Effects of Carbonization Temperature on Porous Properties of Coconut Shell Based Activated Carbon

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Abstract – This research focused on investigating in the effect of carbonization temperature on the porous properties of coconut shell based activated carbon prepared by physical activation with carbon dioxide. The carbonization temperature was studied in the range of 250-750°C by keeping the activation temperature at 850°C for 60 and 120 min. It was found that the porous properties of activated carbon decreased with an increase in carbonization temperature. The char prepared at the lowest carbonization temperature at 250°C and activated at temperature 850°C and time of 120 min gave the activated carbon with the highest of BET surface area and pore volume of 1057 m²/g and 0.532 cm³/g, respectively.

Keywords: Coconut shell char, Carbonization, Activated carbon, Porous properties,

1. Introduction

Activated carbon is a versatile adsorbent because of its potential application in many industries. It is of great interest to engineers and scientists since it can be produced in a wide range of porous properties to suit specific applications. Activated carbon is well known that can be prepared from a variety of carbonaceous precursors such as wood, lignite and nut shells. Coconut shells was selected as the starting material in this work because of its high fixed carbon content (about 21%) and low ash content (less than 1.0 wt%) [1]. There are two methods to prepare activated carbon namely, physical activation and chemical activation. In physical activation, a raw material is first carbonized and then activated with an oxidizing gas such as steam or carbon dioxide. In chemical activation, a raw precursor is impregnated with a chemical activating agent and carbonized in an inert atmosphere. This work is focused on the physical activation since it is widely adopted in practical production and is more friendly to the environment. The primary aim of this work is to investigate the effect of carbonization temperature on pore development in activated carbon. There are some works reporting on the effect of carbonization temperature but mostly were performed at the high temperature range [2, 3]. A wider range of carbonization temperature from 250-750°C is thus selected in this work.

2. Experimental

2.1. Carbonization of coconut shells

Coconut shell was first dried, crushed and sieved to obtain samples of 2.1 mm in particle size. The sample about 15 g was loaded on a ceramic boat which was placed in a horizontal tubular furnace and then heated up to the desired carbonization temperature i.e. 250, 350, 450, 550, 650 and 750°C, at a heating rate of 5°C/min and held for 120 min under the flow of N₂ gas.

2.2. Activation of the carbonized chars

About 3 g of carbonized chars were loaded on a wire mesh screen boat placed in the tubular furnace and then heated up to the desired activation temperature at a heating rate of 5°C/min under the N₂ gas flow. When the activation temperature of 850°C was reached, CO₂ gas was then allowed to flow in the furnace. The activation time was varied at 60 and 120 min. When the activation was completed the sample was cooled to the room temperature under N₂ gas flow.

The porous properties of activated carbons were characterized by nitrogen adsorption isotherm at -196°C with an accelerated surface area and porosimetry system (ASAP-2010, Micromeritics). The BET surface area was calculated from the isotherms by using the Brunauer- Emmett-Teller (BET) equation. The Dubinin–Astakhov (DA) equation was used to calculate the micropore volume. The total volume was found from the amount of N₂ adsorbed at a relative pressure ($P/P₀$) of 0.99 and converted to N₂ volume in liquid state.
3. Results and discussion

3.1. Effect of carbonization temperature on the weight loss

Fig. 1 shows the weight loss during the carbonization at different carbonization temperatures. It is found that the weight loss increased with an increasing in the carbonization temperature and tends to be constant at higher temperatures. This result indicates that the remained amount of volatile matters at lower carbonization temperature is higher than that at higher temperature.

Fig. 1. Effect of carbonization temperature on the weight loss

3.2. Effects of activation conditions on weight loss and porous properties of activated carbon

The total weight loss of activated carbon is defined as the ratio of the sample weight after activation and its initial weight before carbonization. Fig. 2 shows the total weight loss versus carbonization temperature at different activation temperatures and times. The total weight loss tended to decrease with increasing in the carbonization temperature, and it seems to be more significant at high carbonization temperature. This result implies that the char obtained from low carbonization temperature is having high reactivity to be gasified.

Fig. 2. Total weight loss versus carbonization temperature at different activation conditions: ●=850°C, 120 min; ■=850°C, 60 min.

Fig. 3 and 4 shows the effect of carbonization temperature on the porous properties of activated carbon. From these figures, it is found that there is a same trend for both BET surface area and pores volumes in that their values decreased with an increase in carbonization temperature. Based on the investigated results, it can be concluded that the extent of gasification and derived pore development are strongly depended on the carbonization temperature. The char prepared at the lowest carbonization temperature at 250°C and activated at temperature 850°C and time of 120 min gave the activated carbon with the highest of BET surface area and pore volume of 1057 m²/g and 0.532 cm³/g, respectively.

Fig. 3. Effect of carbonization temperature on BET surface area of activated carbons at different activation conditions: ▲=850°C, 120 min; ●=850°C, 60 min.

Fig. 4. Effect of carbonization temperature on the pore volumes of activated carbons at different activation conditions: ▼=850°C, 120 min; ●=850°C, 60 min.

4. Conclusions

The porous properties of activated carbon including surface area and pore volume decreased with an increasing in the carbonization temperature. The lowest carbonization temperature at 250°C produced the activated carbon with the highest porous properties for activation temperature at 850 C and 60 and 120 min of activation time.

References