Original Research Article

Preparation and Characterization of Adsorbent Carbon Derived from *Cocus nucifera* at an Elevated Temperature

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A B S T R A C T

Coconut shells were used as a raw material to produce powdered adsorbent carbon of size less than 2mm. The pH, electrical conductivity, proximate analysis (moisture content, volatile matter, ash content and fixed carbon content), ultimate analysis (Carbon, Hydrogen, Nitrogen and Sulphur content), bulk density, particle density, total organic carbon and yield (percentage recovery) were analyzed as per the standard procedures. The raw material of about 20 kg was converted to adsorbent carbon of about 6 kg through thermochemical conversion in the absence of oxygen. The produced carbon was rich in carbon (91.27 percentile), with least 1.50 percentile of ash content and this attribute figures out the nature of material with its lower inorganic content and high fixed carbon content which is ingrained to its organic nature.

Introduction

Carbon particles/fibres own exceptional properties. Agricultural products are rich in carbon contents and are budding source for carbon production. They are cheap, easily available and renewable. These factors make it to be more potent than any other material. Thermochemical processes that converts the carbonaceous materials to char (fixed carbon), with enhanced surface area and adsorptive power is said to be activated carbon and the process, carbonization(Bello, 2016).

The use of activated carbon has gained attention on an industrial scale, which includes the purification of gases, removal of organic pollutants from water, as catalysts in some catalytic processes and in the electrochemical devices as electrode materials. Although the activated carbon was the first recognized adsorbent and is still used in industry, the development of appropriate methods to make them and the understanding of their porous structure still continue. Various carbon rich materials are being used to produce activated carbon, such as sugarcane bagasse, nutshells, forest residues, tobacco. The availability and abundance of

agricultural residues make them a good source of raw materials. The coconut shells have no little or no economic value and their disposal is not only costly but cause environmental problems (Li *et al.,* 2008). Since, the waste generated by the agricultural sector is either left with no use, therefore the concept of utilizing it in an effective manner can be a great part of reducing its quantity. The conversion of coconut shell to activated carbon would add a value to these produces and suits to be the cheap and best alternative for other carbon sources.

Adsorbent Carbon from *Cocos nucifera* (Coconut shell) influenced by raw material and production of coconut shell based activated carbon is limited to South India mainly because of concentration of coconut production. The town Pollachi in the shadows of Western Ghats has ambient conditions for the growth of coconut trees. One of the major challenges associated with adsorption using activated carbon is its cost effectiveness. Researches in the recent past have mainly focused on the preparation of the activated carbon from agricultural waste materials as an alternative for the commercial activated carbon (Horsfall, 2007).

Materials and Methods

Collection of raw materials

Cocos nucifera (Coconut) shells was collected from various parts of Pollachi as a raw material for the production of adsorbent carbon and then pretreatment was carried out before producing activated carbon.

Pre-treatment of raw materials

The coconut shells were sun dried for about 8-12 hrs for the complete removal of moisture content present in it. The dried shells were then sorted and packed in zip lock cover for further process. This material stands to be the precursor for the further activation under the exposure of various atmospheric conditions.

Carbonization method

The biochar production was carried out in a slow pyrolysis unit as shown in figure 1, where it is a double walled cylindrical chamber with two hollow portions covered with charcoal of shells in the smaller part and dried Coconut shells of about 20 kg in the bigger part. Above all, there exist a narrow chimney along with the lid which helps in removing the exhaust and preventing the formation of ash due to excess heat inside. This setup constitutes a pyrolytic chamber wherein a huge biomass quantity can be converted to biochar under high temperature. The dried shells were then exposed to 450°C in the chamber resulting in carbonized shells called biochar with a high amount of fixed carbon. The pyrolysis was carried out continuously for 2 hours without any disturbance and removal of chimney. After completion of the process, when the unit was cooled to its normal temperature, the chimney was removed and the lustrous and good conditioned shells of about 6 kg were removed from it. There was 30 % yield recovery from 20 kg of Coconut shells. The adsorbent carbon was broken into small pieces, crushed using a wooden hammer, sieved to obtain a size less than 2 mm (Fig. 2) and stored in hot air oven at 60°C for studying its characteristics.

Results and Discussion

The adsorbent carbon produced is needed to be studied for understanding the potential powers and stability when compared to other adsorbents. The initial characteristics/ parameters such as pH, electrical conductivity, proximate analysis (moisture content, volatile matter, ash content and fixed carbon content), ultimate analysis (Carbon, Hydrogen, Nitrogen and Sulphur content),

bulk density, particle density, total organic carbon and yield (percentage recovery) were analyzed as per the standard procedures and shown in table 1.

Carbonization

For adsorbent carbon to have desired properties, the temperature should be maintained where carbonization takes place. The carbonization influences the molecular architecture of carbonized material. Disturbances in the elementary microcrystalline structure by the presence of imperfect or partially burnt off carbon layers changes the arrangement of electron cloud in the carbon skeleton. As a result, unpaired electrons appear and the condition influences the adsorption properties of the activated carbon, especially for polar and polarisable substances (Ekpete *et al.,* 2011). The temperature of 450°C was chosen for the production of carbonized shells. It was observed that if the temperature increases, there is increase in ash content and huge lose of carbon was noticed.

pH and EC

The pH and EC of material was analyzed using pH meter (M/s. Elico, India) and Conductivity meter (M/s. Elico, India) was found to be 8.79 and 1.70 dS m^{-1}, respectively. Okieimen (2007) and Ahmedna (2007) have reported that pH in range of 6 – 8 is acceptable for carbon in its application purpose. The measured pH is slightly higher than the above said value, which is acceptable.

Bulk density and particle density

The bulk density and particle density are physical properties which determine its filterability character and it was found to be 0.51 g cm^{-3} and 0.06 g cm^{-3}, respectively. The

bulk density 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 (Okieimen (2000). It was determined by Okieimen (2000) that generally 0.5 g/cc is adequate in sugar decolourization, which states the produced adsorbent can be used as filter.

Total organic carbon

The total organic carbon was found to be 86.22% which indicates its higher carbon content. The Coconut shells are biodegradable and organic in nature, upon carbonization the shells are thermo-chemically converted to carbon, with less ash and moisture content.

Proximate analysis (moisture content, volatile matter, ash content and fixed carbon content)

The proximate analysis results were given in table 2. The moisture content has no effect on adsorptive power unless it increases the weight and hinders the porous nature. The results indicate that 1.50 % of moisture content (by mass) was found in the produced adsorbent carbon because of complete removal of moisture through evaporation and only 1.35 % of ash content (on dry basis, by mass) was found in it which means almost all the material was converted to carbon. The ash content affects the adsorbent by reducing its overall activity and efficiency of reactivation. Lower the ash content better is the adsorbent quality and it indicates smaller particle density which means the material is suitable for adsorbent in any of the column or fixed bed reactor (Ekpete *et al.,* 2011).

Ultimate analysis (C, H, N, & S)

The ultimate analysis results were given in table 3 which indicates that carbonization temperature manipulated the properties of

adsorbent with a higher Carbon percentage of about 91.27 % followed with 3.12 % Nitrogen, 0.48 % Hydrogen and with zero percentage of Sulphur content.

Table.1 Characteristics of Adsorbent Carbon from coconut shells prepared at 450°C

S.No	Property	Coconut shell
1	pH	8.79
2	EC (dS m^{-1})	1.70
3	Bulk density (g cm^{-3})	0.51
4	Particle density (g cm^{-3})	0.06
5	Total organic carbon (%)	86.22
6	Yield (%)	30

Table.2 Proximate analysis

S.No	Property	Coconut shell
1	Moisture content (%)	1.50
2	Volatile matter (%)	79.57
3	Ash content (%)	1.35
4	Fixed Carbon (%)	17.58

Table.3 Ultimate analysis

S.No	Property	Coconut shell
1	Carbon (%)	91.27
2	Hydrogen (%)	3.12
3	Nitrogen (%)	0.48
4	Sulphur (%)	0

Figure.1 Pyrolysis unit

Figure.2 Adsorbent prepared through carbonization process
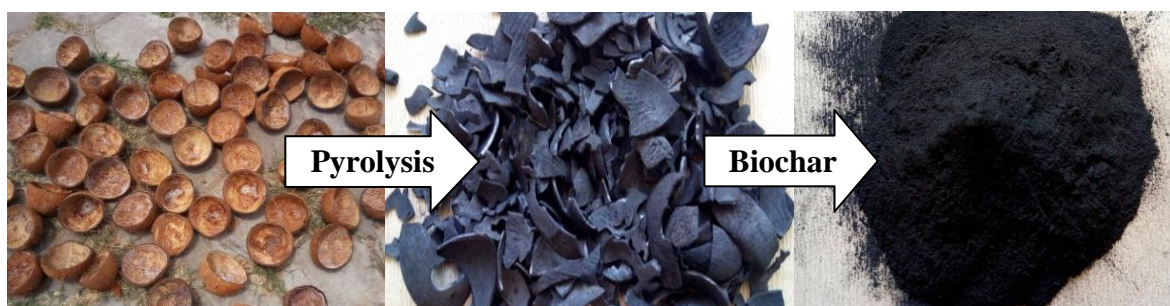
In conclusion, the produced adsorbent carbon is rich in carbon percentage. It can be well utilised for activation to enhance its textural properties, surface area and porosity. The Coconut shells are best alternative against commercial activated carbon because it is accessible and cheap in south Indian states. It can be a beneficial product for the improvement of farming community in marketing sector and stays a perfect part in waste water treatment systems at the industrial level.

Acknowledgement

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