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THE PRODUCTION OF ACTIVATED CARBON DERIVED FROM COCONUT SHELL: STUDY OF QUALITY PARAMETERS REGARDINGVARIOUS CHEMICAL ACTIVATOR

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ABSTRACT

Activated carbon has been used in various industrial sectors. This research then conducted an investigation to find a new raw material namely coconut pulp that can be used for producing activated carbon (AC). In this work, the quality of produced AC was further measured using SII No. 0258-88 methods. The experimental data revealed that coconut pulp can be a reliable alternative material for AC production in which it could meet the standard values of AC products for industrial purposes such as water content, ash content, and absorption of iodine by 3.8%, of 2.42%, and 847.48 mg/g, respectively, while the optimal conditions of activation process was using HCl activator by 0.5 M.

KEYWORDS: Activated carbon, Activator, concentration, coconut.

1. INTRODUCTION

Activated carbon (AC) has been widely used in various industries (Medhat et al, 2021). This material can be derived from agricultural waste or plant remains (Martini, 2016, Jamilatun & Setyawan, 2014).

In general, AC can be utilized or added in several manufacturing products acting as catalyst, color absorption, purification agent, and adsorbent to adsorb assorted types of pollutants such as dyes, heavy metals, oil and grease (Singh et al, 2019). The AC can also be derived from various sources available in nature such as coconut shell, bark, banana peel, mango peel, leaves, fruit peel, zeolite, nut shell, animal bone, and fly ash (Afroze et al, 2018, Agarwal et al, 2020, Bhatacharjee et al, 2020, Bibaj et al, 2019, Bilal et al, 2021, Chakrabhorty et al, 2020, Danish et al, 2018, Martini et al, 2020). For many industrial sectors in Indonesia, the demand of AC is relatively high. Unfortunately, the fulfillment of this demand mostly be solved by importing solution (Sahara et al., 2017).

In accordance with this issue, some research has been conducted to produce AC from low-cost and abundant materials in nature including coconut plant wastes available massively in Indonesia. In general, AC production processes consist of two stages, namely carbonization and chemical activation (Karimi et al., 2020). Carbonization can be defined as pyrolysis process or incomplete combustion of basic material used in the absence of air. In order to increase the carbonized material performance, the activation process is then needed to convert raw materials into AC which have better parameters such as larger porosity and specific surface area. There are various chemicals that are available for carbon activation purpose such as $CaCl_2$, $Ca(OH)_2$, NaCl, $MgCl_2$, HNO_3, HCl, $Ca_3(PO_4)_2$, H_3PO_4, and $ZnCl_2$ (Martini et al, 2021, Ashraf et al, 2020).

Therefore, this work then investigated coconut pulp as low cost material for producing AC. Besides that, the type and concentration of activators would also be analyzed and compared with each other to obtain AC having the best quality based on several parameters including volatile matter, water and ash content values.

2. MATERIALS AND METHODS

The experimental set up was prepared using laboratory equipment such as beaker glass, furnace, vacuum pump, sieve, crucible, electric oven, centrifuge, analytical balance, pH meter, titration apparatus. Coconut pulp was obtained from coconut milk sellers in Plaju Modern Market, Palembang, Indonesia. HCl, $ZnCl_2$, NaCl, aquadest, starch, sodium thiosulfate, and iodine were obtained from the laboratory supplier.

Carbon Manufacturing

Firstly, coconut pulp was dried in the laboratory oven before it was carbonized in the furnace for 15 min at temperature of 300^{o}C. Furthermore, the charcoal was activated using HCl, $ZnCl_2$ and NaCl solution with concentration of 0.2 M, 0.3M, 0.4M 0.5M and 0.6M for 24 hr. The sample was then filtered with filter paper, and washed with distilled water until it reached pH 7. The sample was dried again for 2 hr before conducting the measurement of volatile matter, moisture content, absorption of iodine, and ash content values.

Volatile Matter (SII) Analysis

To begin with, the AC was heated at temperature of 950^{o}C in furnace. When the temperature was reached, the carbon was allowed to cool in the furnace. After cooling process, it was put in a desiccator and weigh. The volatile matter can be calculated by following equation 1.

$$\%Volatile\ \ matter = \frac{a - b}{a} x100\% \qquad (1)$$

Where a is the initial weight of AC and b is the weight of AC after heating (grams).

Water Content Analysis (SII)

Around five grams of AC was put into a porcelain crucible. It was then put in an oven at temperature 115^{o}C for 3 hr, before cooling it in a desiccator and weighing. The water content can be calculated by equation 2.

$$\text{Water content} = \frac{a - b}{a} x100\% \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (2)$$

Where a is the initial weight of AC (gr) and b is the weight of AC after drying (gr) (Pambayun et al., 2013).

Analysis of Absorption of Iodine (SII)

Firstly, around one gram of AC was weighed and mixed with 50 ml of 0.1 M iodine solution, then shaken with a shaker for 15 min. The sample was then centrifuged. Around 10 ml of the sample solution was taken and titrated with 0.1 N sodium thiosulfate solution. If the yellow color of the solution began to fade, 1% starch solution then was added as an indicator until the color of solution changed. Absorption of iodine can be calculated by equation 3.

$$\text{Absorption of Iodine, mg/g} = \frac{(10 - \frac{V\,x\,N}{0,1})\,x12,69\,x\,5}{W} \qquad \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

Where V is the required sodium thio-sulfate solution (mL), N is normality sodium thio-sulfate solution, The number of 12.69 is the amount of iodine corresponding to 1 ml of 0.1 N sodium thio-sulfate solution, and W is the mass of the sample (gr) (Arlofa, 2016).

Ash Content Analysis

Around 5 gr of AC was put into a porcelain before it was put at furnace at 800^{o}C for 2 hr.

When the carbon became ash, it was cooled in a desiccator and weighed until a constant weight was obtained. The ash content then can be calculated using equation 4 (Sahara et al., 2017).

$$\text{Ash content} = \frac{Ashweight}{sampleweight} x\ 100\% \quad (4)$$

3. RESULTS AND DISCUSSION

Volatile Matter analysis

Fig. 1 illustrates the results of experimental work regarding volatile matter measurement of AC treated at temperature of 950°C.

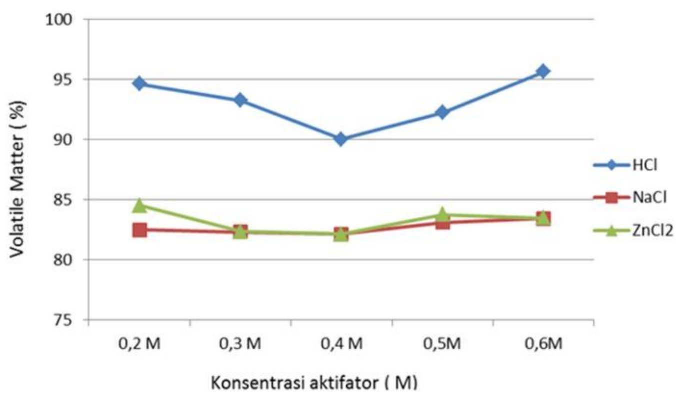

Figure 1: Volatile Matter Analysis.

The values of volatile substances depict the content of volatile compounds contained in AC. This study found that the values of volatile matters ranged within 82% to 95.62%. For HCL activator, the lowest volatile substance content was 90.03% obtained at 0.4 M of HCl, while the highest value was 95.62% happened at 0.6 M. For NaCL activator, the lowest volatile substance content was 82.12% using 0.4 M, while the highest was 83.42% at 0.6 M of solution. Eventually, for the $ZnCl_2$ activator, the lowest volatile substance content was 82.12% using 0.4 M, while the highest was 84.52% using 0.2 M. In this case, AC produced in this work cannot meet the quality standard stipulated in SII No. 0258-88 as the maximum volatile matter value must be 15%. This may indicate that coconut pulp has a smooth structure leading to more combustible behavior.

Water Content Analysis

Analysis on water content is carried out to determine the remaining water content in AC, and the outcome can be seen in Fig. 2.

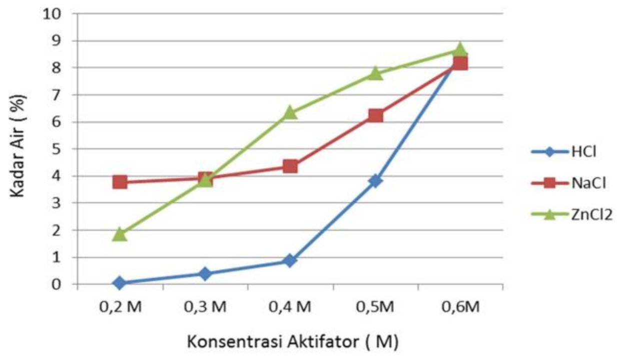

Figure 2: Water Content Analysis.

Based on the figure, it can be seen that water content of AC produced in this study ranged from 0.05 to 8.7%. It also can be considered that greater activator concentration would lead to increasing water content in AC. This may link to higher amount of absorbed water through the solution.

However, this work found that water content values could meet thequality standard stated in SII 0258-88 in which a maximum water content value is 4.4% for powdered AC (Sahara et al., 2017).

Iodine Absorption Analysis

Iodine absorption analysis relates to the ability of AC to absorb small diameter molecules where smaller size of AC could indicate higher absorptioncapacity. The number of molecules adsorbed can be influenced by the volume of carbon pores. Adsorption equilibrium may be achieved if the adsorbate molecule is polar and a vapor liquid to fill all the pores of AC (Atmayudha, 2007). The analysis in iodine adsorption level was depicted in Fig. 3.

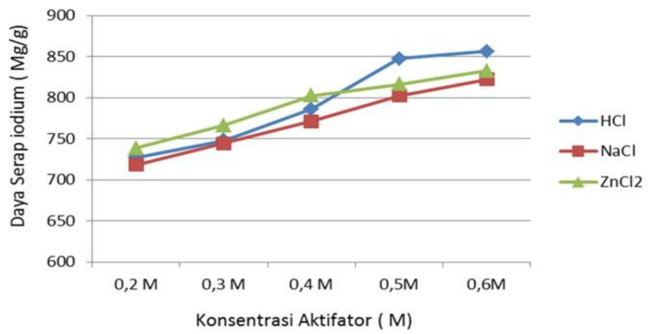

Figure 3: Analysis of the Absorption of Iodine.

This study found that iodine absorption values ranged from 718 to 850 mg/g in which most of them could meet the quality standard of AC stated in SII-0258-88. These values were leveraged by the magnitude of the absorption of iodine on AC pores regarding the active sites after activation process.

Ash Content Analysis

Ash content can be referred to the percentage of ash produced from complete combustion of the organic material which cannot be burned further after combustion. The outcome of ash content analysis was depicted in Fig. 4.

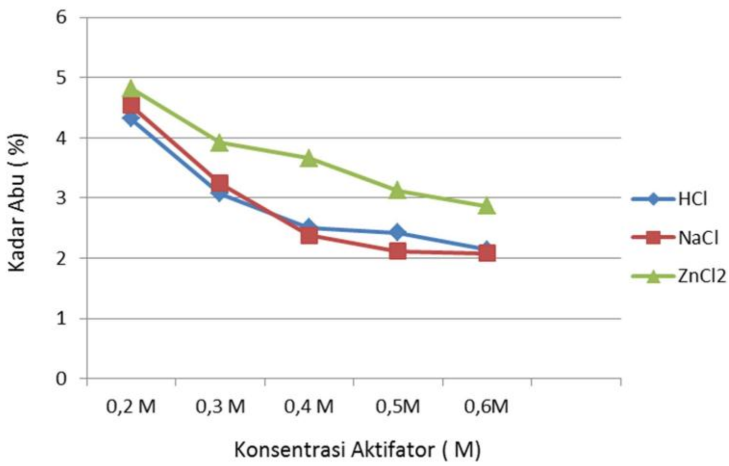

Figure 4: Analysis of Ash Content.

Based on the figure, it can be seen that ash content ranged from 2.08 to 4.82%. Specifically, the lowest ash content was 2.08% using NaCl activator with a concentration of 0.6M, while the highest was 4.82% using ZnCl2 activator with a concentration of 0.2 M. It can be concluded that higher concentration of the activator could increase ash content value. However, the level of temperature also influenced ash content obtained during experiment (Jamilatun & Setyawan, 2014)

4. CONCLUSION

This work has produced and investigated coconut pulp-based activated carbon that can be used in the manufacturing processes based on SII 0258-88 standard. The optimum operating condition for activation process was found at 0.5 M HCl activator resulting in AC having the values of water content by 3.8%, ash content by 2.42%, and absorption of iodine by 847.48 mg/g. Ultimately, the activator concentration can affect the quality of AC in terms of absorption ability.

REFERENCES

1. Afroze, S. & Sen, T. K. A review on heavy metal ions and dye adsorption from water by agricultural solid waste adsorbents. *Water, Air, & Soil Pollution,* 2018; 229: 225.
2. Agarwal, A., Upadhyay, U., Sreedhar, I., Singh, S. A. & Patel, C. M. A review on valorization of biomass in heavy metal removal from wastewater. *Journal of Water Process Engineering,* 2020; 38: 101602.
3. Arlofa, N. Kondisi Optimum Konsentrasi Aktivator Dan Suhu Biosorben Pada Zat Warna Tekstil. *Semnastek Fakultas Teknik Universitas Muhammadiyah Jakarta, 2016*; 1–7.
4. Ashraf, A., Bibi, I., Niazi, N., Ok, Y.S., Murtaza, G., Shahid, M., Kunhikrishnan, A., Li, D., Mahmood, T. Chromium (VI) sorption efficiency of acid-activated banana peel over organo-montmorillonite in aqueous solutions, International Journal Phytoremediation, 2017; 19: 605-613.
5. Atmayudha, A. Pembuatan Karbon Aktif Berbahan Dasar Tempurung Kelapa dengan Perlakuan Aktivasi Terkontrol Serta Uji Kinerjanya. *Skripsi FT UI*, 2007; 850.
6. Bhattacharjee, C., Dutta, S. & Saxena, V. K. A review on biosorptive removal of dyes and heavy metals from wastewater using watermelon rind as biosorbent. *Environmental Advances,* 2020; 2: 100007.
7. Bibaj, E., Lysigaki, K., Nolan, J., Seyedsalehi, M., Deliyanni, E., Mitropoulos, A. & Kyzas, G. Activated carbons from banana peels for the removal of nickel ions. *International journal of environmental scienceand technology,* 2019; 16: 667-680.
8. Bilal, M., Ihsanullah, I., Younas, M. & UL Hassan Shah, M. Recent advances in applications of low-cost adsorbents for the removal of heavy metals from water: A critical review. *Separation and Purification Technology,* 2021; 278: 119510.
9. Chakraborty, R., Asthana, A., Singh, A. K., Jain, B. & Susan, A. B. H. Adsorption of heavy metal ions by various low-cost adsorbents: a review. *International Journal of Environmental Analytical Chemistry*, 2020; 1-38.
10. Danish, M., Ahmad, T. A review on utilization of wood biomass as a sustainable precursor for activated carbon production and application, Renewable and Sustainable Energy Reviews, 2018; 87: 1-21.
11. Hartanto, S., & Ratnawati. Pembuatan Karbon Aktif dari Tempurung Kelapa Sawit dengan Metode Aktivasi Kimia. *Jurnal Sains Materi Indonesia*, 2010; *12*(1): 12–16.
12. Jamilatun, S., & Setyawan, M. Pembuatan Arang Aktif dari Tempurung Kelapa dan Aplikasinya untuk Penjernihan Asap Cair. *Spektrum Industri*, 2014; *12*(1): 73. https://doi.org/10.12928/si.v12i1.1651.

13. Karimi, H,. Heidari, M.A., Emrooz, H.B.M., Shokouhimehr, M., 2020.
14. Carbonization temperature effects on adsorption performance of metal-organic framework derived nanoporous carbon for removal of methylene blue from wastewater; experimental and spectrometry study, Diameter Related Material., 108: 107999.
15. Lempang, M. Pembuatan dan Kegunaan Karbon Aktif. *Info Teknis EBONI*, 2014; *11*(2): 65–80. http://ejournal.forda-mof.org/ejournal- litbang/index.php/buleboni/article /view/5041/4463arang.
16. Martini, S. Development of an Efficient Integrated System for Industrial Oily Wastewater Treatment, in, Curtin University, 2016.
17. Martini, S., Afroze, S., & Ahmad Roni, K. Modified eucalyptus bark as a sorbent for simultaneous removal of COD, oil, and Cr(III) from industrial wastewater. *Alexandria Engineering Journal*, 2020; 59(3): 1637-1648.
18. MARTINI, S., AFROZE, S., RONI, K.A., SETIAWATI, M., KHARISMADEWI, D. A review of fruit waste-derived sorbents for dyes and metals removal from contaminated water and wastewater. *Desalination andwater treatment*, 2021; 235: 300 - 323.
19. Medhat, A., El-Maghrabi, H H., Abdelghany, A., Abdel Menem, N., Raynaud, P., Moustafa, Y. M., Elsayed, M.A. Efficiently activated carbons from corn cob for methylene blue adsorption, Applied Surface Science Advance, 2021; 3: 100037.
20. Pambayun, G. S., Yulianto, R. Y. E., Rachimoellah, M., & Putri, E. M. M. Pembuatan Karbon Aktif Dari Arang Tempurung Kelapa Dengan Aktivator ZnCl2 dan Na_2CO_3 Sebagai Adsorben Untuk Mengurangi Kadar Fenol Dalam Air Limbah. *Jurnal Teknik Pomits*, 2013; *2*(1): 116–120. https://doi.org/10.12962/j23373539.v2i1.2437.
21. Sahara, E., Dahliani, N. K., & Manuaba, I. B. P. Pembuatan Dan Karakterisasi Arang Aktif Dari Batang Tanaman Gumitir (Tagetes Erecta) Dengan Aktivator NaOH. *Jurnal Kimia*, 2017; *1*: 174.https://doi.org/10.24843/jchem.2017.v11.i02.p12.
22. Singh, R., Nidheesh, P.V., Sivasankar, T. Integrating ultrasound with activated carbon prepared from mangosteen fruit peel for reactive black 5 removal, Environmental Engineering Management journal. 2019; 18: 2335- 2342.