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STUDY OF THE SPECIFICATIONS OF CARBON PREPARED FROM CARBONIZATION OF FIG LEAVES USING A STRONG BASE

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Abstract. This study investigates the preparation and physicochemical characteristics of activated carbon derived from fig leaves through carbonization and chemical activation using potassium hydroxide (KOH). Fig leaves were selected as a low-cost lignocellulosic precursor, and the effect of different fig-leaf-to-KOH ratios (1:0.5, 1:1, 1:1.5, and 1:2) on the properties of the resulting activated carbon was evaluated. The prepared samples were characterized using iodine number, methylene blue adsorption, bulk density, moisture content, ash content, and pH measurements. Increasing the KOH ratio generally enhanced pore development and adsorption performance while reducing bulk density. The sample prepared at a 1:2 fig-leaf-to-KOH ratio showed the best overall performance, with an iodine number of 1156.1 mg/g and methylene blue adsorption of 224.7 mg/g, together with low density and near-neutral pH. These findings demonstrate that fig leaves can serve as a promising agricultural-waste precursor for producing activated carbon with useful adsorption characteristics. The approach provides a potential pathway for converting biomass waste into a value-added material for environmental and industrial applications.

Keywords: Activated carbon, fig leaves, potassium hydroxide, chemical activation, adsorption, agricultural waste

Introduction

It has been the focus of many research efforts in recent years to try to develop materials that include carbon from agricultural wastes as a more sustainable and economically viable option to fulfill the demand for environmentally friendly materials. In this field, activated carbon has become an important material due to its multifaceted use in water purification, air treatment, catalytic processes, and energy storage technologies. High specific surface area, the highly developed porous architecture and excellent adsorption properties are the main features of its versatility and effectiveness in these given applications.

The utilization of biomass for the advanced manufacturing of carbonaceous materials is on the rise in recent years due to its advantage of low cost, abundant resources, and the mitigation of agricultural wastes, not only in economy but also in the environment. Fig leaves are also one of those promising resources which have a significant amount of carbon-rich lignocellulosic components namely cellulose, hemicellulose and lignin. All these components play role in the development of good carbonaceous structure and high porosity after carbonization and chemical activation process, making them more suitable for using in the production of activated carbon for adsorption application, and in different environmental applications.

There are several unique applications of activated carbon (AC) in comparison to the inorganic adsorbent materials used routinely in adsorption. It is especially used as a catalyst or catalyst support for industry. It also has many applications in environmental pollution control and decolorization processes. Moreover, besides the treatment of contaminated water, activated carbon has been applied for purification of gases and liquids. Furthermore, there are medical applications, such as the adsorption of toxic substances and the treatment of drug and pharmaceutical compound overdoses, as well as many others [1], [2]. In recent years, activated carbon has been produced from all agricultural wastes too [3] which has been used to treat contaminated water using locally available animal bone waste and processed into activated carbon [4]. It has also been developed using other plant wastes such as banana peels [5], coconut shells [6], [7], apricot kernels [8], date pits [9], corn cobs [10], mango kernels [11] and Flower derived High Capacacity porous Carbon Paper [12], [13]. Activated carbon is a carbonaceous material that has an extremely developed pore structure was formed by the carbonization and activation processes. Such as micropores, mesopores, macropores, structural defects, surface functional groups, etc. all play an important role in its adsorption capacity.

Activated carbon is a highly porous carbonaceous material with a well-developed carbonization and activation process. The adsorption capacity is greatly affected by the development of micropores, mesopores, macropores, as well as structural defect and surface functional group. [14]. Typically, activated carbon can be produced in two ways: physical or chemical activation [15].

Methods

Instruments and Equipment Used

a. It operates in the visible region of the spectrum (Spectrophotometer)
b. Electric oven (1000°C)
c. Electric shaker
d. Mortar
e. Desiccater
f. Steel Stainless

Preparation of the Raw Material

The raw material was obtained in its natural dry state and then ground into a fine powder to increase its surface area, thereby maximizing the interaction between the raw material and the carbonizing agent to achieve optimal results.

Initial Carbonization Process

A 10 g sample of the prepared fig leaf powder was mixed with potassium hydroxide (KOH) at different weight ratios (2:1, 1.5:1, 1:1, and 0.5:1, w/w, fig leaf powder) in a stainless-steel container. The mixture was thoroughly homogenized and then heated at 400 °C for 2 hours.

Final Carbonization Process

Then the temperature was raised slowly to 600 °C and kept the second carbonisation stage for 2.5 hours stirring on a shaker which releases the carbonisation gases and volatile compounds. After the reaction period, the reaction container was taken out, and the carbon product was purified and then characterized.

Purification of the Prepared Activated Carbon

The purification process was designed to remove any residual chemicals, oils, greases, and inorganic impurities from activated carbon produced. The carbon material was washed a few times with distilled water in order to wash off the alkaline materials like potassium hydroxide (KOH). This was followed by treatment with 40mL of the 15% hydrochloric acid (HCl) solution for the removal of any possible metal ion and mineral impurities present in the sample. After being treated with the acid solution, a series of distilled water washings were performed to remove any traces of the acid solution.

Next the purified activated carbon was dried in oven at 140 °C. Following drying, the dried material was powdered by using a ceramic mortar and pestle. Last but not least, the processed sample was placed in a sealable container and kept in a sealed environment to prevent atmospheric air and moisture from affecting the sample.

X / M *D=I.N.

Where:

X: Weight of iodine adsorbed by the activated carbon (mg).

M: Weight of the activated carbon sample used.

D: Correction factor.

Measurements Performed on Activated Carbon Samples

Active carbon's external surface area was calculated according to the amount of methylene blue adsorbed from an aqueous solution. For the study of adsorption properties of carbon based materials this technique is widely used. In this technique, 0.1 g of activated carbon was placed accurately in conical flask having 100 mL aqueous solution of methylene blue (20 ppm). This mixture was then shaken for 24 hours on an electric shaker at room temperature for dyeing to adsorb on the surface of the carbon.

If the solution was no longer colored by methylene blue, the solution was again mixed with 50 mL of the methylene blue solution. The process was repeated until a further addition of the solution would not change the colour of the dye appreciably. The activated carbon was then left to settle and the liquid separated out from the solid core. Some of the solution formed was poured into a spectrophotometric cuvette and the absorbance was read at 670 nm.

A calibration curve was established using standard methylene blue solutions with concentrations of 5, 10, 15, 20, and 25 ppm. The absorbance of each standard solution was measured at 670 nm under identical analytical conditions. The calibration curve was constructed by plotting the absorbance values against their corresponding methylene blue concentrations. This curve was then used to determine the residual dye concentration in the solution and evaluate the adsorption capacity of the prepared activated carbon [17].

Determination of Moisture Content

The prepared activated carbon was allowed to cool in the laboratory for 24 hours and then dried in an oven at 140 °C for 2 hours. The sample was then dried and weighed once the sample has cooled down. In order to know the moisture content, the difference of masses of the sample before and after drying was used to determine the moisture content [18] as a percentage.

Determination of Activated Carbon Density
To ensure that the activated carbon completely fills the volume of the flask, a known amount of the carbon was added to a 5mL volumetric flask and gently compacted. The level of the surface of the carbon particles was then adjusted with the leveling mark of the flask. Then a measure of the sample was obtained with an analytical balance and its density was computed from the following equation [18]:
Density = Mass / Volume (g/cm³)
Determination of Ash Content Percentage
Determine the ash content percentage in the ignition residue.Determine the percentage of ash in ignition residue.
A suitable amount of activated carbon (1 g) was weighed and placed in a porcelain crucible and heated in the furnace at 1000 °C for 1.5 hrs till it attains constant weight. Following the heat treatment, the crucible was allowed to cool to room temperature, in a desiccator. After that, the residue left was weighed and the ash percentage was calculated per gram of the sample used [18].
Determination of the pH of Activated Carbon
One-half gram sample of activated carbon was added to the distilled water and shaken for 30 minutes to allow the carbon material to interact with the water. This mixture was then filtered and then measured the pH of the filtered mixture with a suitable pH measurement instrument [18].

Results and Discussion
Activated carbon has a wide range of applications in environmental protection and industrial processes, particularly in air purification, where it is used to eliminate gaseous pollutants and unpleasant odors. Also used in drinking water treatment to remove undesirable odors and selectively recover desirable odors. Furthermore, activated carbon also has a significant application in controlling pollution in the air due to its ability to adsorb oxides of sulfur, nitrogen, and carbon [19]. One of the important applications is the removal of small amounts of radioactive contaminants from nuclear reactors [20], [21], [22]. Activated carbon is highly utilized in wastewater treatment for removing color dyes and organic contaminants from water by its adsorption phenomenon. It's also employed in consuming water purification to remove dangerous pesticides. Moreover, the strong adsorption characteristics has caused many other medical applications such as gas removal, removal of toxic substances and so on apart from its various other industrial and environmental applications [23], [24].
Although modern activated carbon did not come into existence until much later, the use of charcoal for removal as an adsorbent can be dated back to ancient civilizations. In the eighteenth century, scientists started to investigate the adsorptive properties of charcoal, with an emphasis on removing impurities from liquids and capturing gases. These initial studies were the base on which the following carbon preparation and activation techniques were developed, which are based on the use of various carbonaceous precursor materials [25], [26]. Production of activated carbon, as a commercial product, started in the early twentieth century, industrial production in the USA first occurred in 1913. The use of trichlorophenols grew significantly during the late 1920s and early 1930s, and they are now widely used for water treatment applications to remove undesirable tastes and unpleasant odours [27], [28].

In this study, the selection of Fig leaves for producing activated carbon is due to its lignin content and the rigidity of its structure. The activating agent for the dehydrogenation in the preparation was KOH. Various KOH to fig-leaf-powder ratios (from 0.5:1 to 2:1 (w/w)) were examined. Such a mixture was heated to 660 °C, while stirring continuously to obtain the fusion, and the fusion was continued until the material turned black colour. The resulting material was then promptly protected from the effect of air and heated for three more hours at 660 °C. The carbonized product was repeatedly washed with distilled water to remove impurities and finally the wash without inducing any alkaline reaction was test with litmus paper, the wash condition was neutral. This material was then refluxed with an adequate amount of 15% hydrochloric acid (HCl), which removes mineral impurities and ash residue which may be present on the activated carbon during the reaction. The treated material was washed, using distilled water, several times after the acid treatment to remove any traces of the acid. The purified product was subsequently dried for 24 hours and then studied to study the pore type and size generated from alkaline activation. It implies breaking the carbonaceous structural framework and the addition of a dehydrogenation reaction [29]. The density, moisture content, and ash content of the carbonized samples were also measured [30], [31] and the values obtained for these prepared carbonized samples are presented in Table (1).

Table 1. Properties of Activated Carbon Prepared by Modified Carbonization and Chemical Treatment

Sample	Fig leaves: KOH	Iodine No. (mg/gm)	Methylene Blue (mg/gm)	Ash (%)	Humidiy (%)	Density gm/cm^3
1	1:0.5	975.5	41.4	0.63	6.8	0. 32
2	1:1	983.3	73.8	0.9	9.3	0.09
3	1:1.5	1088.9	89.9	0.813	9.9	0.08
4	1:2	1156.1	224.7	1.15	14.0	0.06
B.D.H.		908	90	3.2	0.8	0.325

From the data shown in Table (1), it can be seen clearly that there was a significant increase in development of the porosity and adsorption value of the iodine as the percentage of the activating agent was increased from 0.5 to 2% with respect to the commercial activated carbon. The effectively prepared samples showed large density along with good adsorption performance among the prepared samples and have also put up reasonably high iodine number 908 and methylene blue adsorption value of 90 with respect to the B.D.H. commercial activated carbon. Moreover, the content of ash of the commercial activated carbon was nearly 5 times higher than the prepared activated carbon samples [32], [33].

On the other hand, increasing the amount of the alkaline activating agent led to a decrease in the density of samples (2, 3 and 4). This loss could be due to the large destruction of the carbonaceous structure during the carbonisation process, leading to increasing distance between carbon layers and decreasing mass per unit volume. Thus, the activated carbon produced became less dense with higher amounts of the activating agent [34], [35].

These structural changes were associated with a significant improvement in the adsorption of iodine; sample (4) having the highest adsorption among them, compared with commercial activated carbon. Furthermore, the external surface properties and porosity of the sample, as given by the methylene blue adsorption capacity, was about three times higher than that of the commercial sample [36], [37].

Conclusions and Recommendations

Conclusions

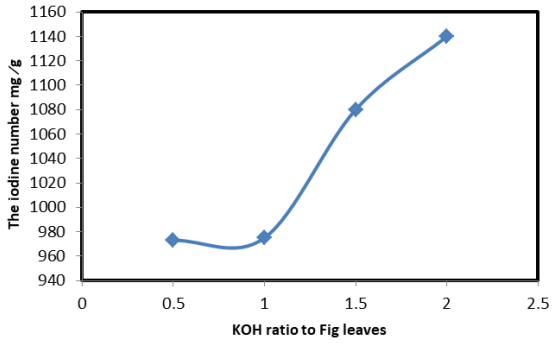
The results obtained in this study indicated that the prepared activated carbon of 4th sample shows good adsorption capacity with the value of 921.31 mg/g, neutral pH and also low bulk density with the value of 0.048 g/cm3. The structure sense exhibits the potential to be a good adsorbent for various applications. Furthermore, when using fig leaf powder as a precursor, it showed a good adsorption activity indicating that fig leaves would be better raw material for the preparation of activated carbon with better adsorption properties.

Recommendations

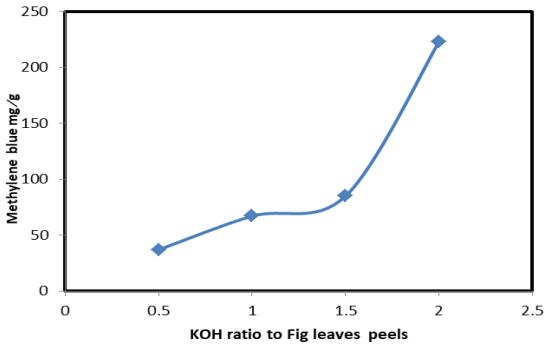
Further studies will be recommended to attempt the following changes to the preparation parameters: optimization of the preparation parameters, improvement of adsorption measurement reproducibility and most importantly, an improved and more economical use of the raw material, particularly on the lower value of fig leaves.

In addition, the possibility of using the prepared active carbon in medical and pharmaceutical industry such as wound materials and adsorption of the gastrointestinal gas is worth further investigation. However, the suitability of these applications will have to be determined by extensive biocompatibility testing, toxicological testing, purity testing and chemisorption testing to certify both the safety and effectiveness of the material.

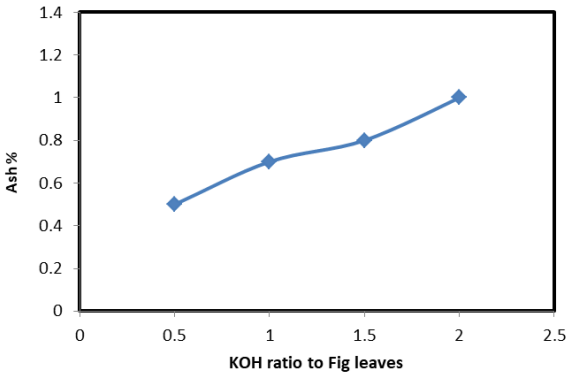
Apart from this, the lack of any S and N containing compounds should be confirmed using proper analytical techniques. About their absence alone, it cannot be said that the prepared activated carbon that has been made for medicines is clinically safe.



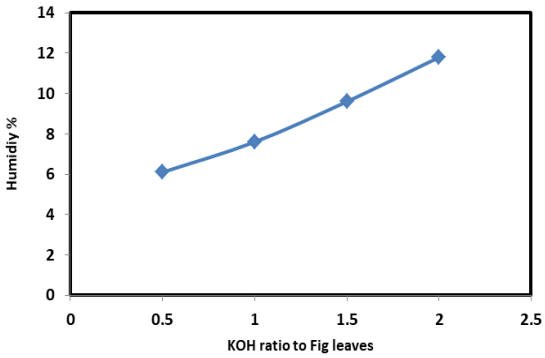
"FIGURE 1",The relationship between the added (KOH)ratio and the iodine number



"FIGURE 2",The relationship between the added (KOH) ratio and the Methylene blue



"FIGURE 3",The relationship between the added (KOH) ratio With Ash content in activated carbon



"FIGURE 4",The relationship between the added (NaOH) ratio With Humidiy content in activated carbon

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