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OPTIMIZATION IN PREPARATION OF SPENT MUSHROOM FARMING WASTE ACTIVATED CARBON BY KOH ACTIVATION

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ABSTRACT

This study investigates the utilization of Spent Mushroom Farming Waste (SMFW) as a potential precursor for activated carbon (AC) preparation. The AC preparation was conducted using chemical activation method with potassium hydroxide (KOH) as activating agent. The SMFW was impregnated with KOH, dried and carbonized in furnace. The AC was washed using hydrochloric acid (HCl) and distilled water, dried and sieved. The investigated optimization parameters were 0.25 to 1.25 impregnation ratio, 30 to 90 minutes activation time and 400 to 700 ^{o}C activation temperature. The prepared AC was measured by quantitative and qualitative analysis. The quantitative analysis referred to carbon percentage yield which represents the quantity of the AC produced. Meanwhile, qualitative analysis was measured by iodine number that reveals the adsorption capacity, high porosity and surface area of AC. The optimum conditions were observed at impregnation ratio KOH: SMFW of 0.5, activation time of 45 min and activation temperature of 500 °C at percentage yield of 21 % and iodine number of 484 mg/g. The AC was characterized with FTIR and proximate analysis. This study provides economic importance due to energy consumption minimization and applicable for industrial application.

Keywords: Spent Mushroom Farming Waste (SMFW); Activated Carbon (AC); potassium hydroxide (KOH); optimization parameters

INTRODUCTION

Activated carbon (AC) is a great potential adsorbent in industrial application. AC is applicable in removing contaminants especially in wastewater treatment. AC performance is evaluated by percentage yield and iodine number. Chemical activation in AC preparation increases the carbon yields due to reduction of tar formation [1]. Potassium hydroxide (KOH) acts as activating agent that enhances the porosity and develops high surface area through intercalation of potassium (K) in the AC. According to Gautam *et al*. [2] the KOH activation was effective for increasing micro-pore volume and carbon porosity. Previous study by Okman *et al*. [3] showed high percentage yield and iodine number by using grape seeds AC with KOH activating agent.

Recently, AC that prepared from agricultural waste has overcome drawbacks of commercial AC. Commercial AC that derived from coal based carbon is high cost, non-renewable resource and has a long-term environmental effect. Meanwhile, AC from agricultural waste is low cost, renewable resource and environmental friendly. Spent mushroom farming waste (SMFW) is one of the potential agricultural waste. SMFW is a waste discarded from mushroom cultivation farm. Abundance of SMFW waste creates a disposal problem. Therefore, utilization of SMFW as precursor in AC preparation leads to cost reduction and conversion waste to useful product.

In this study, *Pleurotus* SMFW is chosen as precursor in preparation of AC. SMFW consists of sawdust and rice husk as the major components. Previously, the AC has been obtained from sawdust [4-5] and rice husk [6-7]. These materials can produce high porous carbonaceous carbon [8]. Therefore, both materials are promising precursors for the AC. There is a limited study on utilization combination of components sawdust and rice husk. Thus the SMFW is selected in this study as the precursor for AC preparation.

The aim of this study is to optimize SMFW AC preparation parameters of impregnation ratio (IR) of KOH: SMFW, activation time and activation temperature through carbon yield and iodine number. The characteristics of SMFW AC is analyzed with chemical characterization of FTIR and proximate analysis.

EXPERIMENTAL

Material.
Spent mushroom farming waste (SMFW) used for preparation of activated carbon was provided by C&C Mushroom Cultivation Farm, Johor, Malaysia.

Preparation of Activated Carbon.
The SMFW was impregnated with the KOH for 24 hours. The slurry was then dried for 24 hours at 80 ^{0}C. Then, the impregnated precursor was carbonized in muffle furnace. The sample was washed until neutral pH with hydrochloric acid and distilled water to remove residual KOH and dried at 80 ^{0}C. Finally, the prepared AC was sieved to size of 150 micrometer and kept in drying cabinet prior to use. The optimized parameters include impregnation ratio of 0.25 – 1.25, activation time of 30 – 90 minutes and activation temperature of 400 – 700 ^{o}C.

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Characterization of Activated Carbon.

The Fourier Transform Infrared (FTIR) spectra was - determined using Series 100 Perkin Elmer Fourier Transform Infra-Red (FTIR) spectroscopy in the ange of 400-4000 cm^{-1} for surface functional group identification. Proximate analysis was determined using Thermogravimetric analyzer TA Model SDT Q600 V8.3, under nitrogen gas atmosphere with heating condition following the ASTM D2974.

RESULTS AND DISCUSSION

Impregnation Ratio of KOH and SMFW.

Figure 1 shows the quantitative analysis of AC at different impregnation ratio of KOH: SMFW. The carbon yield of impregnation ratio (IR) was slightly increased from 0.25 to 0.50 and then decreased gradually from 0.50 to 1.25. Decreased in the carbon yield with increased IR was due to increase the carbon burn-off. Increased the IR increased the weight loss due to volatile matter was released from the intensifying dehydration and elimination reactions [9]. This observation was in agreement with Ahmed & Theydan [10] who prepared activated carbon from Siris seed pods. Meanwhile, the iodine number increased with increased the IR from 0.25 to 1.25. This happened was due to increase in concentration of activator led to destruction of micropores and turned to a larger pore. In this study, the condition of 0.5 IR, which carbon yield of 19% and iodine number of 462 mg/g, has been chosen for the next parameter analysis.

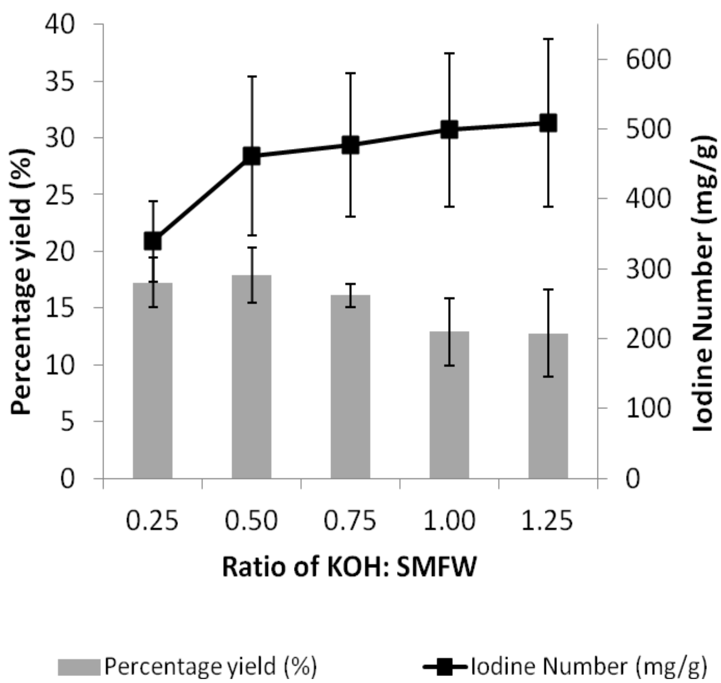

Figure 1: The percentage yield and iodine number of activated carbon at different impregnation ratio of KOH: SMFW (activation time at 60 minutes and activation temperature at 600 ^{o}C)

Activation Time.

Figure 2 shows the percentage yield and iodine number of AC at different activation time. The carbon yield increased from 30 to 45 min and generally decreased from 45 to 90 min. Meanwhile, there was an increasing trend of iodine number from 30 min until 60 min but decreased at 75 min. The trend was then increased at 90 min. The fluctuation trend of carbon yield and iodine number implied that the activation time is not significantly affecting the carbon yield and iodine number. Similar findings by Sudaryanto [11] reported that activation time showed no significant effect on the pore structure of activated carbon produced from cassava peel. Therefore, 45 min activation time, at carbon yield of 22% and iodine number of 359 mg/g, has been chosen for subsequent experiment.

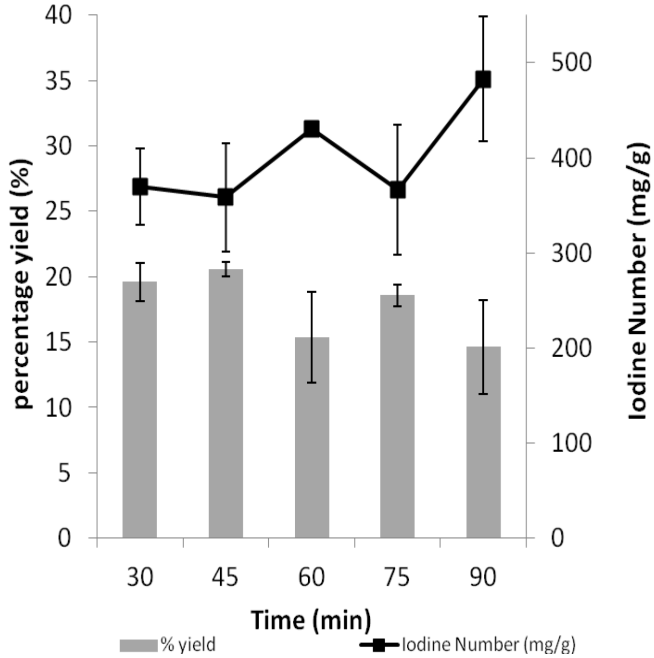

Figure 2: The percentage yield and iodine number of activated carbon at different activation time (impregnation ratio 0.5 and activation temperature at 600 ^{o}C)

Activation Temperature.

Figure 3 shows the percentage carbon yield and iodine number performance of AC under influenced of activation temperature. The carbon yield was decreased by increased the temperature from 400 ^{0}C to 700 ^{0}C. This was due to the loss of volatile matter during carbonization. Meanwhile, the iodine number is constant from 400 ^{0}C to 600 ^{0}C but increased at 700^{0}C. Increased the temperature resulted in increasing devolatilization which further developed the pore structure and increased the iodine number. Sentorun-Shalaby *et al*. [12] reported that at higher activation temperature, activation of apricot stones became more extensive and widened porous structure, thus resulted in a lower solid yield and high iodine number. In this study, the 500 ^{0}C, that the SMFW produced 21% of carbon yield and 484 mg/g of iodine number, has been chosen as activation temperature as optimum condition for AC preparation.

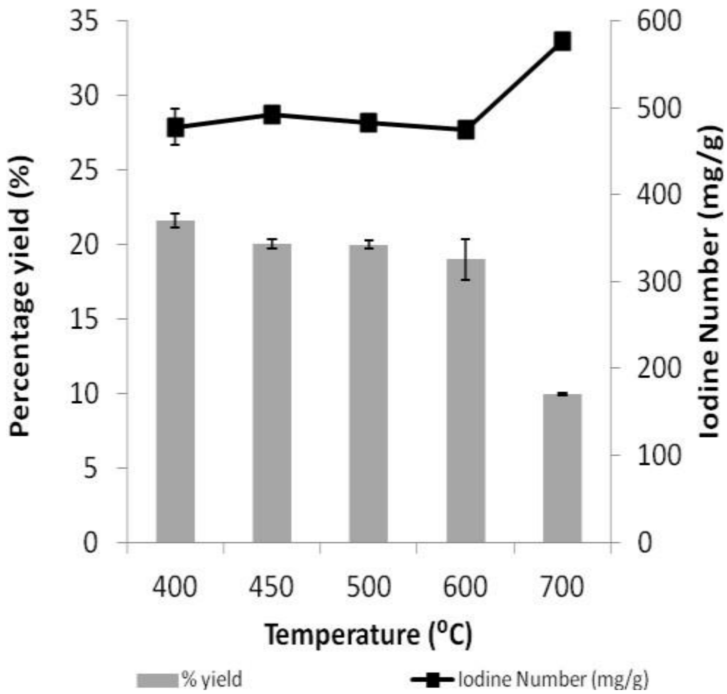

Figure 3: The percentage yield and iodine number of activated carbon at different activation temperature (impregnation ratio 0.5 and activation time at 45 minutes)

Characterization of Activated Carbon

FT-IR.

The surface chemistry of SMFW AC was investigated through determination of the functional group of AC. From the spectrum, the band at 3405 cm^{-1} attributed to the hydrogen bond between –OH in the AC surface or –OH in water molecule. Besides, band at 1384 cm^{-1} attributed to stretching vibration of C-N bond and band at 1714 cm^{-1} attributed to the C=O stretching bond of ketone. The N-H stretch bond at band 3500 cm-^{1} showed amine group in the AC.

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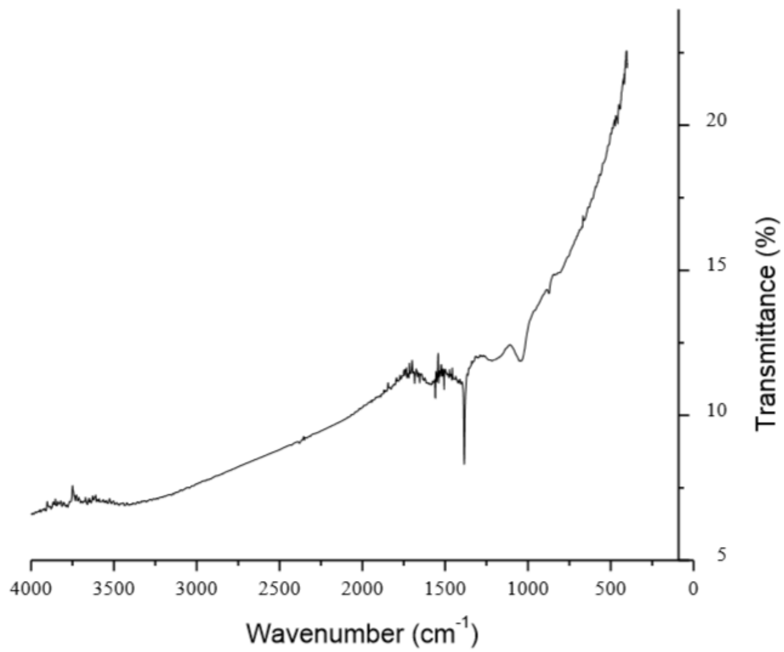

Figure 4: FT-IR spectrum of SMFW AC

Proximate Analysis.

The surface chemistry of SMFW AC was further investigated with proximate analysis. Table 1 shows the comparison of proximate analysis between raw and AC SMFW. A 4.5 % of moisture content analysis of AC was comparable with 4.8% of moisture content analysis measured using moisture analyzer. After activation process of SMFW, volatile matter content significantly decreased 31.1 % while fixed carbon content increased extensively at 24.4 %. This was due to pyrolytic effect occurred during degradation of organic matter at high temperature [6]. Produced gas and liquid tars discharged contributed to forming a high purity carbon material.

Table 1: Proximate analysis of raw SMFW and SMFW AC

Sample	Moisture (%)	Volatile matter (%)	Fixed carbon (%)
Raw SMFW	4.1	82.3	7.8
SMFW AC	4.5	51.2	32.2

CONCLUSION

As conclusion, a 21% of carbon yield and 484 mg/g of iodine number were determined at optimum 0.5 IR, 45 minutes activation time and 500 ^{0}C activation temperature. The chemical characterization revealed the present of hydroxyl, carboxyl and amine groups were important in adsorption process and loss of volatile matter increased the fixed carbon through proximate analysis of raw SMFW and SMFW AC.

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