PREPARATION AND PROPERTIES OF ACTIVATED CARBON FROM RICE HULLS

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Introduction

Since activated carbon can be manufactured with various pore structures, it has been widely used as a typical adsorbent. The use of activated carbon has rapidly increased in order to solve the environmental problems with increasing amount of hazardous pollutants in both water supplies and flue gases. The demand for activated carbon in Korea is about 25,000 tons per year and is expected to grow with 20 % of annual increasing rate for the next five years. Although two thirds of the amounts of activated carbon needed are produced domestically, the raw materials for the product such as coconut shell char and palm shell char are still imported from foreign countries. As a result, it is necessary to establish the manufacturing process of activated carbon from the feedstocks which are abundant in the country and inexpensive. The rice hull forms about 20 wt% of a kernel of unhusked rice, and is produced annually 50 million tons in the world and 1.2 million tons in Korea. This kind of organic waste is cheap and can be a problem of disposal[1]. In this work, we have activated rice hulls using steam as the activation agent. The influence of various operating variables on the yield and adsorption quality was investigated with the purpose of finding the most appropriate production conditions.

Experimental

The rice hulls obtained from a rice-cleaning mill were washed a couple of times using distilled water in order to get rid of the pounding residues and then dried in a oven. Samples of the dried hulls(about 25 g) were carbonized in a tube furnace in a stream of nitrogen by heating at a rate of 5 ℃ up to 700 ℃ and maintaining at 700 ℃ for 2 hours. The carbon obtained were subsequently activated at temperatures between 750 and 900 ℃ in a stream of moisture containing nitrogen. The concentration of steam was controlled by the temperature of a constant-temperature water bath in which the nitrogen flow was saturated with water. The degree of activation was varied by the activation temperature, the amount of water vapor, and the activation time. The characterization of the activated carbon was conducted by N_2 gas adsorption at 77 K using a Qunatachrome automated adsorption apparatus(Autosorb-1). The BET and DR equations were used to calculate the surface areas, pore size distributions, and micropore volumes of the activated carbon.

Results and Discussion

Table 1 shows the proximate analysis(on a dry basis) of the rice hull and other precursors for activated carbon. Comparing the carbonized rice hull with the other precursors, the rice hull has a shortcoming of high content of ash which is mainly composed of silica. However, The silica could be efficiently removed by the leaching with NaOH solution, and then the treated hull could be estimated as a good precursor for activated carbon. The yield and surface area of carbonized rice hull was about 37 % and 160 m^2/g. Since the thermal pyrolysis occurred around 400 ℃ far below the carbonization temperature, the carbonization temperature does not have a significant effect on the yield and surface area of the resulting chars. Activation yield varied from 80 to 40 % with increasing activation temperature, amount of water vapor, and the activation time. Fig. 1 shows the influence of activation temperature on the surface area of activated carbon. The maximum surface areas were obtained from 825 to 850 ℃ depending on the other activation conditions. The surface areas were relatively low(about 300~550 m^2/g) due to high content of ash. As the carbonized char was activated after removing the ash part by leaching with 1 N NaOH solution at 100 ℃, the surface areas usually enhanced about 2~3 times up to 1200 m^2/g compared to those for the activated carbon without NaOH treatment. This improvement could be explained by the increase of fixed carbon due to the ash removal and the effect of chemical activation by NaOH. In fact, the surface area of the char increased twice by the NaOH treatment only. Fig. 2 shows a general trend between the surface area and the activation yield. The maximum surface areas were obtained with around 60 % of the activation yield. An abrupt drop of the surface area near 40 % of activation yield(or 60 % of Burn-off) is because that the carbonized char consists of 36 % of ash and the content of fixed carbon is quite low in this region. The obtained activated carbon has uniform pore structures as shown as Fig. 3 and the average pore diameter increased with raising the activation temperature. The micropore volume increased with raising the activation temperature up to 825 ℃ and then decrased with further increase in the temperature.

Acknowledgements

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References

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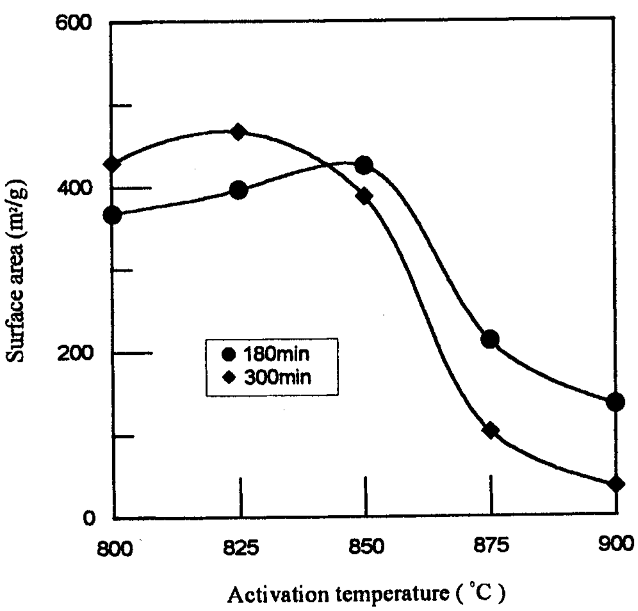

Fig. 1. Effect of Activation temperature on Surface area (Steam flow rate : 50ml/min)

Table 1. Proximate analysis of rice hull and other raw materials

	VM(wt%)	FC(wt%)	Ash(wt%)
Rice Hull	63.2	23.5	13.3
Carbonized Rice Hull	-	63.9	36.1
Coconut Shell Char[2]	~13	~85	~2
Palm Shell Char[2	~15	~81	~4
Bituminous Coal[3]	~35	~55	~10

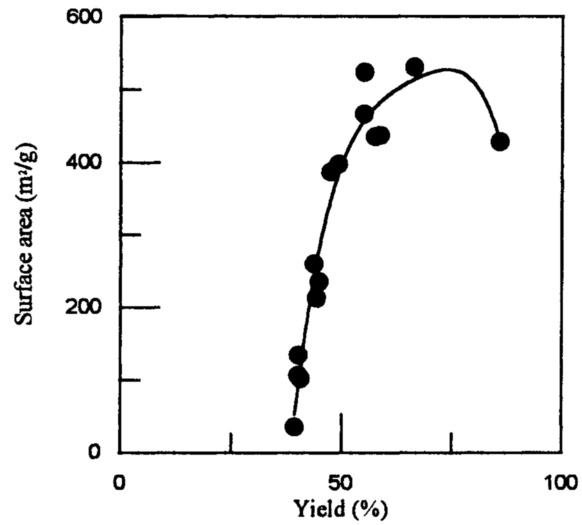

Fig.2. Relation between Surface area and Activation yield

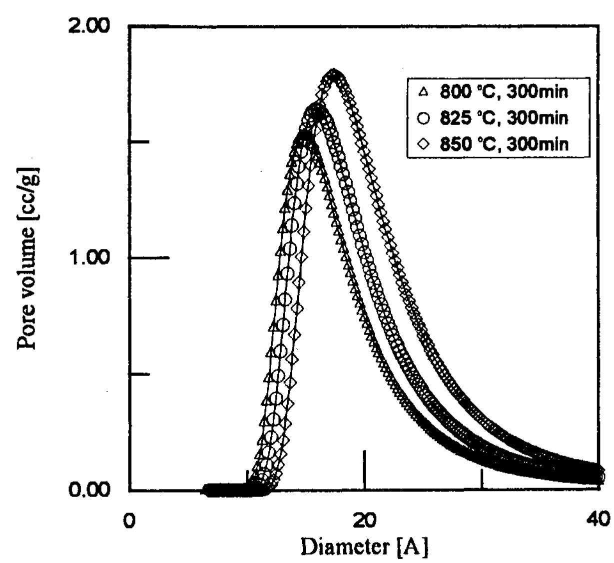

Fig.3. Pore size distribution with different Activation temperatures