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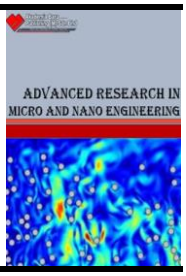

Production of Activated Carbon from Pod Mahogany (*Afzelia xylocarpa* (Kurz) Craib) Activated by using Potassium Hydroxide

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ABSTRACT

This research aims to study the production of Activated Carbon from Pod mahogany (*Afzelia xylocarpa* (Kurz) craib) activated by using potassium hydroxide (KOH) for will be used data as a basis for the possibility of further use benefits in the future. The production process of activated carbon from maca pods consists of 2 steps as the carbonization and the chemical activation process at a temperature of 400 °C and held for 45 min (16 °C/min) under N_2 atmosphere. When finished, take the Maca Mong pod char and grind it through a sieve size 0.3 mm, then store it in a wrap for use in the second step. The second step, is to take crushed Maca Mong pod Charcoal (0.3 mm) 100 g and 300 g of KOH in a ratio of 1:3 (Charcoal: KOH) mixed into 500 ml of distilled water (water Distilled 5ml/g of Char), then heat it at a temperature of 800 °C for 1 hours (heating rate of 16 °C/min) under N_2 atmosphere. The activated carbon (AC) out of the furnace and wash it with distilled water 2 times, slowly adjust the pH value to the neutral value with HCl 1M. When the pH value adjustment is complete, the product was dried in an oven at 110 °C for 6 hrs. Take the AC produced was analysed at the Laboratory. In conclusion, the production of AC from Pod mahogany activated by using KOH in a ratio of 1:3 (Charcoal: KOH) heat it at a temperature of 800 °C for 1 hours (heating rate of 16 °C/min) under N_2 atmosphere. The AC can be applied to a variety of applications, such as a gas storage material and as an adsorption material for wastewater treatment or drinking water purification because AC has an adsorption average pore diameter of 17.4486 Angstrom and BET surface area of 1,007.6692 (m^2/g).

1. Introduction

Activated carbon is a material consisting of carbon as the main component [1]. It must go through the Carbonization process at a temperature range of 300 – 400 °C at the condition of Inert or oxygen limited, to remove tar from charcoal [2,3]. In order to use the obtained char to produce activated charcoal, it must undergo an activation process. Activation can be divided into two methods: first, physical activation, temperature range 700 – 1,100 °C with steam or Inert [4,5] and second, chemical activation, temperature range used 400 – 800 °C, which depends on the most commonly used

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chemicals are H_3PO_4, $ZnCl_2$ and KOH [6-8]. Both of these activation methods have the same goal in order to make the activated carbon porous and form many nanometer cracks. [9-11] The pores of activated carbon serve to absorb water pollutants and air pollution [12] such as copper ions [13], CO_2 [14,15], etc. Common materials used to produce activated carbon include minerals such as lignite [16,17] and agricultural waste such as rubberwood sawdust [18-20], coconut shell [21,22], juniper berries [23], rice husk [24], Palm Shell [25], *Parinari macrophylla* Shell [26], etc.

Mahogany (*Afzelia xylocarpa* (Kurz) craib) or Maca Mong in Thai name, is a deciduous tree. This tree has a height of 30 meters and a maximum trunk diameter of 150 cm. It is found in Thailand. It has been used in various fields such as furniture, wood carving, etc. [27,28]. The pod has a hard shell when the pod is mature and fallen, it will split into 2 halves, inside the pod there are 3-4 seeds, which are oval shaped. The seeds are about 2-3 cm. While these Maca Mong pods are typically left to decompose naturally, there is a lack of reported serious use of mature Maca Mong pods, and no instances have been documented of their application in activated carbon production. Consequently, this study produces activated carbon from Maca Mong pods using the carbonization method and chemical activation with KOH as the activation agent. The generated data will serve as a basis for exploring potential future applications of Maca Mong pods.

2. Methodology

Collected the mature pods of Maca Mong in the area of Rajamangala University of Technology Isan. Surin Campus, Mueang District, Surin Province, Thailand. Cleaned Maca Mong pods with water to remove dirt, and dry them in the sunlight until dry. Then leave it at room temperature and cut it to a size of 2-5 cm packed in plastic bags ready for use in the experiment.

The production process of activated carbon from Maca Mong pods consists of 2 steps as the carbonization and the chemical activation process follows (Figure 1):

The first step is carbonization; take the Maca Mong pod size of 2-5 cm from preparation, to dry in the oven at a temperature of 110 ^oC for 4 hours. When drying is complete, the Maca Mong pod is into Carbonization at a temperature of 400 ^oC, and held for 45 minutes (with a heating rate of 16 ^oC/min) under a nitrogen (N_2) atmosphere. Subsequently, the resulting Maca Mong pod char was finely ground through a 0.3 mm sieve and stored for use in the subsequent step.

The second step is the chemical activation process; take crushed Maca Mong pod Charcoal (0.3 mm.) 100 g and, 300 g of potassium hydroxide (KOH) in a ratio of 1:3 (Charcoal: KOH). This mixture was blended with 500 ml of distilled water, then the mixture was stirred overnight using a magnetic stirrer.

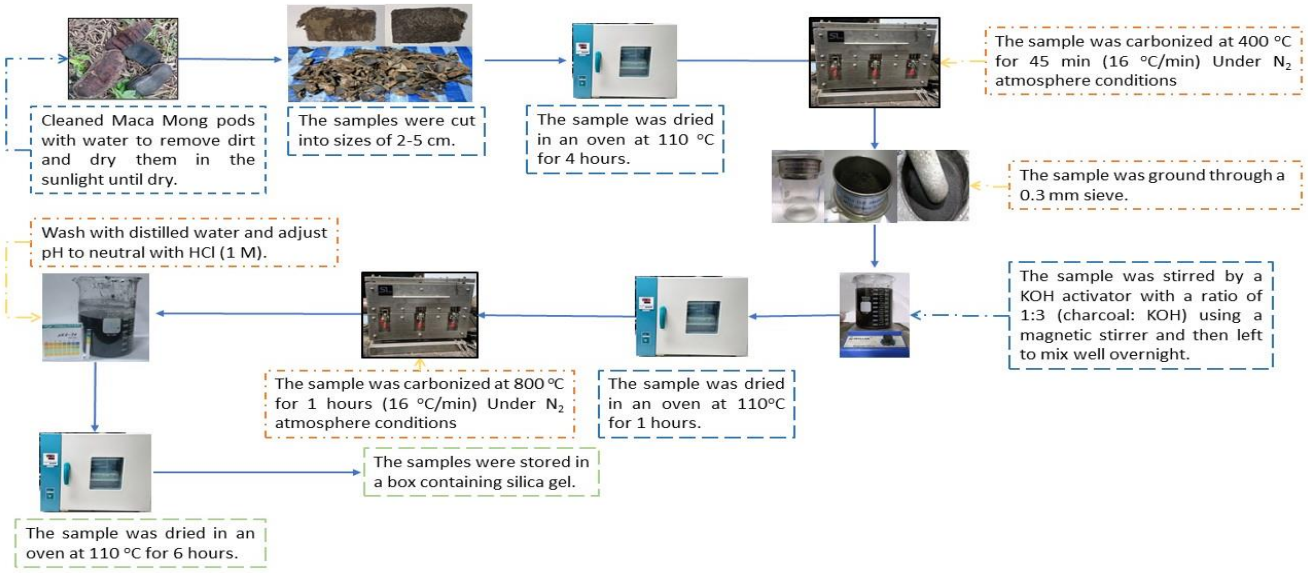

Fig. 1. The process of activated carbon synthesis

Take it dry at a temperature of 110 °C in the oven for 1 hour, with heat it at a temperature of 800 °C for 1 hour (heating rate of 16 °C/min) under a nitrogen (N_2) atmosphere. After the machine has cooled, take the activated carbon (AC) out of the furnace and two washes with distilled water. Then, slowly adjust the pH value to the neutral value with 1M Hydrochloric acid (HCl). When the pH value adjustment was complete, the product was dried in an oven at 110 °C for 6 hours. Finally, the dried product is collected in a sample bag and stored in a sealed silica gel box to prevent moisture (Figure 1) for use in the analysis step.

Table 1
Method analysis of the Maca Mong pod and activated carbon produced (AC)

Parameter	Unit	Method analysis
Proximate		
- Moisture (As received basis)	%wt.	In-house method based on ASTM D3302 and ASTM D7582
- Volatile matter (As received basis)	%wt.	In-house method based on ASTM D7582
- Fixed Carbon (As received basis)	%wt.	In-house method based on ASTM D7582
- Ash (As received basis)	%wt.	In-house method based on ASTM D7582
Ultimate		
- H	%wt.	CHNS/O Analyzer
- S	%wt.	CHNS/O Analyzer
- O	%wt.	CHNS/O Analyzer
- N	%wt.	CHNS/O Analyzer
- C	%wt.	CHNS/O Analyzer
Iodine number (As received basis)	mg/g	Titrimetric method
BET Surface area (As received basis)	m^2/g	Static volumetric N_2 gas adsorption method
Adsorption average pore diameter (As received basis)	Angstrom	Static volumetric N_2 gas adsorption method

The analysis of the activated carbon derived from the Maca Mong pod encompassed various parameters, consisting of proximate and ultimate characteristics, iodine absorption, area size, and pore size. The analysis was conducted using the methods detailed in Table 1, performed at the Central Equipment Center Laboratory, Prince of Songkla University, Hat Yai Campus, Songkla Province, Thailand.

3. Results

The results of the characteristic of Maca Mong pod raw, Maca Mong pod Charcoal and Maca Mong pod activated carbon (AC) have been presented in Table 2-3, outlining the key findings of the analysis.

3.1 Proximate and Ultimate Analysis

The results showed that the proximate analysis value, namely Moisture; Volatile matter; Fixed carbon and Ash of Maca Mong pod raw contains 6.99, 72.19,16.49 and 4.33% by weight; Maca Mong pod Charcoal at 400 ^{o}C (45 min.) was 4.55, 34.44, 49.94 and 11.08 % by weight and Maca Mong pod activated carbon (AC) from Maca Mong pod Charcoal and KOH in a ratio (1:3) at 800 ^{o}C (1 hour) was 11.98, 14.28, 65.44 and 8.30 % by weight respectively (Table 2).

The ultimate analysis value, namely Hydrogen (H), Sulphur (S), Oxygen (O), Nitrogen (N) and Carbon (C) of Maca Mong pod raw contains 4.95, <0.01, 41.19, 0.48 and 43.01 % by weight; Maca Mong pod Charcoal was 3.34, <0.01, 18.00, 1.06 and 63.39 % by weight and activated carbon (AC) was 0.24, <0.01, 6.03, 0.46 and 72.11 % by weight respectively (Table 2).

Table 2
Proximate and ultimate analysis of Maca Mong pod (raw), Char and activated carbon (AC)

Parameter	Maca Mong pod (raw)	Char at 400 ^{o}C (45 min.)	AC (1:3) at 800 ^{o}C (1 hour)
Proximate analysis (elements in % by weight of total composition)			
Moisture	6.99	4.55	11.98
Volatile matter	72.19	34.44	14.28
Fixed Carbon	16.49	49.94	65.44
Ash	4.33	11.08	8.30
Ultimate analysis (elements in % by weight of total composition)			
H	4.95	3.34	0.24
S	<0.01	<0.01	<0.01
O	41.19	18.00	6.03
N	0.48	1.06	0.46
C	43.01	63.39	72.11

In this study, the proximate and ultimate analysis value, compare with Maca Mong pod, Maca Mong pod Charcoal and activated carbon (AC) from Maca Mong pods, was found that the Maca Mong pod had the highest values of Volatile matter (72.19%), Hydrogen (H) content and Oxygen (O) content (41.19%) but had the lowest values of Moisture (4.33%) and Carbon (C) content (43.01%). The Maca Mong pod Charcoal had the highest values. Ash (11.08 %) and Nitrogen (N) content (1.06%) were the highest but had the lowest Moisture values (4.55%) and, activated carbon (AC) has Moisture (11.98%), Fixed Carbon (65.44 %) and Carbon (C) (72.11%) have the highest, but the lowest values were Volatile matter (14.28%), Hydrogen (H) (0.24%), Oxygen (O) (6.03%) and Nitrogen (N) (0.46%), while the Sulphur (S) values for all samples were the same at <0.01%.

Weerawong [29] stated that a higher Volatile Matter value indicates increased combustibility and, therefore, the Maca Mong pod has the highest suitability for use as biomass fuel, followed by Char and AC, respectively.

3.2 Iodine Number Analysis

The ability to absorb iodine of Maca Mong pod Charcoal and activated carbon (AC) from Maca Mong pods. It was found that charcoal from Maca Mong pods had an average iodine Number value of 955.39 mg/g and activated carbon (AC) had an average value of 318.04 mg/g respectively (Table 3).

3.3 BET Surface Area and Adsorption Average Pore Diameter Analysis

The overall external and internal surface area of porous solids was determined by measuring the amount of physically adsorbed gas according to the Brunauer, Emmett and Teller (BET) method. The BET Surface area and Adsorption average pore diameter analysis of Maca Mong pod Charcoal with an initial particle size of 0.3 mm and activated carbon (AC). The BET Surface area of derived activated carbon (AC) was discovered an average value of 1,007.6692 m^2/g and the Adsorption average pore diameter had an average value of 17.4486 angstroms respectively. While Maca Mong pod Charcoal could not be analysed for BET Surface area and Adsorption average pore diameter due to the presence of oil ingredients (Table 3). BET surface area is 1,007.6692 (m^2/g), which has a high surface area similar to that of commercially available high quality activated carbon.

Table 3
Comparison of characteristics of char, Iodine Number, BET surface area and adsorption average pore diameter of activated carbon

Sample	Iodine Number (mg/g)	BET surface area (m^2/g)	Adsorption average pore diameter (Angstrom)
Char at 400 ^oC	955.39	Non-analysis	Non-analysis
AC 1:3 IR at 800 ^oC	318.04	1,007.6692	17.4486

The adsorption average pore diameter of AC was 17.4486 Angstrom (1.74 nm). This study of activated carbon has an Adsorption average pore diameter close to the experiment of Wasutha *et al*., [18] which studied Activated Carbon (AC) from Rubberwood by chemical activation with KOH but setup varied in terms of carbonization duration and gradual heating at 800 °C, which used carbonization duration more than this study. The result was that the adsorption average pore diameter of the Activated Carbon (AC) from Rubberwood was 1.82 nm (18.2 Angstrom).

4. Conclusions

In conclusion, the production of Activated Carbon from Maca Mong pod (*Afzelia xylocarpa* (Kurz) craib) activated by using potassium hydroxide (KOH) in a ratio of 1:3 (Charcoal: KOH) heat it at a temperature of 800 ^oC for 1 hours (heating rate of 16 ^oC/min) under N_2 atmosphere. Activated carbon products have an adsorption average pore diameter was 17.4486 Angstrom (1.74 nm), with the pore sizes ranging smaller than 2 nm, which the IUPAC classified is called microporous [30]. Therefore, activated carbon prepared from the Maca Mong pod can be applied to a variety of applications, such as catalysts in the hydrocarbon processing (petroleum refining) industry and synthetic fuels production of the future [31] and as an adsorption material for wastewater treatment or drinking water purification [32].

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