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Production and evaluation of activated carbon from palm kernel shells

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Abstract

The Shell activated carbon for activated carbon. Activation of char prepared at 600 C. Activated carbon prepared with high temperature char had a significant amount of microspore volume. For all carbonization rates, both microspore and macrospore volumes showed maximum values of carbon burn-off. Only a small amount of mesoporous was developed in the initial stage of activation. However, there has been a rapid development in mesoporous was observed. The pattern has been shown. Therefore, the voracious interest for energizes, eco-friendliness and execution assurance and calls for natural well-disposed elective fills sources, while not over depending on petroleum derivatives. The point of this work was to deliver carbonized carbon from palm kernel shells (PKS) via carbonization strategy at temperature of 600°C. The outcomes demonstrate that the AC created from PKS upon 2 days' corrosive impregnation pursued by carbonization periods, purged both water bodies superior to anything the others on decrease of microbial and smaller scale pollution substance of the water bodies. The ramifications of the outcomes demonstrate that generation of the carbon from PKS is esteem expansion to oil palm handling, lift to the national economy and constructive natural effect to the general population that produce and use PKS. Thus, unique thing conclusions, for instance, bioenergy and bio-broil age for adsorption purposes from palm partition shells, are enabled in system endeavours as against the sole traditional start for warmth creation.

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Keywords: activated carbon, palm kernel shell, carbonization, and porosity.

Introduction

The activated carbon (AC) is the term used to represent a group of absorbing substances of crystalline form with large surface area (1 g of AC has a surface area in excess of 500 m2) and internal pore structures which make the AC more efficient; it is a commonly used absorbent for removal of a wide range of pollutants from wastewater. Numerous activities of men including driving, control age and creation of gear, in the advanced age are fills subordinate [2]. Thus, the voracious interest for energizes, eco-friendliness and execution certification and calls for ecological well-disposed elective fills sources, while not over depending on petroleum products [4]. Palm Kernel Shell (PKS), as a waste result of oil factory which presents extensive natural issue as far as transfer, has been utilized in various applications. PKS is a monetary and naturally practical crude material with potential for sustainable power source industry. An examination on the bio-vitality capability of PKS found higher warming estimation of PKS on a dry and dry fiery debris free premise utilizing bomb calorimetric strategy as 22.94 and 25.75MJ/Kg. Also, different specialists have revealed the warming estimations of PKS [9]. Carbonized carbons are generally utilized as adsorbents in gas and fluid stage partition forms, filtration of items and water cleaning activities.

A standout amongst the most critical fields as far as utilization is in water and wastewater treatment, where Carbonized carbons with a moderately high surface zone and a very much created porosity are required. Normally the generation of Carbonized carbons includes two stages1: the carbonization of the crude materials pursued by a high temperature actuation, at 800-1000 °C, of the subsequent singes [1]. Palm-oil development in Nigeria has appeared monetary hugeness with its extending market request at a normal development rate of 15% per year. Extension of the palm oil industry was trailed by the age of huge measures of results at ranch grounds, oil press and refineries. It has been assessed that the squeezing procedure delivers around 292,367 tons of palm monocarp fiber, 157,428 tons of palm-oil shells and 742,163 tons of void natural product clusters as waste in 1997 [3]. Business procedures to deliver Carbonized carbon utilized an assortment of crude material including peat, coal, wood and coconut shell.

Among these, palm piece shell is the fascinating crude material due to its colossal sums as side-effects in palm oil industry. From proximate investigation, it was seen that palm-oil shells have properties like coconut shell however palm-oil shell has more powder than coconut shell and BET surface region demonstrated that palm-oil shell has higher number of outer pore than coconut shell, so palm-oil shell is probably going to be a forerunner for the generation of Carbonized carbon. Transformation of the palm-oil shell to esteem included item, for example, Carbonized carbon will specifically take care of part of the natural issues and transforming the result into an asset for another industry [5]. In oil palm preparing, palm portion shell (PKS) is generally viewed as waste despite the fact that it is normally utilized as fuel for cooking and in evaporator shooting amid palm oil handling. Most occasions when people produce more PKS than they can promptly utilize, they pile up the rest of rot after some time in an open stockpiling [14]. By this the warming worth is generally decreased along these lines debasing the PKS. An elective utilization of PKS which is financially reasonable is the production of good quality Carbonized carbon because of its high thickness, high carbon and low slag substance [6].

Many Carbonized carbons from carbonaceous biomass have been created and assessed utilizing diverse strategies [2]. Palm kernel shells are squander results of oil palm. Verifiably, the cause of the oil palm could be followed to West Africa, with Nigeria, as the main cultivators of oil palm during the 1950s and late 1960s [9]. Different nations, particularly in the Asia sub-locale, for example, Malaysia and Indonesia presently develop oil palm as a central money crop produce [10]. The creation of palm oil from the organic product cluster produces a ton of strong waste item on an extensive tonnage.

These squanders may originate from the palm organic product fiber, the palm kernel shell and the unfilled natural product bundle [7]. The use of palm portion shell for warm vitality creation by ignition of the palm part as a strong fuel mass is very much archived in the written works. Pot heaters are the most seasoned and least expensive sort of heater, utilized in foundry. Fundamentally the cauldrons are made of high temperature opposing materials for example graphite pot, the heater can be terminated by strong energizes, fluid and vaporous fills a few works have been done on assessment and execution of a portion of these powers for pot heater [11]. Removed monocarp fiber (or exocarp) and natural product shell (or endocarp) are two noteworthy strong squanders from oil palm plants. Gather season in the leaves stacks of farming waste on uncovered land and in canals, this squanders comprises high condition difficulties, being one of the significant oil palm makers on the planet, around two million tons (dry weight) of shell and one million tons of extricated fiber are produced every year [8]. There is have to change over our inexhaustible biomass from oil palm industry make the oil palm shell to get crude material for Carbonized carbon creation. The wide target of this examination is the creation of Carbonized carbon from palm portion shell, to accomplish this investigation, the accompanying explicit destinations will be done: (I) Collection and cleaning of palm kernel shell. (ii) Carbonization of the examples. (iii) Comparing results with literary works. These days, the assets of hardwood are turned out to be constrained and the hardwood cost is over the top expensive. Subsequently, palm kernel shell can be the elective crude material to supplant the hardwood to deliver the Carbonized carbon [13].

Also, the earth can be shielded from an unnatural weather change impact because of logging exercises. Besides, the Carbonized carbon can be utilized in water filtration framework through carbon adsorption so as to get perfect water to humankind. This is on the grounds that the Carbonized carbon has higher adsorption ability to adsorb shading, taste, smell, synthetic concoctions (Cd, Pb and Cr) and substantial metal (Mg and K) because of its propensity of collaboration of components on the outside of Carbonized carbon [11].

Oil Palm Kernel Shell

In oil palm industry, oil palm is produced in 42 countries worldwide on about 27 million acres. Average yields are 10,000 lbs/acre, and per acre yield of oil from African oil palm is more than 4-fold that of any other oil crop, which has contributed to the vast expansion of the industry over the last few decades [5]. In view of the above table, Malaysia is among the world's best makers of palm oil with the current planted zone is growing to around 4.5 million hectares. This is has demonstrated that the wealth of oil palm that will create extensive amount of biomass of oil palm. The biomass of oil palm can be reuse by including the added substance that will deliver great esteem included item. One of case of oil palm biomass is oil palm piece shell (endocarp) [17].

Table 1: Top 10 Countries (% of world production)

No.	**Country**	**No.**	**Country**
1.	Malaysia (44 %)	6.	Cote d’Ivoire(1 %)
2.	Indonesia (35 %)	7.	Ecuador (1 %)
3.	Nigeria (6 %)	8.	Cameroon (1 %)
4.	Thailand (3 %)	9.	Congo (1 %)
5.	Colombia (2 %)	10.	Ghana (1 %)

The oil palm piece shell can be expended in the creation of Carbonized carbon. The choice of oil palm kernel shell to create the Carbonized carbon must be chosen by its thickness of shell; endocarp. Also, the oil palm portion shell must be acquired from 8 years of age oil palm trees to guarantee that the endocarp is thick enough [15]. The endocarp is fluctuating in thickness, with dura types having thick endocarps and less monocarp, and tenera sorts the inverse. By picking the dura sorts of oil palm kernel shell, the

Carbonized carbon can be better in quality. By utilizing these oil palm biomass, the benefit for the maker of oil palm industry can be multiplied and straightforwardly produce Malaysia economy [5]. Below are the characteristics of oil palmorig in that contribute the selection of oil palm kernel shell.

Table 2: Characteristics of Dura oil palm types

Features	**Percentage**
Mesocarp	20-65%
Shell thickness	20-50%
Seed thickness	4-20%

Table 3: Characteristics of Tenera oil palm types

Features	**Percentage**
Mesocarp	60-96%
Shell thickness	3-20%
Seed thickness	3-15%

Materials and Methods

Materials

The chemical method for creating activated carbon was utilized utilizing palm bit shell as the crude material. Five diverse impregnation proportions were utilized at room temperature and at 85 °C and the examples carbonized at between 600 °C and 800 °C. The impact of these fluctuating working parameters on yield and nature of activated carbon were examined. The quality parameters of the portrayed activated carbon were contrasted with quality parameters of actuated carbon utilized in the business. Pyrolysis of palm portion shell were explored utilizing the pyrolysis gear [16,18].

Components of the Pyrolysis Equipment

The components of the pyrolysis equipment are as follow: electrically operated furnace, retort, condensate receiver, pressure gauge, gas cylinder, pyrometer, contactor, gas collection unit, ice bath, galvanized iron hose, rubber gasket, clips, thermostat, heating element, bolts and nuts, lagging components, weigh balance, stopwatch and moisture content extraction oven.

Description of Major Pyrolysis Components

The paralyzer is the equipment used for converting biomass into useful fuels in the absence of oxygen. The major components are discussed as follow:

Metal Furnace: The furnace was constructed using a metal sheet made of mild steel of high heat resistance; the complete metal furnace. The furnace consists of the following;

- Galvanized sheet metal: It serves as a casing or housing for the furnace.
- The furnace: Has four tires that make it to be mobile.

- Pyrometer: It is fixed to the furnace to indicate the temperature at which pyrolysis is taking place.

- Contactor: This is used to maintain the specific temperature at which pyrolysis is taking place.

- Clay: The clay serves as a heat retainer to the generated heat by the heater. It is used because of its low thermal conductivity.

- Glass Fiber: It prevents or it minimizes heat transfer from the inner part to the outer. It is lighter in weight, thereby reducing the total weight of the whole furnace.

- Heater Band: The function of this is to supply the necessary heat needed for the pyrolysis process.

- Retort: The retort is a cylinder container which contains the residues to be paralyzed and is fabricated using mild steel. Mild steel is used because of its high melting point (1400-1600 °C), tensile strength, good machinability and good resistance to corrosion.

- Gas Collection Unit: The gas collection unit is the unit which receives the non-condensable gases from the condensable receiver structure. It is fabricated with galvanized sheet metal because of its good welder ability, bursting, good machinability, heat resistance and corrosion resistance and it is readily available in the market.

- Condensate Receiver: The gas coming from the heated material in the furnace is condensed in the condensate receiver which on it is a pressure gauge to know when the pressure in the condensate receiver is increasing.

- Gas Cylinder: The gas cylinder serves as storage for gas it receives from the gas collection unit. It is connected to the gas collection unit in order to collect the filtered gas from the gas collection unit.

Raw Materials Preparation and Analysis

Production of activated carbon

The palm kernel shell samples will be sourced from Uchi market in Africa. The following steps are taken for the carbonization process. The palm kernel shell was cleaned from other soil material. The palm kernel shell was crushed into smaller sizes. It was then sun dried. The palm kernel shell was weighed using a sensitive electronic weighing balance and recorded. The palm kernel shell was then loaded into the retort. The furnace was switched on and allowed to reach the temperature of 900 °C. The retort was then placed into the furnace and closed. The PKS was allowed to burn for 55 minutes. The retort was then brought out of the furnace after 55 minutes and allowed to cool for about 3-5 minutes before unloading the retort. The charcoal formed was weighed using an electronic weighing balance and sealed in a nylon to prevent contamination and inlet of oxygen (O2) [6,19].

Carbonization of precursor was carried out at a temperature of 600 °C, for palm kernel shell, the carbonization was achieved in a furnace for 30 minutes. The palm kernel shell was cleaned from soil. The palm kernel shell was crushed into smaller sizes. It was then sun dried. The palm kernel shell was weighed using a sensitive electronic weighing balance and recorded. The palm kernel shell was then loaded into the retort. The furnace was switched on and allowed to reach the temperature of 600 °C. The retort was then placed into the furnace and closed. The palm kernel shell was allowed to burn for 30 minutes. The retort was brought out of the furnace after 30 minutes and allows to cool for about 3-5 minutes before unloading the retort. The charcoal formed was weighed using an electronic weighing balance and sealed in a nylon to prevent contamination and inlet of oxygen (O2).

Carbonization and Chemical Activation The sample materials were carbonized in the absence of air in a muffle furnace at a temperature of 550- 700 °C for 30 minutes and the 600 g of carbonized sample was mixed with an aqueous solution of phosphoric acid (activating agent). The mixture was then subjected to heat at a temperature of 120 °C for 3 hours to vaporize the water.

Activation process for Palm kernel shell

In the initiation procedure of palm kernel shell, two substance are utilized are Phosphoric corrosive (H3PO4) and Potassium hydroxide (KOH). The volume of the Phosphoric corrosive weakened was 6.8 cm3 or 0.0068 dm3 in distil water, utilizing condition (2.1) C1V1 = C2V2 (2.1) For the Phosphoric Acid (H3PO4) figuring, Concentration of the corrosive C1= 14.7 M, Volume of corrosive V1=?, Final convergence of the corrosive C2 =0.1 M, Final volume of corrosive V2= 1 dm3, 14.7 × V1 = 0.1 × 1. V1= 0.0068 dm3 = 6.8 cm3 Since, 1 dm3=1 liter For the measure of Potassium Hydroxide (KOH) required: The mass of the KOH to be break down in 1 liter of distil water was 5.87 g. In this way, for the corrosive 6.8 cm3 of H3PO4 was weakened with 1 liter of water and for the base (KOH) 5.87 g was disintegrated in 1 liter of water. After the carbonization of the materials (Palm portion shell). The Materials are enacted utilizing Phosphoric corrosive (H3PO4) and Potassium Hydroxide (KOH) which are weakened with water to diminish the convergence of the Acid (H3PO4) and Base (KOH). About 6.8 cm3 of (H3PO4) was weakened in 1 dm3 of water and about 5.87 g of KOH was weakened in 1 dm3 of water. The accompanying advances are taken for the charcoal enactment. The charcoal of the Palm piece shell were absorbed H3PO4 for 24 hours. The actuated Carbon was dried in an ovum for around 1 hour for every material (Palm bit shell) to acquire the underlying mass of the material before enactment. Beginning mass of palm kernel shell are 688.21 g, 539.89 g, 482.53 g and 707.37 g, individually. The enacted charcoal was then washed with water and KOH, to kill the material been initiated. The initiated charcoal was spot outside for around 3 hours to vanish the dampness in it. The enacted charcoal dried in an ovum for 1-2 hours with a temperature of around 170 °C. The actuated charcoal was grounded to a littler size and after that, was pressed in a dry holder.

Characterization of the Activated Carbon

Proximate Analysis – Moisture Content Determination

The aluminum dish was first weighed, with the first one weighing 14.57 g, second dish weighing 14.46 g and third dish weighing 15.27 g. A mass of 3 g of the palm kernel shell was added to each of the three dishes and they were reweighed again, before drying for a time limit of 30 minutes. After 30 minutes the dishes are weighed again until the weight of the dishes contain the palm kernel shell are stable. Also, a mass of 5 g of palm kernel shell was added to the dishes, before drying for 30 minutes and it was reweighed again. After the final weight has been determined, to obtain the actual mass of the material (palm kernel shell) weight of the aluminum dish is subtracted from the final weight. Actual mass = weight of dish – final weight after dry Therefore, the moisture content is calculated using, using equation (2.2); (2.2) Where, A – Mass of the sample before drying, (g) and B – Mass of the sample after drying, (g) Procedure for iodine solution test on activated carbon Iodine indicates the micro pore (0 - 20 A) content in the activated carbon. Reagents used in the iodine value test are as follow:

Step 1: 10 cc of 0.1 N Iodine solution was put into a conical flask and drops of starch solution was added to it. The pale yellow color of iodine solution turns blue. Titration of the formed solution was done with 0.05 N Sodium Thiosulphate (NaS2CO3.5H2O) till it becomes colorless.

Step 2: 0.1 gm of Activated carbon was weighed accurately. It was poured into a dry flask. 10 cc of 0.1 N Iodine solution was added into the flask containing the activate carbon. The flask was shaken properly for 4 minutes and then filtered. The filtrate was the titrated against standard Sodium Thiosulphate (NaS2CO3.5H2O) using starch as indicator. Burette reading corresponds to A was taken. In calculating the Iodine valve (ID) using equation (2.3) ID = C × Conversion factor (mg/gm) (2.3) Where Blank reading = B and Burette reading = A (2.4) Iodine adsorption number. This is the most fundamental parameter used to characterize activated carbon performance. It is a measure of activity level (Higher degree indicates higher activation), often reported in mg/g (with typical range of 500 – 1200 mg/g). It is a measure of the microspore content of the activated carbon (values > 0 to 20 AO, or up to 2 nm) by adsorption of iodine from solution. It is equivalent to surface area of activated carbon between 900 m2/g and 1100 m2/g.

Surface Area

The specific surface area of activated carbon was estimated using sear method by agitating 1.5 g of activated carbon samples in 100 ml of dilute hydrochloric acid at pH= 3. Then a 30 g of sodium chloride was added while stirring the suspension. The volume was made up to 150 ml with deionized water. The solution was titrated with 0.1N NaOH to rise the PH from 4 to 9 and volume V recorded. The surface area according to this method was calculated as:

$$S = 32V - 25$$

Where S = surface area of activated carbon, V = volume of sodium hydroxide required to raise the pH sample from 4 to 9. The value 32 in equation (2.5) is a dimensional constant measured in per centimetre (cm-1). 25 - 32V S.

Results and Discussion

Carbonization

The thermal degradation of organic matter that yield high carbon in the absence of is known as carbonization or pyrolysis. The process is also commonly called coking because it has large volume use to prepare coke for black furnace. The main objective for carbonization is to produce fuel with a smokeless flume, remove part of the moisture content organic matter, that hinder combustion process, palm kernel are yield carbon with a fuel mass that can be for nonferrous firing. The dull brownish shell of palm kernel shell on carbonization give a brittle, black mass of solid eventual by the pyrolytic action under a controlled atmosphere.

Heating Value of Palm Kernel Shell

The calorific value/higher heating value of the carbonization palm kernel shell as determined for the fuel mass. The heating value of the palm kernel is considerably greater than those of fire wood, peat and lignite and very much close to that of bituminous cows. Thus it suggests that it could be used as a solid fuel both for nonferrous and ferrous foundry practical boiler heating.

Fuel Energy Content and Flume Temper

Energy content represents possibly the single most relevant properties of a fuel. The standard measure of fuel energy content is the heating value or the calorific value. The heating volume is of practical importance as it gives the basis for comparison of all fuel type irrespective of the source. The heat released from a system is consequently used judged the efficiency of such system. Standard heating value analysis measures the heat reused from the fuel when burned with enough air to fully oxidize the fuel (carbon forms CO2, H2 forms H2O). the air/fuel ratio which gives the masses of air /kg of fuel required for combustion is directly proportional to excess air ratio which also lead to reduction on adiabatic flame temperature. Adiabatic flame temperature defines the temperature of products after all chemical reaction has reached equilibrium and when no heat is allowed to enter or leave the combustion chamber. Each fuel has a unique adiabatic flame temperature for a given amount of air, as the ratio of fuel to air varied the adiabatic flame temperature varies.

Furnace Firing

The carbonization of P.K.S was used to melt scraps of aluminum metal as shown below operated locally. Fabricated crucible furnace. The result showed that the carbonization of palm kernel shell produced good heat for the melting of aluminum scrap plate.

Table 4: Characteristics of Duru oil palm types

Features	**Percentage**
Mesocarp	20 – 65%
Shell thickness	20 – 50%
Seed thickness	4 – 20%

Material Energy and the Environment

The coven burner influence of material development and advances in energy is fast becoming a thing of concern to environment. It is obvious that the environment is both the source and sink for material and energy. It is inevitable that development in both areas would have profound effect on the environment. In this case it would be a negative influence, no energy sources are free completely safe or limitless. The use of palm kernel in on alternative fuel will relieve the high demand for fossil fuel as the main source of energy requirement for solid fuel firing of crucible furnace and other heating needs. It will also remove some of the negative influence caused by the over reliance on the fossil fuel. From this study, the performance evaluation of suitability of carbonized palm kernel shell as a veritable alternative to coal and charcoal. Solid fuels are crucible furnace melting of nonferrous metal and other heating needs showed that the palm kernel shell can be deployed for the aforementioned purpose based on the finding of this research. On carbonization palm kernel were observed to burn with flame the higher heating value.

Conclusion

The present examination demonstrated that palm kernel shell can be adequately utilized as a crude material for the arrangement of actuated carbon for use as water treatment material. The level of sanitization however relies upon time of absorbing phosphoric corrosive and carbonization span. The generation of AC from PKS is esteem expansion to palm oil handling which is a veritable financial movement. The AC delivered after absorbing the feedstock corrosive for 48 and 3h carbonization at 600°C is superior to other people and can be additionally advanced to decide its most significant creation parameters.

Recommendation

Having successfully achieved the objective of this study, the following are therefore recommended:

i. The byproducts of palm oil industries should be converted into useful products apart from using them as fuel for steam generation in palm oil factory. From worthless by-products, they would become activated carbon after having been produced, using one step pyrolysis and steam activation.

ii. Research institutes and government agencies should invest in producing activated carbon as a mass product in the long run.

iii. Further study should be carried out using other agricultural wastes.

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