

Kinetic Study of Adsorption Active Carbon Cassava Skin for Removal of Acetic Acid from Aqueous Solution

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Abstract—The amount of liquid wastes containing acetic acid found from food industry such as tofu home industry released is relatively high and pollutes water quality and also environment nearby. Several methods reducing pollutant in liquid wastes are available, one of which is adsorption using carbon as an adsorbent. The production of cassava in Indonesia was about 23.936 tons in year 2013 which produced cassava's skin wastes about 2.393 tons. Mostly these cassava's skin wastes containing around 59.31% carbon is disposed as garbage. This research is to develop more on reducing acetic acid containing in liquid waste by carbon active from cassava's skin with variation of particle sizes, reaction times and acetic acid liquid waste concentrations, and also to study the kinetic reaction of cassava skin active carbon adsorbing acetic acid between Freundlich and Langmuir isotherm equations. The result shows the kinetic adsorption follows Freundlich isotherm equation with maximum capacity of Cassava skin active carbon 0.7 mg/g at particle size of adsorbent of 0.3375 mm and reaction time of 105 minutes.

Keywords—Cassava Skin Wastes, Active Carbon, Adsorption, Kinetic Study.

I. Introduction

Tofu industry generally produces liquid waste containing organic acid mainly acetic acid. The presence of acetic acid in excessive amount will cause pollutant in water sources and produces smell stink, increases soil acidity and decreases water pH. Carbon or graphite as an adsorbent is one of several methods of adsorption for removal organic acid [1], [2].

Indonesia produces large amount of cassava and in year 2013 was totally around 23.936 million tons with the conversion of about 2.292 million tons as cassava's skin solid waste [3]. This solid waste was mainly disposed as garbage. In fact, it can be converted into active carbon material and hence has more added values.

Based on previous experimental result [3], [4], cassava's skin active carbon is able to decrease heavy metal such as Pb ion in a solution. Cassava skin consists of protein, non-reduction cellulose and highly cyanic acid fiber with functional groups of $-OH$, $-NH_2$, $-SH$, and $-CN$ which bonds metals [5]-[7].

In this work, we report an investigation of active carbon from cassava's skin solid waste and its application for removal acetic acid from industrial liquid waste and to find its maximum adsorption capacity in accordance with Freundlich or Langmuir isotherm equations.

II. Research Methodology

A. Producing charcoal from cassava skin and activating it into active carbon.

Cassava's skin was oxidized by burning without excess of oxygen and activated using NaOH 1N solution for 24 hours. The product was neutralized by washing with distilled water until neutral pH, dried in an oven for 100°C, grinded and sieved to obtain particle size of 0.8, 0.55, 0.4625, 0.3375 and 0.1875 mm.

B. Preparing liquid waste containing acetic acid

One liter of acetic acid solution with concentration of 2N was made from acetic acid glacial 100% and diluted

to be 0.5, 0.75, 1, 1.25 and 1.5N in concentration as simulated liquid waste acetic acid.

C. Adsorption tests

About 5 grams of active carbon with particle size of 0.8, 0.55, 0.4625, 0.3375 and 0.1875 mm was placed into each five 250 ml Erlenmeyer flasks. 100 ml simulated sample with concentration of 1N was added into each flasks and shaken it for 15 minutes. The solution was then filtered out from the solid using filter paper and 25 ml of titrant was titrated by 1N NaOH solution and finally its final concentration was calculated. The similar procedure is repeated but using the best particle size obtained from the previous experiment with variation of reaction times for 45, 75, 105, and 135 minutes respectively. The optimal reaction time was determined with the highest amount of adsorbed being absorbed by adsorbent.

The next step is almost similar with the previous procedure but implementing different concentration of acetic acid using the best particle size of adsorbent and the optimal reaction time obtained.

Kinetic reaction model of adsorption [8] given by the following equations:

Langmuir isotherm:

$$Q = \frac{b \cdot K \cdot Ce}{1 + K \cdot Ce} \dots\dots\dots(1)$$

Freundlich isotherm:

$$Q = K \times Ce^{1/n} \dots\dots\dots(2)$$

III. Results and Discussion

A. Optimasing adsorbent

Table 1 and Fig.1 show relation between particle size of adsorbent and absorptivity. The optimum absorptivity found at particle size of 0.3375 mm and it will be used for conducting further experiment with reaction times variation of 45, 75, 105, and 135 minutes.

Table 1. Calculation data of absorptivity for several particle sizes of adsorbent

Particle size (mm)	Weight adsorbent (g)	Initial concentration of acetic acid, Co (N)	Final concentration of acetic acid, Ce (N)	Absorptivity, Qe (mg/g)
0.8	5.0073	1	0.912	105.5339

0.55	5.0011	1	0.876	148.8912
0.4625	5.002	1	0.872	153.6665
0.3375	5.0014	1	0.858	170.4943
0.1875	5.0067	1	0.856	172.7126

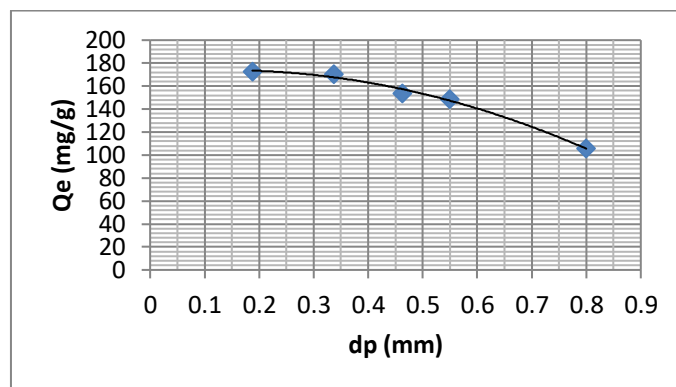


Figure 1. Correlation between particle size and absorptivity

B. Reaction time optimization

Table 2 shows the equilibrium adsorption of active carbon from cassava skin at different reaction times. The equilibrium adsorption was obtained at 105 minutes.

Table 2. Equilibrium adsorption of adsorbent at different time reaction.

Reaction time (mins)	Initial acetic acid concentration (N)	Final acetic acid concentration, Ce (N)	Acetic acid adsorbed (N)	Equilibrium adsorption, Q (mg/g)
15	1	0.876	0.124	148.8674
45	1	0.858	0.142	170.4943
75	1	0.852	0.148	177.5740
105	1	0.848	0.152	182.5228
135	1	0.848	0.152	182.5301

C. Acetic acid liquid wastes concentration

At different liquid waste concentration, the equilibrium adsorption is shown in Table 2. Both Freundlich and Langmuir isotherm equation (1 & 2) can be mathematically converted into equation (3 & 4) as following:

Langmuir isotherm:

$$Q = \frac{b \cdot K \cdot Ce}{1 + K \cdot Ce} \dots\dots\dots(1)$$

$$\frac{Ce}{Q} = \frac{1}{K \cdot b} + \frac{1}{b} Ce \dots\dots\dots(3)$$

Freundlich isotherm:

$$Q = K \times Ce^{1/n} \dots\dots\dots(2)$$

$$\text{Log } Q = \text{Log } K + \frac{1}{n} \text{Log } Ce \dots\dots\dots(4)$$

Plotting equation (3) and equation (4) will determine the fit between Freundlich and Langmuir isotherm and hence its maximum adsorption capacity can be calculated.

Table 3. Equilibrium adsorption of adsorbent at different liquid waste concentration.

Initial acetic acid concentration (N)	Final acetic acid concentration, Ce (N)	Acetic acid adsorbed (N)	Equilibrium adsorption, Q (mg/g)	Ce/Q	Log Ce	Log Q
0.5	0.444	0.056	67.2224	0.0066	-0.3526	1.827514
0.75	0.652	0.098	117.6839	0.0055	-0.1858	2.070717
1	0.848	0.152	182.5228	0.0046	-0.0716	2.261317
1.25	1.048	0.202	242.3354	0.0043	0.02036	2.384417
1.5	1.246	0.254	304.8650	0.0041	0.09552	2.484108
2	1.642	0.358	429.6658	0.0038	0.21537	2.633131

D. Analysis of adsorption capacity of adsorbent.

Applying equation (3) will result a linear line, however Fig. 2 shows a curve line. This indicates that Langmuir equation does not fit to the adsorption isotherm of active carbon from cassava skin.

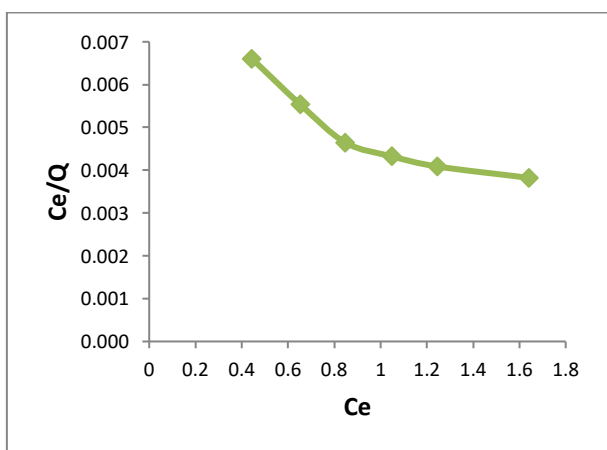


Figure 2. Effect of liquid waste concentration for Langmuir isotherm

On the other hand, plotting equation (4) shows a linear line (Fig. 3). This indicates adsorption isotherm of active carbon from cassava skin is fit with the Freundlich equation. The maximum adsorption capacity calculated is 0.7 mg/g.

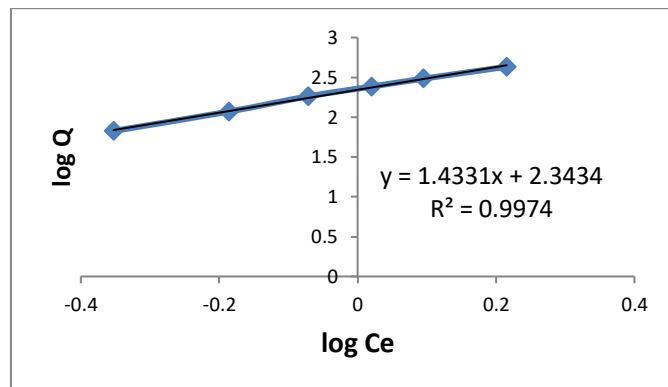


Figure 3. Effect of liquid waste concentration for Freundlich isotherm.

IV. Conclusion

Active carbon from cassava skin can be used to decrease the amount of acetic acid contained in liquid waste. The optimum particle size of the active carbon is 0.3375 mm for reaction time of 105 minutes will produce the adsorption capacity of 0.7 mg/g.

Acknowledgement

Authors would like to thank to our former student Reinal and Artia who have assisted this experimental research. Finally, authors would also like to thank to Politeknik Negeri Ujung Pandang for providing the fund and laboratory facilities to conduct this research.

References

- [1] T. Szabo, A. Szeri, I. Decany, "Composite graphitic nanolayers prepared by self-assembly between finely disperse graphitic oxide and a cationic polymer", Carbon 43, pp. 87-94. 2005.
- [2] Hessler, J.W., "Active Carbon", Chemical Publishing Co Inc., 1951.
- [3] Hartono Tri, Murdiningsih Hastami, HR Yuliani, "Uji Persamaan Langmuir dan Freundlich pada Penjerapan Logam Berat (Ion Pb) dalam Limbah Cair oleh Arang Aktif Kulit Singkong", (Langmuir and Freundlich Equation Test on the Adsorption of Heavy Metals (Pb Ions) in Liquid Waste by Cassava Peel Activated Charcoal), Prosiding Seminar Hasil Penelitian (SNP2M), 1-6, 2020, 978-602-60766-9-4, Makassar: Politeknik Negeri Ujung Pandang.

- [4] Hutapea, Kartini Efridawati, "Penyisihan Kadar Logam Fe dan Mn dari Air Sumur dengan Menggunakan Kulit Singkong Sebagai Adsorben", (Removal of Fe and Mn Metal Levels from Well Water by Using Cassava Peel as an Adsorbent), 2018. <http://repositori.usu.ac.id/handle/123456789/11642>
- [5] Castellan G.W., Physical Chemistry Third Edition. New York: General Graphic Services, 1982.
- [6] Manes, M., Activated carbon adsorption fundamental, in Meyers RA, editor, Encyclopedia of Environmental Analysis and Remediation, Volume 1, J Wiley, New York, 1998.
- [7] Tri Hartono, S. Wang, Qing Ma, Z.H.Zhu, J. Colloid and Interface Science, 118, pp. 114-119. 2009.