Volume 6 Nomor 2 Tahun 2026
JURNAL KIMIA DAN REKAYASA

HCL Activate Concentration Effect On Nanoporied Active Carbon Powder Of Sugarcane Bagasse And Contact Time For Adsorption Of Heavy Metal Lead Pb (II)

Pengaruh Konsentrasi Aktivator HCL Pada Serbuk Nanopori Karbon Aktif Ampas Tebu Dan Waktu Kontak Untuk Adsorpsi Logam Berat Timbal Pb(II)

Narimo,[1*] Peni Pujiastuti,[1] Tri wijayanti,[2]
[1]Faculty of Engineering,Setia Budi University Surakarta Central Java 57127 Indonesia.
[2]Faculty of Pharmacy, Setia Budi University Surakarta Central Java 57129 Indonesia.

[*]Coresponding author : narimousb@gmail.com

ABSTRAK: This far, bagasse waste has only been used as fuel, in its development can also be used as activated carbon for the adsorption of heavy metals including lead Pb (II).
The making nanoporous activated carbon from bagasse are first by drying in the sun, after that crushing it , carbonizing it using a furnace at 300 ^{o}C, and activating it with HCL and ultrasonic irradiation using sonication.
The results of characteristic testing of nano-porous activated carbon powder showed with irradiation taking place at ultrasonic with an amplitude of 40%, namely an average pore radius of 3.3202 e+01 ^{0}A, a surface area of 80.235 m^2/ gr and a water content of 0.71%.
The adsorption test results with the sample solution of $Pb(NO_3)_2$ concentration 100 ppm with each variation HCL 1 N, 2 N, 3 N, 4 N, 5 N, 6 N and the results were tested by Atomic Absorption Spectrophotometry, indicating that the best concentration of HCL solution was 5 N which was able to reduce sample content of Pb (II) was 99.71%. The same thing was done for testing samples of $Pb(NO_3)_2$ solution with each variable activation time of activated carbon 1, 2 , 3 and 4 hours. The test results show that the best activated carbon activation time is 3 hours which can reduce the concentration of Pb (II) samples by 99.68%.

Keywords: activated carbon nanopores; adsorption; bagasse ; lead Pb (II)

ABSTRAK ***:*** Limbah Ampas tebu selama ini banyak digunakan hanya untuk bahan bakar penghasil energi panas dalam bentuk uap (*steam boiler*) pada pabrik gula, tetapi pada perkembangan berikutnya ampas tebu juga dapat dimanfaatkan sebagai karbon aktif untuk adsorpsi logam berat termasuk timbal Pb (II).
Tahapan pembuatan karbon aktif nanopori dari ampas tebu dimulai dengan preparasi bahan baku yaitu pengeringan dibawah sinar matahari kemudian bahan di *crusher*, dikarbonisasi menggunakan *furnace* pada suhu 300 ^{o}C, diaktivasi dengan aktivator HCL dan iradiasi ultrasonik memakai sonikasi.
Hasil pengujian karakteristik serbuk karbon aktif nanopori dari ampas tebu menunjukkan pembentukan pori pada karbon aktif dengan iradiasi berlangsung pada gelombang ultrasonik dengan amplitudo 40 % yaitu radius pori rata rata 3.3202 e+01 ^{0}A, luas permukaan 80.235 m^2/ gram dan kadar air 0,71 %.
Untuk hasil pengujian adsorpsi dengan sampel larutan $Pb(NO_3)_2$ konsentrasi 100 mg/L (100 ppm) dengan masing masing variasi konsentrasi aktivator larutan HCL yaitu 1 N, 2 N, 3 N, 4 N, 5 N, 6 N dan hasilnya diuji dengan Spektrofotometri Atom Serapan (AAS) menunjukkan bahwa konsentrasi aktivator larutan HCL terbaik adalah 5 N, mampu menurunkan kadar sampel Pb (II) sebesar 99,71 %. Hal yang sama dilakukan untuk pengujian sampel larutan $Pb(NO_3)_2$ dengan masing masing variabel lama waktu aktivasi karbon aktif yaitu 1 jam, 2 jam, 3 jam dan 4 jam, hasil pengujian menunjukkan bahwa waktu aktivasi karbon aktif terbaik adalah 3 jam mampu menurunkan kadar sampel Pb (II) sebesar 99,68 %.

Kata Kunci : ampas tebu, nanopori karbon aktif , adsorpsi, timbal Pb (II)

1.INTRODUCTION

The amount of bagasse in Indonesia is very abundant, almost close to the amount of sugarcane production in Indonesia. This is because from the sugarcane production process, 5-10% sugar is obtained, about 90% bagasse is obtained, and the rest is molasses and water. As data, sugarcane production in Indonesia in 2015 reached 2,534,872 tons (Badan Pusat Statistik Indonesia. 2015). Bagasse is a waste material and so far, bagasse is only thrown away or for sugar cane companies it is used as fuel for steam boilers and paper raw materials (Purnawan et al,2012). The abundance of bagasse in Indonesia and the carbon content of 43% to 47% in bagasse are strong reasons to use it as activated carbon (Andaka,2011) All raw materials containing carbon can be made into activated carbon including bagasse and it is able to absorb the heavy metal lead Pb (II) (Salihi,et al)

Adsorption is one of the separation methods for metal absorption due to its efficiency, low cost, simplicity and high selectivity. The adsorption process is expected to be able to take heavy metal ions from the waters. This technique is more profitable than other techniques in terms of efficiency. In addition, the cost aspect is also not so great, the design is simple and there are no side effects of toxic substances (Fazlzadeh et al, 2011) . Adsorption is a surface phenomenon. It is the addition of certain component concentrations on the surface between two phases. Adsorption can be divided into physical and chemical adsorptions. This adsorption method is very dependent on the surface area of the adsorbent because the surface of the adsorbent is very useful for attracting particles in gases or liquids (Nurdila et al,2015) Activated carbon is an amorphous material is used as a gas absorber, bleaching agent, metal absorber, and so on. The selection of raw materials from activated carbon is determined based on the amount of carbon content in the material. Three stages manufacture of activated carbon is the dehydration process, the carbonization process and the activation process. The quality factors of activated carbon are the type of material,technology, processing method, accuracy and product size. Powder form of nano-porous activated carbon of bagasse has better adsorption capacity than nano-porous activated carbon of bagasse in tablet form for the adsorption process of lead Pb (II) and chromium (VI) heavy metals (Narimo et al,2019).

Standard of industrial activated carbon quality have been made by Indonesia, namely SII 0258-79 which was later revised to SNI 06-3730-1995. Nanotechnology is the science and engineering of materials, functional structures and devices on a scale of 1-100 nanometers (Yuvakkumar et al,2011). Nanometer-sized materials have physical and chemical properties that are superior to large-sized materials (100 – 2500 nm). This is because the nanoparticles have a larger surface area. These properties can be changed through controlling the size of the material, setting the chemical composition, modifying the surface, and controlling the interactions between particles (Abdullah et al,2008) The physical vibration produced by the sonicator in the form of ultrasonic is a longitudinal mechanical wave that cannot be heard by the human ear because it has a high frequency but can propagate in solid, liquid and gaseous media and can be used to make particles smaller and homogeneous (Zhou et al,2009). Physically porous carbon consists of a solid material that contains carbon and an empty cavity / pore (Yang et al,2008).

2.RESEARCH METHODS

This research was carried out at the Chemical Engineering Operations Laboratory and Chemical Analysis at Setia Budi University, Surakarta, Mathematics and Science Laboratory at Unnes Semarang.

The adsorption chemical analysis method used Atomic Absorption Spectroscopy instrumentation, the chemical characterization of the material used Brunaur Emmett and Teller, the analysis of water content using the thermo-gravimetric method, the ash content using a furnace, for the jod number using the volumetric method.

2.1 Chemicals and Instrumentation

Materials and chemicals used in this research were bagasse sugarcane,solution $Pb(NO_3)_2$, HCl, and aquadest.The iodine test was carried out with the aid of standard $Na_2S_2O_3$ solution, standard iodine, standard KIO_3, 10% KI, 2N H_2SO_4, 1% amylum indicator, and lead filter paper.

Instrumentations used in this research were *Atomic Absorption Spectroscopy* (AAS), *Brunaur*, *Emmett and Teller* (BET), Sonicators, glass beaker, pH meter, furnace, oven, shaker, porcelain dish, desiccator, analytical balance, funnel, clamp, stative, 200 mesh sieve, filter paper, burette, crusher, pH meter, condenser, water heater, erlenmeyer, pipette , and glassware commonly used in laboratories for iodine analysis.

2.2 Procedure

2.2.2 Manufacture of Sugarcane Bagasse

The results of drying bagasse in the sun are then cut and crushed with a crusher. The results were sieved using a 200mesh sieve. The powder was burned in a furnace for 30 minutes at a temperature of 300°C. After the carbon is formed, cool it in a desiccator.

2.2.2 Chemical Activation

The carbon formed is then chemically activated with HCl solution activator with various concentrations: 1 N, 2 N, 3 N, 4 N, 5 N and 6 N. Carbon activation is carried out by refluxing for 2 hours and then filtered and cooled in the form of slurry and then ultrasonically irradiated by sonication for the manufacture of nanoporous activated carbon.

2.2.3 Production of Nanoporous activated carbon from bagasse

The way to make nanoporous activated carbon from bagasse is as follows :

The resulting activated charcoal which has been refluxed in the form of a slurry is sonicated for 15 minutes with an amplitude of 40% on a Sonicator without pause.

The activated charcoal are filtered, washed with distilled water, and dried in an oven at a temperature of 105°C to remove the water, then the cavity in the activated carbon is checked with a BET tool to determine the size of the surface area, pore radius and composition of nanoporous activated carbon. from bagasse.

2.2.4 Testing of bagasse nanoporous activated carbon adsorption with a $Pb(NO_3)_2$. Solution

Testing the adsorption power of nano activated carbon bagasse pore with $Pb(NO_3)_2$. solution is carried out as follows: The adsorption power was tested at an optimum pH of 6 with a solution of $Pb(NO_3)_2$ with a concentration of 100 mg/L (100 ppm). Variable activation of bagasse nanoporous activated carbon using HCl solution with various concentrations: 1 N, 2 N, 3 N, 4 N, 5 N and 6 N, with a time of 2 hours. The nanoporous activated carbon was put into an Erlenmeyer containing a solution of $Pb(NO_3)_2$, shaken with a shaker for 1 hour at a speed of 150 rpm and then filtered with lead filter paper. The filtrate was taken and then tested with AAS to determine the lead content of Pb(II).

3. RESULT

The results of optimization of bagasse nanoporous activated carbon include identification of water content, ash content and absorption capacity of the production of activated carbon from bagasse waste.

Figure 1. Sugarcane Bagasse Drying (private collection)

Figure 2. After crushing bagasse((private collection)

Figure 3 Bagasse activated carbon after activation and irradiation. (private collection)

Results of optimization of bagasse activated carbon including identification of water content, ash content, and absorption capacity of I_2 in accordance Standard according to SNI-06-3730-1995 as follows:

Table 1.Activated Carbon Quality Standard SNI-06-3730-1995

Descriptions	Quality Requirement	Research Results
Water content (%)	Max 15	0,71
Ash content (%)	Maks 10	6,53
Adsorption of I_2 (mg/g)	Min 750	938,42

The results of the research on adsorption of nanoporous activated carbon from bagasse against heavy metal Pb(II) with HCL activator with time variations: 1 hour, 2 hours, 3 hours and 4 hours are as follows:

Table 2.Adsorption with time variation

Time (hour)	Initial conc (ppm)	Final conc (ppm)	Decreased conc (ppm)
1	100	38,52	61,48
2	100	3,30	96,70
3	100	0,32	99,68
4	100	9,57	90,43

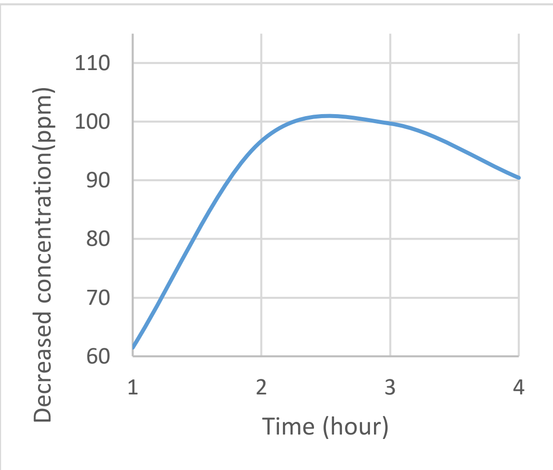

Figure 4.Adsorption with time variation

The adsorption of activated carbon nanopore bagasse against heavy metal Pb (II) in $Pb(NO_3)_2$solution with various concentrations of HCL activator are as follows:

Table 3.Adsorption with various concentrations of HCL

Time (hour)	Initial conc (ppm)	Final conc (ppm)	Decreased conc (ppm)
1	100	0,76	99,23
2	100	0,66	99,34
3	100	0,38	99,62
4	100	0,32	99,68
5	100	0,29	99,71
6	100	0,29	99,71

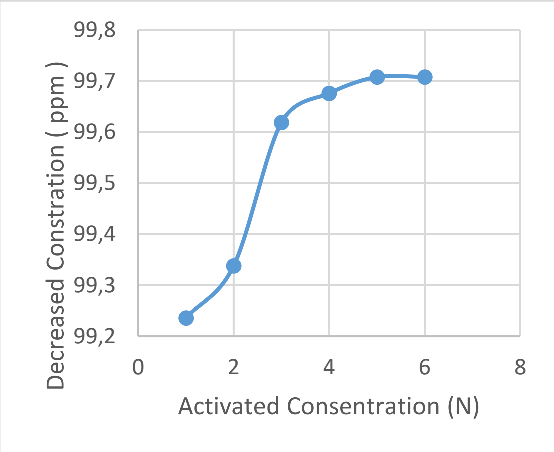

Figure 5.Adsorption with various concentrations of HCL.

CONCLUSION

Optimization of bagasse nanoporous activated carbon (Saccharum officianarum) including water content of 0.71%, ash content of 6.53% and absorption of I_2 938.42% complies with the Quality Standard of Activated Carbon according to SNI-06-3730-1995.The activation process of making nanoporous activated carbon from bagasse with time variations showed the highest absorbance at 3 hours was 99.68 ppm.

The activation process of making nanoporous activated carbon from bagasse using HCL solution activator showed no significant effect, that at a concentration of 5 N gave the highest absorbance was 99.71 ppm.

REFERENCES

Abdullah,M.,Virgus,Y.,Nirmin,&Khairurrijal. **2008**.Review : *Sintesis Nanomaterial. Jurnal Nanosains & Nanoteknologi,*1(2),33-57.

Andaka, G. **2011**. *"Hidrolisis Ampas Tebu Menjadi Furfural dengan Katalisator Asam Sulfat". Jurnal Teknologi*, 4(2) : 180 – 188.

Badan Pusat Statistik Indonesia. **2015**.*Statistik Tebu Indonesia 2015.*Jakarta: Suryamin.

Fazlzadeh,M.,Rahmani,K.,Zarei,A.,Abdoallahzadeh,H.,Nasiri,F.,&Khosravi. **2016**. *A Novel Green synthesis of zero valent iron nanoparticles (NZVI) using three plant extract and their efficient aplication for removal of Cr (VI) from aqueous solutions.Advanced Powder Tecnology.*

Mystrioti,C.,Xanthopoulou,T.D.,Tsakiridis,P.E.,Papassiopi,N.,&Xenidis,A. **2016** . *omparative Evaulation of five plant extracts and juices for nanoiron synthesis anfd apllication for hexavalent chromium reduction.Science of the total enviromental* ,539,105-113.

Narimo, Sajidan, Masykuri, M. dan Sri Budiastuti. **2019**.*"Sugar cane Bagasse Wastes as Activated Charcoal Nanpore Powder and Tablets for Adsorption Heavy Metal Pb(II) Wsate"* AIP *Conference Proceedings* 2202,020073.

Nurdila, F.A., N.S.Asri. dan E. Suharyadi. **2015**. "Adsorpsi Logam Tembaga (Cu), Besi (Fe), dan Nikel (Ni) dalam Limbah Cair Buatan Menggunakan Nanopartikel Cobalt Ferrite ($CoFe_2O_4$)". *Jurnal Fisika Indonesia,* 19(55) : 23 – 27.

Purnawan, C., D. Hilmiyana. dan E. Fatmawati. **2012**. *"Pemanfaatan Limbah Ampas Tebu untuk Pembuatan Kertas Dekorasi dengan Metode Organosolv". Jurnal Ekosains*, 4(2) : 1 - 6.

Salihi, I.U., Kutty, S.R.M. and M .H. Isa. **2017**. *" Adsorption of Lead ions onto Actived Carbon Derived from Sugarance Bagasse"*. Makalah disajikan dalam 7th International Conference on Key Engeneering Materials. Malaysia.

Soliemanzadeh, A., & Fekri,M. **2017**. *The Application of Green tea extract to prepare bentonite-supported nanoscale zero-valent iron and its perfomance on removal of Cr (VI);Effect of relative parameters and soil experiments.Microporous and mesoporous Materials*,239,60-69.

Yang, J. Liu, J. Chen, X. Hu, Z. Zhao, G. **2008**, *Carbone Electrode Material with High Densities of Energi and Power, Acta Physica-Chimica Sinica*, 24: (13-19).

Yuvakkumar,R,Elango,V.,Rajendran, V.,&Kannan,N. **2011**. *Preparation and Characterization of Zero Valent Iron. Digest Journal of Nanomaterials and Biostructures*, 6(4),1771-1776.

Zhou, B. F.H., and Luo, Y. **2009**. Ultrasound echance sanitizer efficacyin reductio of Escherichia coli 0157: H7 population on spinach leaves. Journal of Food Science 74 : 308-13.