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https://doi.org/10.15017/2552945

出版情報：Proceedings of International Exchange and Innovation Conference on Engineering & Sciences (IEICES). 5, pp.84-86, 2019-10-24. 九州大学大学院総合理工学府
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The Effect of Post Treatment in Pore Development of Activated Carbon Prepared from Rice Husk

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Abstract: *The silica removal by post-treatment of activated carbon derived from rice husk has been conducted. Effect of post-treatment was observed by measuring the change of pore properties of carbon materials. Activated carbon prepared by steam activation has total surface area 285.5 m^2/g. After post-treatment, the total surface area of activated carbon is increased to 1170.9 m^2/g. From the Scanning Electron Microscope (SEM) images, it is found that the activated carbon derives from rice husk has non-uniform carbon frame shape and this frame was broken after post-treatment.*

Keywords: activated carbon; rice husk; steam activation; post-treatment.

1. INTRODUCTION

Rice is a major food crop for many countries and its husk has been produced in large quantity. Unfortunately, due to high silica content and low nutrition, rice husk is not suitable as animal feedstock or as compost materials. Therefore, recent method to reduce rice husk is by burning it in the open air which causing environmental pollution [1]. In order to decrease the rice husk amount without adding more environmental problems, it is necessary to convert this biomass into another material with a higher value.

Activated carbons are very important adsorbents which are used for many applications such as CO_2 adsorption [2] and air conditioning [3]. They have been prepared from various kinds of precursors such as biomass [3], fabric waste [4], and coals [5]. The utilization of biomass is promising because it is sustainable and low cost. Rice husk has been used as an activated carbon precursor in some previous studies[6][7]. However, rice husk contains 15% of ash which 90% of the ash is SiO_2 [8][9]. SiO_2 in carbon materials is needed to be removed in order to increase the surface area and impurity of activated carbon [10]. Several methods to remove SiO_2 from the surface of carbon materials have been reported in prior researches[11][12]. Therefore, in the present study, the activated carbon from rice husk had prepared by steam activation then the effect of post-treatment of activated carbon on its pore development was studied.

2. MATERIALS AND METHOD

2.1 Materials

Rice husk was pretreated by soaking in warm water (60°C) for 3 h to remove some ash content. The rice husk was then dried in an oven at 100°C for overnight. Dried rice husk was carbonized at 900°C for 1 h by a 15°C/min heating rate and 200 cm^3/min of N_2 gas flow rate. The carbonization product was activated by using steam at 900°C for 30 minutes. The activated carbon then was post-treated using KOH 2M and warm water at 90°C for 24 h to reduce silica content that can still block the pores of activated carbon [13]. The prepared materials were labeled as RHC (carbonized material), RHAC (activated carbon without post-treatment), RHAC-DW (activated carbon post-treated with distilled water), and RHAC-KOH (activated carbon post-treated with KOH).

2.2 Characterization

The pore properties of char and activated carbon before and after post-treatment was characterized by N_2 adsorption-desorption at 77K (Fig. 2) using Quantachrome NOVA3200e, SA and Pore Size Analyzer (USA). All pore properties were calculated by using NLDFT (non-localized density functional theory). The surface morphology of activated carbon was observed by the Scanning Electron Microscope JFM-6700, JEOL.

3. RESULTS AND DISCUSSION

Before biomass was converted into carbon materials, it was pretreated by 60°C of distilled water to reduce the mineral contents. There was a 9% mass loss of rice husk after being pretreated using warm water. It might be due to the dissolution of some inorganic materials such Al_2O_3, SiO_2, Fe_2O_3, CaO, MgO, Na_2O, and K_2O from rice husk into the water[14]. The pre-treated biomass then were carbonized and activated by steam. The yield of activation is 44.7% with an overall yield is 13.5%.

Fig. 1 Demonstrates that before activation, char derives from rice husk possess some pores. More pores were formed after activation (b) and it is shown that activated carbon derives from rice husk has non-uniform pores and cavities, different pore size and shapes. The structure of activated carbon was broke after post-treatment with both distilled water (c) and KOH (d).

The post-treatment by warm water broke the carbon structure and causing the decrease in the total surface area (Table 1). On the other hand, the post-treatment by KOH at 90°C not only broke the structure of activated carbon but also broadened the pores. Post-treatment by KOH were able to produce more micropores and enlarging the existed micropores into bigger pores. This phenomenon can be observed from the pore size distribution graph (Fig. 3).

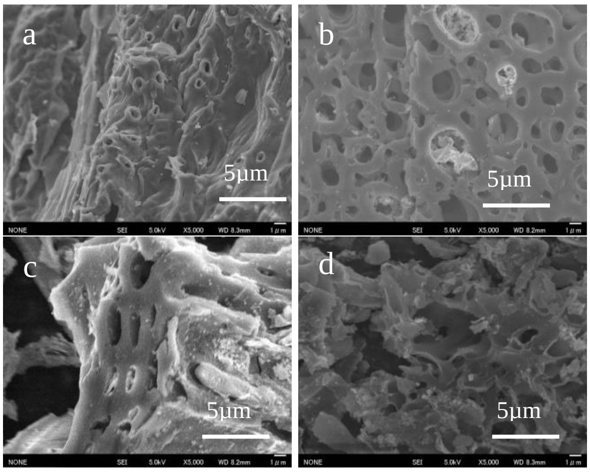

Fig. 1. SEM images of: (a) RHC, (b) RHAC, (c) RHAC-DW, and (d) RHAC-KOH.

Fig. 2 shows the nitrogen adsorption-desorption isotherm of all materials. From Fig. 2, it can be seen that adsorption of N_2 onto RHAC and RHAC-KOH were following the combination of type I and IV which is typically for microporous (type I) and developed mesopores (type IV) according to the classification of IUPAC [15]. On the other hand, N_2 adsorption onto RHC and RHC-DW are following the combination of type I and type II which indicate that both materials have a small number of micropores and nearly to the non-porous material.

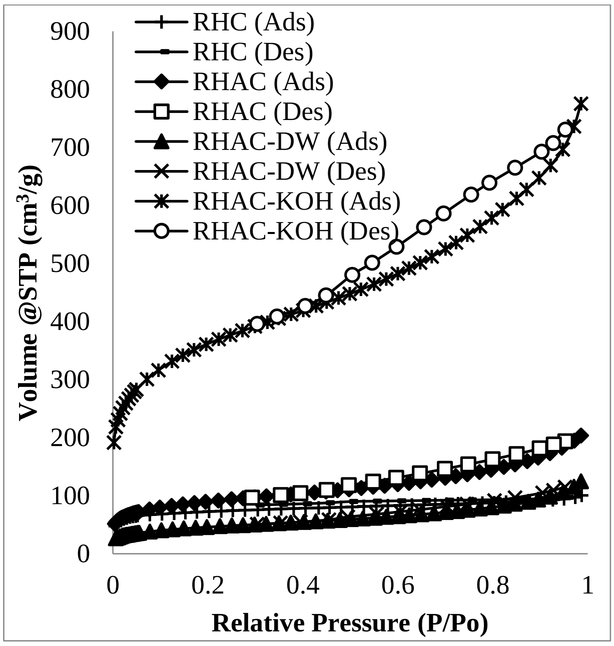

Fig. 2. N_2 adsorption-desorption isotherms of carbon materials at 77K.

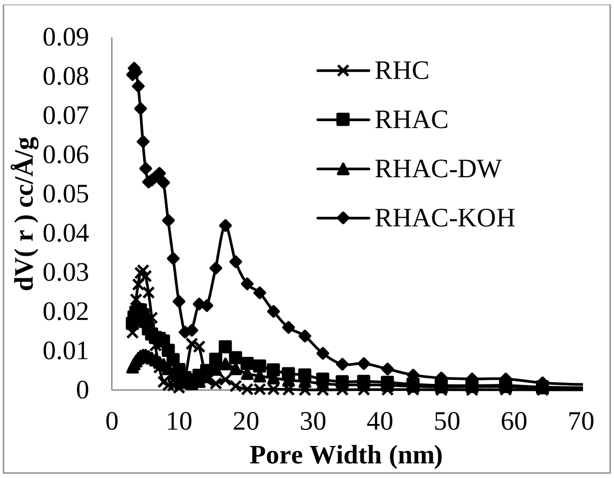

Fig. 3. Pore size distribution of the carbon materials.

Fig. 3 demonstrates how the pore development happened. It is shown that RHC has a small number of micropores. After activation (RHAC), the peak intensity at around 5 nm was decreased. Moreover, there is broadened and shift peak into bigger pore width which indicates after activation, instead of producing new micropores, the steam reacts with existed pores to created bigger pores. After being post-treated with deionized water, the number of pores and surface area of RHAC-DW reduced. Surface area of RHDAC-DW (140.7 m^2g^{-1}) is smaller than RHC (239.5 m^2g^{-1}) and RHAC (285.5 m^2g^{-1}) which means that post-treatment by warm deionized water was not favored to increase the porosity of activated carbon. On the other hand, bigger and higher peaks were produced after post-treatment by KOH (RHAC-KOH) which demonstrate that more blocked pores of activated carbon opened [13]. This result also supporting by the total surface area of RHAC-KOH which is 1170.9 m^2/g with total pore volume is 1.07 cm^3/g. This value shows that post-treatment of activated carbon by KOH can effectively enrich the porosity of activated carbon.

The pore properties of all carbon materials are represented at Table 1. From that table, it is confirmed that RHAC-KOH has the highest total surface area, total volume, and micro-porosity compare with other prepared carbon materials. This result is higher compare with prior research that produced activated carbon by chemical activation[16][6].

Table 1. Pore properties of carbon materials.

Samples	S_{total}^a ($m^2\ g^{-1}$)	V_{total}^b ($cm^3\ g^{-1}$)	S_{micro}^c ($m^2\ g^{-1}$)	V_{micro}^d ($cm^3\ g^{-1}$)
RHC	239.5	0.14	238.11	0.13
RHAC	285.5	0.28	254.3	0.16
RHAC-DW	140.7	0.17	120.84	0.09
RHAC-KOH	1170.9	1.07	1064	0.69

4. CONCLUSIONS

The study investigated the effect of post-treatment of activated carbon prepared from rice husk by steam. As treated by KOH, the surface area of activated carbon increased more than 4 times of the surface area of activated carbon without post-treatment. The pore volume raised more than 7 times compare to before post-treatment.

5. REFERENCES

[1] E. Menya, P. W. Olupot, H. Storz, M. Lubwama, and Y. Kiros, "Production and performance of activated carbon from rice husks for removal of natural organic matter from water: A review," *Chem. Eng. Res. Des.*, vol. 129, pp. 271–296, 2018.

[2] M. Muttakin, A. Pal, K. Uddin, K. Thu, K. Ito, and B. Baran Saha, "Experimental study of CO_2 adsorption kinetics onto activated carbon Experimental study of CO2 adsorption kinetics onto activated carbon," vol. 4, pp. 2018–2028, 2018.

[3] A. Pal, S. Mitra, K. Thu, and B. B. Saha, "Improved adsorption uptake of ethanol and CO2 onto biomass based activated carbons," *Proc. Int. Exch. Innov. Conf. Eng. Sci.*, vol. 3, pp. 127–128, 2017.

[4] T. L. Silva, A. L. Cazetta, P. S. C. Souza, T. Zhang, T. Asefa, and V. C. Almeida, "Mesoporous activated carbon fibers synthesized from denim fabric waste: Efficient adsorbents for removal of textile dye from aqueous solutions," *J. Clean. Prod.*, vol. 171, pp. 482–490, 2018.

[5] A. H. Jawad, K. Ismail, M. A. M. Ishak, and L. D. Wilson, "Conversion of Malaysian low-rank coal to mesoporous activated carbon: Structure characterization and adsorption properties," *Chinese J. Chem. Eng.*, no. xxxx, 2019.

[6] N. Yalçin and V. Sevinç, "Studies of the surface area and porosity of activated carbons prepared from rice husks," *Carbon N. Y.*, vol. 38, no. 14, pp. 1943–1945, 2000.

[7] S. Sugashini and K. M. M. S. Begum, "Preparation of activated carbon from carbonized rice husk by ozone activation for Cr(VI) removal," *Xinxing Tan Cailiao/New Carbon Mater.*, vol. 30, no. 3, pp. 252–261, 2015.

[8] M. S. Masoud, W. M. El-Saraf, A. M. Abdel - Halim, A. E. Ali, E. A. Mohamed, and H. M. I. Hasan, "Rice husk and activated carbon for waste water treatment of El-Mex Bay, Alexandria Coast, Egypt," *Arab. J. Chem.*, vol. 9, pp. S1590–S1596, 2016.

[9] C. B. Majumder, M. Sharma, and G. Soni, "A simple non-conventional method to extract amorphous silica from rice husk," *Bioresour. Technol.*, pp. 0–4, 2014.

[10] N. M. Hieu, V. V. Korobochkin, and N. V. Tu, "A Study of Silica Separation in the Production of Activated Carbon from Rice Husk in Viet Nam," *Procedia Chem.*, vol. 15, pp. 308–312, 2015.

[11] M. Rhaman, M. Haque, M. Rouf, M. Siddique, and M. Islam, "Preparation and characterization of activated carbon & amorphous silica from rice husk," *Bangladesh J. Sci. Ind. Res.*, vol. 50, no. 4, pp. 263–270, 2015.

[12] M. Li, S. Ma, and X. Zhu, "Preparation of activated carbon from pyrolyzed rice husk by leaching out ash content after Co2 activation," *BioResources*, vol. 11, no. 2, pp. 3384–3396, 2016.

[13] J. H. Lee, Y. J. Heo, and S. J. Park, "Effect of silica removal and steam activation on extra-porous activated carbons from rice husks for methane storage," *Int. J. Hydrogen Energy*, vol. 43, no. 49, pp. 22377–22384, 2018.

[14] W. Xu *et al.*, "Comparative study of water-leaching and acid-leaching pretreatment on the thermal stability and reactivity of biomass silica for viability as a pozzolanic additive in cement," *Materials (Basel).*, vol. 11, no. 9, 2018.

[15] K. Stafford, W. Sing, and J. Rouquerol, "Reporting Physisorption Data for Gas / Solid Systems INCLUDING CATALYSIS * REPORTING PHYSISORPTION DATA FOR GAS / SOLID SYSTEMS with Special Reference to the Determination of Surface Area and Porosity," *Pure Appl. Chem.*, vol. 57, no. January 1985, pp. 603–619, 2016.

[16] W. Zhang *et al.*, "Direct carbonization of rice husk to prepare porous carbon for supercapacitor applications," *Energy*, vol. 128, pp. 618–625, 2017.