Activated Carbon Producing from Young Coconut Coir and Shells to Meet Activated Carbon Needs in Water Purification Process

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Abstract. Young Coconut products have many benefits for society as for drinks and medicine, and it produces young Coconut shells and coir waste. The contents of cellulose and carbon elements are interesting to be utilized to be activated carbon. This research aimed to know the activator concentration of hydroxide potassium chemical and heating physical with microwave electrical power to produce activated carbon products. This research was conducted in laboratory experiments with chemical and physical activation methods, measuring proximate and iodine product numbers. The result showed that activated carbon from young Coconuts shells and coir with activation process used chemical activation and produced activated carbon products that met SNI standard number 06-3730-1995. Iodine number of activated carbons was in the range of 1776.60 mg/g – 2220.75 mg/g, iodine number as more than 23.5% of SNI Standard.

1. Introduction
Coconut production in Indonesia tends to be stable with the planting and replanting of this plant. In Indonesia, coconut production was 2.6 million tons in 2018, and the export amount was more than USD 1.3 million [1]. The size of production could produce more than 1.8 tons of coconut coir and 33 million tons of coir dust [2]. The coconut fiber is 35% of the total coconut weight. The potential use of coconut coir as a bio sorbent is quite high. Bio sorbent is used to remove heavy metals from high enough water. It is used because coconut coir contains lignin (35% - 45%) and cellulose (23% -43%). Coconut is not only produced copra but is also consumed in the form of young Coconut. Coconut can be used as a medicine, and coconut meat is popular in Indonesia. If we do not exploit the waste of coconut shells properly, it will pollute the environment. Coconut content can be used as activated carbon to absorb ammonia, nitrite, and nitrate in water. Activated carbon is an amorphous compound that is produced from materials containing carbon or charcoal, and it is treated to obtain high adsorption power. The adsorption capacity of activated carbon for iodine number is 750 mg/g [3]–[7]. Coconut coir could be made of activated carbon, and it was successful in absorbing various impurities [8]–[10]. This research was not using coconut husks and shells. This research did not conduct several tests like iodine absorption, ash content, and water content. Foo and Hameed (2012) stated that the good activation of activated carbon from coconut fiber was KOH. The result of the activated carbon test was an adsorption monolayer; methylene blue was 418.15 mg/g, and carbon yield was 80.75%. BET produced 1356.25 m2/g, Langmuir’s surface area was 2040.01 m2/g, and pore volume was 0.78 m3/g [11]. However, activated carbon produced has not been applied to reduce the content of ammonia, nitrite, and nitrate. Activated carbon from coffee grounds was able to decrease the content of nitrite, and nitrate was about 64.69%, 52.35%, and 86.4% in 30 minutes, and the pH was 7 [12]. Amin et al. (2016) stated that activated carbon from corn corps was able to reduce the content of......
ammonia, nitrite, and nitrate levels of 51.29%, 31.93%, and 58.71% in 10 minutes, and the pH was 6 [13].

2. EXPERIMENTAL

2.1 Materials and Tools Preparation
This research used some materials, such as young Coconut coir, as a raw material of activated carbon, potassium hydroxide, nitrogen (N2), and distilled water. This research used several tools, such as a furnace, microwave, and desiccator, which have been available in the chemical laboratory in the Department of Chemical Engineering, Faculty of Industrial Technology, ITATS. Before the researchers used the tools, the tools have been checked the condition and the maximum temperature could be achieved.

2.2 General Procedures
Preparing raw materials was the first procedure to activated carbon manufacture from young Coconut coir and shells. The raw materials are young Coconut coir and shells. These materials are available in the young Coconut shop in Surabaya, and they gave for free. Young Coconut coir and shells were still fusing, and we needed to cut them into small pieces with the size of 2 x 2 cm. The pieces of coir and shells were dried with the sunlight, and we needed to put them into the oven at 110°C for 30 minutes. Those materials need to be carbonized at a temperature of 500°C for 2 hours. Then, the carbons which have been formed were cooled in the desiccator. Carbon was needed to be chemically activated using KOH solution, and the concentrations were 10, 20, and 30% at room temperature for 8 hours. The researchers washed the carbon using distilled water until the carbon had neutral pH (6 to 7), and we measured it using universal pH paper. This carbon was physically activated by heating in the microwave at the temperature of 600°C in 30 minutes, and it was also flowing N2 gas. After this process, we needed to cool it in the desiccator. Activated carbon was pulverized by grinding in a porcelain crucible. Activated carbon was sieved through a 60 mesh. Furthermore, the researchers determined the quality of activated carbon by measuring several parameters like water content, ash content, evaporation content, bound carbon content, Iodine number, and BET. This study used the analysis method of the quality test for activated carbon characteristics based on SNI 06 – 3730 – 1995 regarding the characterization of activated carbon.

![Description of the figure](image)

Figure 1. Physics Activation Tools Series

2.3 Analysis
The activation result of activated carbon was characterized by measuring water content, carbon content, volatile matter, ash content, and iodine absorption. Analysis of moisture content, volatile matter, and ash content, using the ASTM method. Fixed carbon is calculated by equation (1).

\[
\text{Fixed Carbon} = 100\% - (\text{volatile matter} + \text{water content} + \text{ash content}) \tag{1}
\]
Activated carbon which met the standard, was used to reduce nitrite and nitrate level in drinking water treatment processes in Surabaya.

3. Result and Discussion

3.1 Volatile matter
The analysis result of volatile matter from activated carbon originated from young Coconut coir, and shells of young Coconut can be seen in Figure 2. It showed that volatile matter which was contained on activated carbon was 17-49%. The result showed that the greater the microwave power used, the higher the microwave temperature was obtained. So, volatile substance’s levels in activated carbon decreased. It was in accordance with the research result of activated carbon from coal. Volatile substances would be decreased by increasing activation temperature because of the imperfect decomposition of non-carbon compounds [6], [14].

The concentration difference of activating agent used was Potassium Hydroxide, and it affected activated carbon. The greater the Potassium Hydroxide concentration obtained, the lower the Volatile matter of activated carbon produced. It was conducted because Potassium Hydroxide had a high concentration, and it affected the ash content in the form of metal oxides inside of charcoal which was consisted of non-volatile minerals to be higher. At the same time, the number of volatile minerals became tiny because the volatile matter of activated charcoal was decreasing.

The activation process of volatile matter content from young Coconut coir and shells produced potassium hydroxide of 30% wt, and heating with a microwave power of 600W and 800W was below 25%. The condition of activated carbon volatile matter met the standard of SNI 07-3730-1995. However, activated carbon in the potassium process of hydroxide KOH 10-20% at 600 and 800 W did not meet the quality standard of activated charcoal. This condition happened because there were still non-carbon compounds in activated carbon, and it attached to the surface of activated charcoal, especially H and O atoms which were strongly bound to the C atom on the surface of activated charcoal in the form of CO$_2$, CO, CH$_4$ and H$_2$ [14].

3.2 Volatility

![Figure 2. Effect of Potassium Hydroxide (KOH) Concentration on the Activated Carbon Volatility](image)

3.3. Water Content

![Figure 3. Effect of KOH concentration on the activated carbon ash content on the Chemical-Physical](image)
Moisture content in the activated charcoal was the water amount in the activated charcoal. Water content determination of activated charcoal was to know the characteristics of activated charcoal hygroscopic [4], [5], [15], [16]. This research showed the content water between 2 - 18%. Figure 3 shows that the water content of activated charcoal has a higher concentration of activating substance in the form of potassium hydroxide activator, causing a lower water content of activated charcoal. It was because 30% KOH solution contained higher metal oxide composites than water in the 10 and 20% KOH solution. The water content of activated charcoal met SNI standard number 06-3730-1995 regarding activated charcoal quality was a maximum of 15% for activated charcoal in powder form. But it was different with activated carbon, which was chemically activated of 10% KOH concentration and 600 W microwave power was 18%. Moisture water could be affected by several processes, but moisture content excess could be adjusted in the final condition by drying [5].

3.4 Ash Content

![Figure 4](image)

**Figure 4.** Effect of KOH concentration on the Activated Carbon Ash Carbon in Physical-Chemical Activation

3.5 Iodine Number

![Figure 5](image)

**Figure 5.** Effect of KOH concentration to the activated carbon Iodine number in Physical-Chemical Activation

Determination of activated charcoal absorption to iodine was representative of activated charcoal’s ability to absorb colored solutions or impurities. The iodine number of activated carbons to the iodine was related to the surface is from activated carbon. The greater the iodine number produced, the higher activated carbon ability adsorbed iodine. Figure 5 shows products of activated carbon. These products had iodine absorption between 1776.60 mg/g – 2220.75 mg/g, and it had an excess of 136% from the standard. The best iodine absorption was obtained at 30% chemical activation condition at 800 W power. Iodine number, which was directly proportional with the concentration of the activated agent, was KOH and microwave power. The higher the KOH concentration and microwave power obtained, the greater the iodine number produced. It was because of the surface area width in activated carbon. So, it was able to absorb the subtract in the form of a large amount of iodine. The higher concentration of the activation chemical solution produced, the stronger the chemical solution effect binding the carbonization residue tar compounds to exit through the micropores of the activated
charcoal. Increasing absorption showed that there were carbon atoms in the form of hexagonal crystallites. So, the gaps or pores which were formed between the crystallite layers were also getting bigger [6].

3.6 Fixed Carbon

![Figure 6](image)

**Figure 6.** Effect of KOH concentration to the Activated Carbon Fixed from young Coconut coir and shells with physical – chemistry activation

Fixed carbon is the content of element carbon which is existing in activated carbon. Carbon content which was bound of carbon content, was produced from this study between 23-72%. Figure 6 was known that concentration and microwave power were directly proportional with pure activated carbon content, which was insignificantly produced. There was a carbon produced met SNI standard number 06-3730-1995. The SNI standard number 06-3730-1995 was activated carbon was activated with 30% KOH and 800W power microwave. The high carbon content was influenced by water content, ash content, and volatile matter content in activated carbon. Several researchers had the same trend in the research result. The low fixed carbon content could be conducted by reducing water content, volatile matter, and ash content.

The adsorption power of activated carbon to the iodine was related to the surface width of activated carbon. The higher the iodine amount increased, the greater activated carbon ability adopted iodine. Activated carbon with activation combining between chemical and physical had an iodine absorption capacity between 1776.60 mg/g – 2220.75 mg/g. The best iodine absorption was obtained in the condition of 30% chemical activation at 800 W. Iodine number was directly proportional with the concentration of the activating agent. It was KOH and microwave power. The greater the KOH concentration and microwave power, the higher the iodine number obtained. It was because of the large surface of activated charcoal, and it was able to absorb the subtraction of iodine in the substrate. Increasing absorption capacity showed that there was carbon atom forming hexagonal crystallites, so there were bigger gaps or pores between the crystallite layers [5].

4. Conclusion

This study showed that young Coconut coir and shells could be made of activated carbon. The activation process used chemical and physical activation, and it utilized KOH and microwave power which produced activated carbon products. The products met SNI standards. The iodine number of activated carbons was in the range of 1776.60 mg/g – 2220.75 mg/g.

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5. Reference

[1] J. C. Alouw and S. Wulandari, “Present status and outlook of coconut development in Indonesia,” *IOP Conf. Ser. Earth Environ. Sci.*, vol. 418, no. 1, 2020, doi: 10.1088/1755-1315/418/1/012035.

[2] Z. Mahmud and D. A. N. Yulius, “Prospek Pengolahan Hasil Samping Buah Kelapa,” *Perspektif*, vol. 4, no. 2, pp. 55–63, 2015, doi: 10.21082/p.v4n2.2005.

[3] L. E. Laos, “Pemanfaatan Kulit Singkong Sebagai Bahan Baku Karbon Aktif,” *JIPF (Jurnal Ilmu Pendidik. Fis.*, vol. 1, no. 1, p. 32, 2016, doi: 10.26737/jipf.v1i1.58.

[4] D. Y. Purwaningsih, A. Budianto, A. A. Ningrum, and B. T. Kosagi, “Produksi Karbon Aktif Dari Kulit Singkong Dengan Aktivasi Kimia Fisika Menggunakan Gelombang Mikro,” in *Seminar Nasional Sains dan Teknologi Terapan VII*, 2019, pp. 663–670, [Online]. Available: https://ejurnal.itats.ac.id/sntekpan/article/view/622/427.

[5] A. Budianto, E. Kusdarini, N. H. Amrullah, E. Ningsih, K. Udyani, and Aidawiyah, “Physics and chemical activation to produce activated carbon from empty palm oil bunches waste Physics and chemical activation to produce activated carbon from empty palm oil bunches waste,” *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 1010, 2021, doi: 10.1088/1757-899X/1010/1/012016.

[6] I. A. W. Tan, A. L. Ahmad, and B. H. Hameed, “Optimization of preparation conditions for activated carbons from coconut husk using response surface methodology,” *Chem. Eng. J.*, vol. 137, no. 3, pp. 462–470, 2008, doi: 10.1016/j.cej.2007.04.031.

[7] I. A. W. Tan, A. L. Ahmad, and B. H. Hameed, “Preparation of activated carbon from coconut husk : Optimization study on removal of 2 , 4 , 6-trichlorophenol using response surface methodology,” *J. Hazard. Mater.*, vol. 153, pp. 709–717, 2008, doi: 10.1016/j.jhazmat.2007.09.014.

[8] K. Y. Foo and B. H. Hameed, “Coconut husk derived activated carbon via microwave induced activated carbon : Effects of activation agents , preparation parameters and adsorption performance,” *Chem. Eng. J.*, vol. 184, pp. 57–65, 2012, doi: 10.1016/j.cej.2011.12.084.

[9] I. Irmanto and S. Suyata, “PENURUNAN KADAR AMONIA, NITRIT, DAN NITRAT LIMBAH CAIR INDUSTRI TAHU MENGGUNAKAN ARANG AKTIF DARI AMPAS KOP,” *Molekul*, vol. 4, no. 2, pp. 105–114, 2009.

[10] A. You, M. A. Y. Be, and I. In, “Utilization of coconut husk waste in the preparation of activated carbon by using chemical activators of KOH and NaOH Utilization of Coconut Husk Waste in the Preparation of Activated Carbon by Using Chemical Activators of KOH and NaOH,” in *AIP Conference Proceedings*, 2020, vol. 060026, no. September.

[11] K. Y. Foo and B. H. Hameed, “Coconut husk derived activated carbon via microwave induced activation : Effects of activation agents , preparation parameters and adsorption performance,” *Chem. Eng. J.*, vol. 184, pp. 57–65, 2012, doi: 10.1016/j.cej.2011.12.084.

[12] I. Irmanto and S. Suyata, “PENURUNAN KADAR AMONIA, NITRIT, DAN NITRAT LIMBAH CAIR INDUSTRI TAHU MENGGUNAKAN ARANG AKTIF DARI AMPAS KOP,” *Molekul*, vol. 4, no. 2, pp. 105–114, 2009.

[13] A. You, M. A. Y. Be, and I. In, “Utilization of coconut husk waste in the preparation of activated carbon by using chemical activators of KOH and NaOH Utilization of Coconut Husk Waste in the Preparation of Activated Carbon by Using Chemical Activators of KOH and NaOH,” in *AIP Conference Proceedings*, 2020, vol. 060026, no. September.

[14] K. Y. Foo and B. H. Hameed, “Coconut husk derived activated carbon via microwave induced activation : Effects of activation agents , preparation parameters and adsorption performance,” *Chem. Eng. J.*, vol. 184, pp. 57–65, 2012, doi: 10.1016/j.cej.2011.12.084.

[15] I. Irmanto and S. Suyata, “PENURUNAN KADAR AMONIA, NITRIT, DAN NITRAT LIMBAH CAIR INDUSTRI TAHU MENGGUNAKAN ARANG AKTIF DARI AMPAS KOP,” *Molekul*, vol. 4, no. 2, pp. 105–114, 2009.

[16] B. Agus, S. Sumari, P. Wahyu Setyo, and Wahyudi, “Production of Various Chemicals from Nyamplung Oil with Catalytic Cracking Process,” *Indian J. Sci. Technol.*, vol. 11, no. 37, pp. 1–7, 2018, doi: 10.17485/ijst/2018/v11i37/129866.