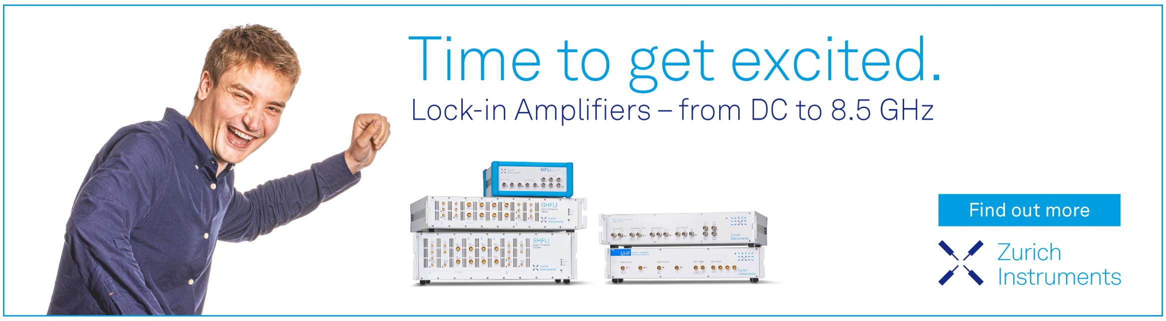
RESEARCH ARTICLE | SEPTEMBER 25 2014

Annealing effect on the particle size and chemical composition of activated carbon obtained from vacuum furnace of teak sawdust FREE

B. Armynah; D. Tahir; N. Jaya

AIP Conference Proceedings 1617, 19–21 (2014)
https://doi.org/10.1063/1.4897094



Annealing effect on the Particle Size and Chemical Composition of Activated Carbon Obtained from Vacuum Furnace of Teak Sawdust

B. Armynah[1], D. Tahir[1,*], and N. Jaya[1]

[1]*Department of Physics, Hasanuddin University, Makassar 90245 Indonesia*
** Email: dtahir@fmipa.unhas.ac.id*

Abstract. Activated carbon was produced from sawdust by using physical method in a high temperature vacuum furnace without additional chemical. Fast pyrolysis process was carried out prior in fluidized a bed furnace to produce char before activation process. Experiments were conducted to investigate the influence of various process parameters such as particle size, activation temperature and activation time on the quality of the activated carbon. In addition, the chemical composition studies were done by using x-ray fluorescence (XRF) spectroscopy. The crystallite sizes were calculated by using Scherer equation based on x-ray diffraction (XRD) spectroscopy data. The pyrolysis temperature and time were varied from 600^{o}C to 900^{o}C and from 3 hours to 6 hours, respectively. The particle size of activated carbon was increase with increasing temperature. The composition and crystallite size of the prepared activated carbon was compared with the non-activated carbon. The results indicated that the teak sawdust carbon could be employed as a low cost alternative to produce commercial activated carbon.

Keywords: XRF, XRD, particle size, Annealing, Chemical composition
PACS: 81.70.jb, 87.85.jf, 88.20.dj.

INTRODUCTION

Activated carbon usually use in wide range application from environmental; waste water treatment, mercury removal, water purification, and gas purification to energy storage; super-capacitor and battery. Various materials are used to produce activated carbon and most commonly used are agriculture waste such as coconut shell, durian peel, tropical wood, groundnut shell, and sawdust [1-4]. It is interest to select the teak sawdust as the raw materials to make activated carbon. Wood based industries such as traditional houses industries and furniture industries in almost all regions in Indonesia have been using teak wood as the main supporting materials. These industries are produced to the large volume biomass in the form of offcut, wood barks, and sawdust. In order to maximize use of the wood residue especially sawdust and waste minimization, the effective way is convert the sawdust residue to activated carbon [3-7].

Physical and chemical methods are common method to convert the sawdust residue to activated carbon. Chemical method is relatively expensive and polluting the environment due to usage of chemical addition and not for physical method. Physical method is selected in this study by using vacuum furnace without any additional chemical in order to enhance the porosity of the carbon matrix [4, 5, 7].

The main focuses in this study are temperature annealing effect on particle size and chemical composition of activated carbon based on teak sawdust.

EXPERIMENT

The waste teak sawdust was collected from a local furniture industry in Makassar, South Sulawesi area. The sawdust was sieved and washed with distilled water to remove any residue and dried in oven for 15 hours at 80^{o}C. After the sawdust was dry, the materials were pyrolized in bed furnace at temperature 400^{O}C for 45 minutes and resulting char. Activation of the char was done by using vacuum furnace at different temperature and time annealing. The activation process was undergone at temperature 600, 700, 800, and 900^{O}C for 3, 4, and 5 hours.

The samples were characterized by using x-ray fluorescence (XRF) spectroscopy for determine the chemical composition and x-ray diffraction (XRD) spectroscopy for determine the particle size.

.

RESULTS AND DISCUSSION

The results of XRD for activated carbon based teak sawdust materials at increasing temperature from 600^{O}C to 900^{O}C are shown in Figure 1. The XRD

3rd International Conference on Theoretical and Applied Physics 2013 (ICTAP 2013)
AIP Conf. Proc. 1617, 19-21 (2014); doi: 10.1063/1.4897094

spectra were used to calculate the particle size of activated carbon with increasing temperature and time annealing using Scherrer's formula [7];

$$d = \frac{0.9\lambda}{B\cos\theta_B} \quad (1)$$

where λ, θ_B and B are the X-ray wavelength (1.54 Å), Bragg diffraction angle and line width at half maximum, respectively.

Fig. 1 shows XRD spectra of samples for temperature and time annealing were varied from 600°C to 900°C and 3 hours to 5 hours, respectively. Particle size as a function of temperature and time annealing are shown in Table 1 and it was observed that there is not significant increase in the crystallite size with increasing the temperature annealing. The crystallite size of activated carbon based teak sawdust was around 8.3 nm at 600°C which small increase to 8.9 nm when the sample was heated to 900°C. For varying annealing time the crystallite size shows similarity and there is no significant change for increase the annealing time. The increase in the crystallite size for increasing the annealing temperature is due to the merging of the smaller particles into large ones do to the merging of the smaller particle into larger ones [7].

XRF usually use to determine the chemical composition in many field such as; in geology, in archeology, in pharmacy, in biology, in physics, and in environment [8]. In this study, we used XRF to determine the chemical composition of activated carbon, as can be seen in Table 2. The Ca, K, and Px are the main chemical oxide in the activated carbon based on teak sawdust. The Ca compositions were decrease with increasing annealing time for temperature 700°C, 800°C, and 900°C and vice versa for temperature 600°C. For K and Px compositions are not significantly change when the time is increase. The compositions were slowly increases with increasing temperature for 4 hour annealing. The change in the composition shows the effect of temperature annealing were influence to the composition may due to the oxidation state of some chemical oxide.

TABLE 1. Particle size of chart teak sawdust.

Time (hours)	Temperature (°C)			
	600	700	800	900
3	8.3	8.8	9.0	8.9
4	8.2	8.2	8.5	8.8
5	8.9	8.9	9.1	9.0

TABLE 2. Chemical composition of activated carbon from XRF spectroscopy data as a function of temperature (600°C to 900°C) and time annealing (3 to 5 hours).

Oxide	0°C	600°C /time(hours)			700°C/time(hours)			800°C/time(hours)			900°C/time(hours)		
		3	4	5	3	4	5	3	4	5	3	4	5
Ca	49.54	47.47	54.96	55.64	55.35	55.92	48.82	60.67	58.67	55.81	57.72	57.84	54.18
K	33.80	37.79	43.38	42.53	43.04	42.66	38.57	37.89	38.76	41.33	40.64	40.43	43.88
Mg	15.16	11.09	-	-	-	-	11.17	-	-	-	-	-	-
Px	0.97	1.09	1.15	1.28	1.36	1.16	1.10	1.12	1.39	1.49	1.32	1.45	1.61
Zn	0.27	0.273	0.234	0.258	-	-	-	-	-	-	-	-	-

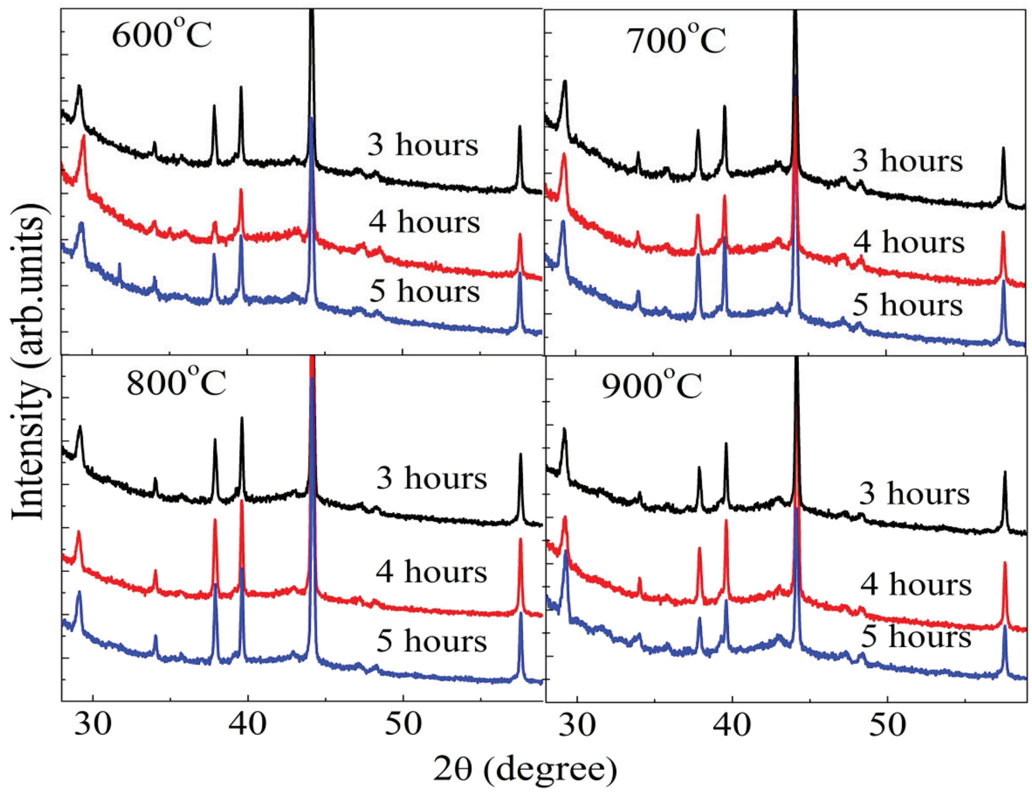


FIGURE 1. XRD spectra of activated carbon based on teak sawdust as a function of temperature and time annealing.

CONCLUSIONS

In summary, the crystallite size calculated based on XRD spectra of activated carbon based teak sawdust was around 8.3 nm for annealing at 600°C and increase to 8.9 nm for annealing at 900°C. For varying annealing time the crystallite size shows similarity and there is no significant change for increase the annealing time. From XRF data, K and Px compositions are not significantly change when the time is increase. The compositions were slowly increases with increasing temperature for 4 hour annealing. The change in the composition shows the effect of temperature annealing were influence to the composition may due to the oxidation state of chemical oxide. The results indicated that the teak sawdust carbon could be employed as a low cost alternative to produce commercial activated carbon.

ACKNOWLEDGMENTS

This work was supported by directorate general of higher education (DGHE), Ministry of Education and Culture, Indonesia, by the Hasanuddin University grant.

REFERENCES

1. K. Y. Foo and B. H. Hameed, *Bioresource Tech.***111**, 425-432 (2012).
2. K. Mohanty, D. Das, and M. N. Biswas, *Chem. Eng.* **115**, 121-131 (2005).
3. S. Noonpui, P. Thiravetyan, W. Nakbanpote, and S. Netpradit, *Chem. Eng.* **162**, 503-508 (2010).
4. E. Taer, M. Deraman, I. A. Talib, A. A. Umar, M. Oyama, and R. M. Yunus *Current Appl. Phys.***10**, 1071-1075 (2010).
5. B. G. P. Kumar, K. Shivakamy, L. R. Miranda, and M. Velan, *J. Hazard. Mater.***136**, 922-929 (2006).
6. A. K. Yadav, R. Abbassi, A. Gupta, and M. Dadashzadeh, *Ecological Eng.*52, 211-218 (2013).
7. F. Kurosaki, H. Koyanaka, T. Hata, and Y. Imamura, *Carbon* **45**, 671-673 (2007).
8. M. Inoue and I. Hirazawa, *J. Crystal Growth* **380**, 169-175 (2013).
9. C. Roldan, J. Ferrero, D. Juanes, J. Carballo, A. Calvo, and M. Aguiar, *Rad. Phys. Chem.***82**, 7-11 (2013)