carbons activated by HNO_3 and H_3PO_4 shows that the percentage of fixed carbon is higher in the carbon activated by HNO_3. Thus, in the present case activation by HNO_3 seems to give a better activated carbon product. Details about the result are given in Table IV.

TABLE IV: VALUES OF PROXIMATE ANALYSIS OF THE SYNTHESIZED ACTIVATED CARBONS

Samples	BVC (HNO_3)	BVC (H_3PO_4)
Moisture Content %	4..2	2.5
Volatile matter content %	35.7	46.3
Ash content %	1.2	2.4
Fixed carbon %	58.9	48.8

L. SEM Analysis

There are larger numbers of pores present in the carbon activated by Nitric acid (HNO_3). The carbon activated by phosphoric acid (H_3PO_4) results corroborates the results obtained from iodine number where iodine number of HNO_3 activated carbon was found to be greater than the H_3PO_4 activated carbon. The formation of a well developed porous structure consisting of both micro and macropores in a uniform pattern was observed more with BVC (HNO_3).

M. Fourier Transform Infrared Spectroscopy (FT-IR)

The results for FT-IR of the two different carbons activated with HNO_3 and H_3PO_4 are presented in Fig. 4 and 5. The band at around 3550-3100 cm^{-1} is due to the absorption of water molecules as result of an O-H stretching mode of hydroxyl groups and adsorbed water [43]. Bands at 2920-2450 cm^{-1} are due to BVCν_s(C-H) and ν_{as}(C-H) vibrations (s=symmetric, s=asymmetric). The C=O vibration near 1821-1615 cm^{-1} could be due to carboxylic acid, aldehydes, ketones, esters, and lactones groups. The ν(C=C) vibration mode at about 1510 cm^{-1} is probably due to stretching vibration of C=O moieties of conjugated systems or aromatic ring stretching coupled to highly conjugated carbonyl groups [44]. The bands in 1416 and 1419 suggest the existence of some aliphatic species on the carbons [45]-[47]. While the bands at 1158, and1125 cm^{-1} are probably due to C-O stretching bonds in phenols, ethers, lactones [52]. The formation of C-O stretching of oxygenated groups may be attributed to redox reactions of incorporated HNO_3 and H_3PO_4 with carbon during the chemical treatment. The band at wave number below 925 cm^{-1} may be related to out-of-the-plane bending modes [48].

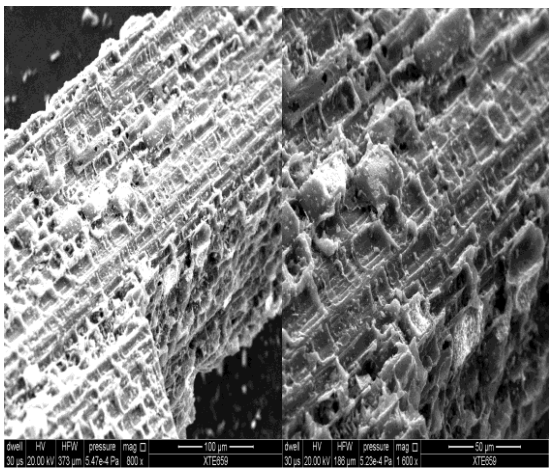


Fig. 3. SEM micrograph of BVC (HNO_3) at 800x and 1600x magnification.

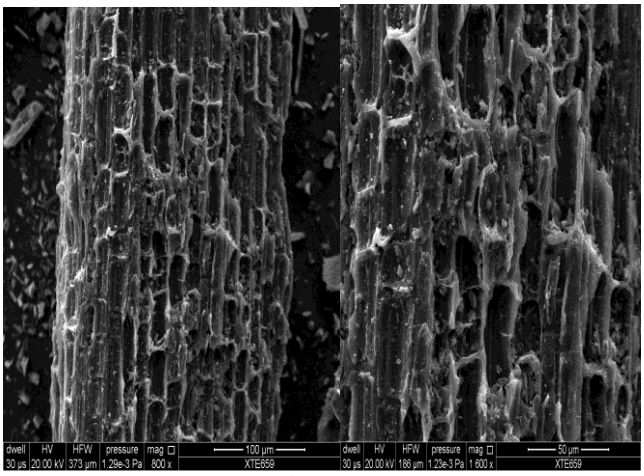


Fig. 4. SEM micrograph of BVC (H_3PO_4) at 800x and 1600x magnification.

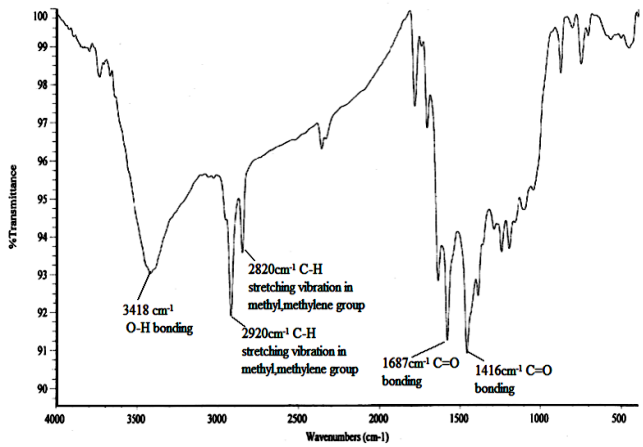


Fig. 5. FTIR spectra for BVC (HNO_3).

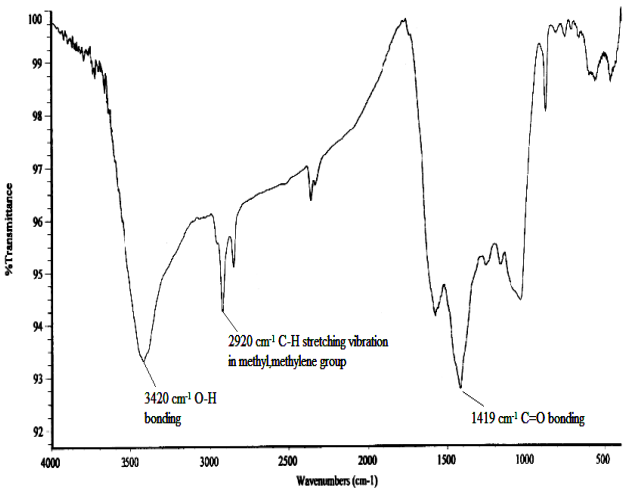


Fig. 6. FTIR spectra for BVC (H_3PO_4).

IV. Conclusion

Physical characterization of the synthesized adsorbents shows activation by HNO_3 is better than H_3PO_4 for a given biowaste material. This is well supported by the fact that BVC (HNO_3) has a high iodine number indicating the acid treatment of activated carbons from nitric acid brought a great amount of surface oxygen groups of acidic nature. However, both the synthesized adsorbents have higher apparent densities which provide greater volume activity and hence better quality of activated carbon. Matter soluble in water was negligible for both the adsorbents, these low values indicate that the prepared activated carbon adsorbents are well suited for ground and surface water analysis as it may not alter the physical properties of water. BET studies indicate a high value for BVC (HNO_3) which is a very important parameter because the particle size and surface area plays an important role in adsorption. Studies on proximate analysis shows both the synthesized adsorbents have less moisture, ash content and volatile matter which suggests an extremely high surface with a maximum adsorption capacity. The statement is well supported by the SEM studies where the SEM micrographs suggest BVC (HNO_3) had greater number of pores than other adsorbents under study. The spectroscopic data shows a sharp peak at 1687 and 1678 cm^{-1} for BVC (HNO_3) and BVC (H_3PO_4). This corresponds to carbonyl functional group, thus indicating oxygen functional group on the surface of the adsorbents which enhances the adsorption property of Bamboo activated carbons. The determination of these properties may be helpful in knowing the character of the adsorbents in general and their use in particular. The chemical structure of the activated carbon was found to be influenced markedly with its activation scheme. These activated carbons are being used for the removal of trace elements like Pb, Mn and organic dyes from aqueous phase as adsorption.

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Conflict of Interest

Authors declare that they do not have any conflict of interest.

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