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Mangrove Based Activated Carbon: Synthesis and Characterization

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Abstract

This paper deals with synthesis and characterization of mangrove based activated carbon. Highly porous activated carbon (AC) is prepared by KOH activation of carbonized mangrove. KOH activation process has been conducted at two weight ratios (4 and 6) of KOH and two activation temperatures (600°C and 700°C). The properties of the activated carbon including surface area, pore volume, and pore width have been determined by adsorption of N_2 at 77K using alpha-s method. It is found that mangrove-derived AC possess total surface area, and pore volume as high as about 2830 m^2g^{-1} and 1.90 cm^3g^{-1}, respectively at activation temperature 700°C with 6 times KOH agent. The surface structure of the carbonized mangrove and activated carbon are also observed using scanning electron microscopy (SEM).

1. Introduction

Activated carbon (AC) is one of the most common and promising adsorbents for application of the adsorption cooling systems due to its porosity[1]. However, widely used AC is expensive, made from non-renewable sources such as coke and petroleum residue. Recently, notable researchers have been prepared the ACs by chemical and physical activation from different source of waste biomasses. Hao et al.[2] synthesized ACs from hydrothermally carbonized waste biomass for CO_2 capture from flue gas. Mahammad et al.[3] prepared AC from the pyrolysis (500°C, 1 h) of pineapple waste biomass (leaves, stem, and crown) impregnated with $ZnCl_2$ for dye removal. Resulting AC showed surface area as high as 914.67 $m^2\,g^{-1}$. Kyzas et al.[4] investigated the use of ACs after pyrolysis of waste potato peels. Highest achievable surface area is 1041.43 $cm^2\,g^{-1}$. Other related articles can be found elsewhere[5–7].

In this study activated carbon have been synthesized from mangrove by activating agent as a potassium hydroxide (KOH). KOH activation process has been conducted at two weight ratios (4 and 6) of KOH and two activation temperatures (600°C and 700°C). The properties of the activated carbon including surface area, pore volume, and pore width have been determined by adsorption of N_2 at 77K using alpha-s method. The surface structure of the carbonized mangrove and AC are also observed using SEM.

2. Experiments

2.1. Synthesis of activated carbon (AC)

Synthesization process of activated carbon from mangrove can be explained as follows. At first, mangroves are crushed into a particle size around 5 mm. The crushing mangrove are then dried in air oven at 100°C for 48 hours. Vacuum drying at 105°C for 1 hour is accomplished after air drying. Carbonization process is then carried out at 500°C at a heating rate 10°C/min with N_2 flow rate 100 cc/min for 1 hour. Fig. 1 shows the synthesis scheme of mangrove based AC. After that KOH activation process has been conducted at two weight ratios (4 and 6) of KOH and two activation temperatures (600°C and 700°C). The porous properties of the resulting activated carbon have been characterized by nitrogen adsorption/desorption isotherms at 77K.

3. Results and discussion

3.1. Yield

After drying process of raw mangrove, it is found the average water content of mangrove is about 7.5 wt.%. Average yields of carbonized mangrove is found to be 32 wt.%. From the experiment, it is seen that at low temperature and low mass ratio of KOH helps to get high yield. In case of activation temperature at 600°C and four times KOH, M-C500A600K4 provides yield about 55 wt.% whereas at 700°C and six times KOH produce yield about 41 wt.%.

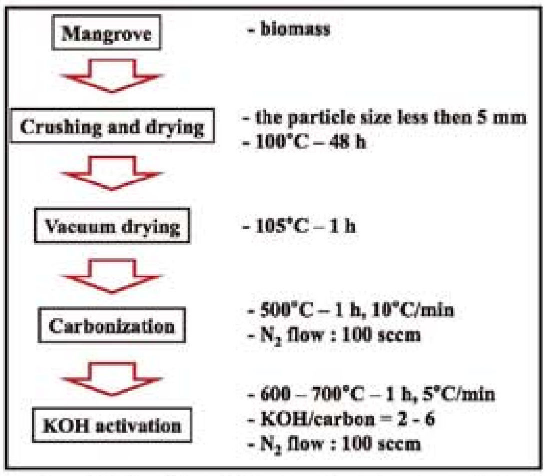

Fig. 1. Synthesis scheme of mangrove-based activated carbon.

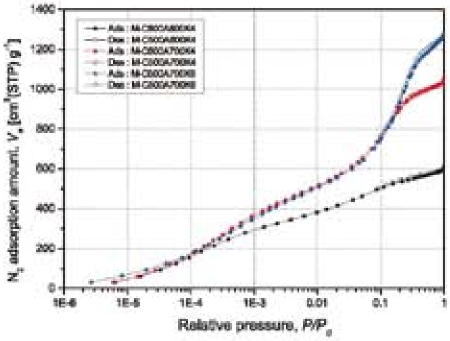

Fig. 2. N_2 adsorption/desorption isotherms of mangrove - derived activated carbon at 77K.

Table 1. Porous properties and activation yield of mangrove-derived AC.

Sample	α_s				Activation yield [%]
	Total surface area [m²/g]	External surface area [m²/g]	Micropore volume [cm³/g]	Average pore width [nm]	
*M-C500A600K4	2,131	10.68	0.90	0.84	54.61
M-C500A700K4	2,878	17.47	1.56	1.09	49.84
M-C500A700K6	2,827	37.33	1.89	1.35	41.06

*M: Mangrove; C500: Carbonized at 500°C; A600: Activation at 600°C; A700: Activation at 700°C; K4: Weight ratio (KOH: Sample = 4: 1); K6: Weight ratio (KOH: Sample = 6: 1).

3.2. Porosities and surface structure of AC

Fig. 2 shows N_2 adsorption isotherms of mangrove-derived AC. Table 1 represents the porous properties of three AC samples. M-C500A600K4 possess lowest surface area and pore volume among others. However, increasing in activation temperature with same KOH ratio (4 times), surface area and pore volume increases to value 2878 m^2g^{-1} and 1.56 cm^3g^{-1}. The average pore width of three samples varies between 0.8 nm to 1.3 nm. Fig. 3 shows the surface structure of the carbonized mangrove at 500°C and KOH AC at various activation conditions.

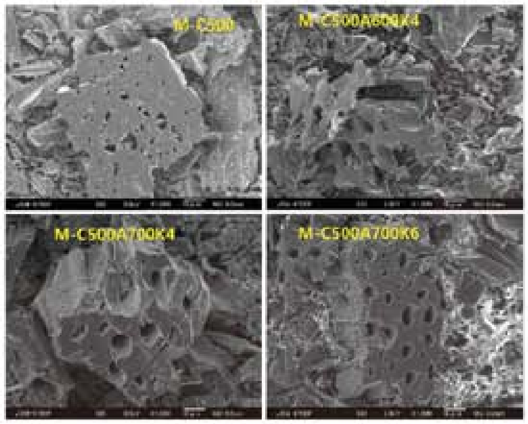

Fig. 3. SEM images of carbonized mangrove and three AC samples.

4. Conclusion

The impact of activation temperature and KOH ratio on the yield, surface area, and pore creation of mangrove-based AC have been investigated. It is found that drying mangrove provides a yield of 32 wt. % after carbonization process. All prepared AC samples show high surface area. It is worthy to note that mangrove-derived AC possess surface area, and pore volume as high as about 2830 m^2g^{-1} and 1.90 cm^3g^{-1}, respectively at activation temperature 700°C with 6 times KOH. In general, increasing activation temperature and mass ratio of KOH/carbon can increase porosity, however, there has also constraint. Conclusively, mangrove-based high surface area and large pore volume AC could be promising absorbents for adsorption application.

References

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