



Digital Receipt

This receipt acknowledges that Turnitin received your paper. Below you will find the receipt information regarding your submission.

The first page of your submissions is displayed below.

Submission author: Widi Astuti
Assignment title: Synthesis of magnetically separable...
Submission title: Teak leaf-based activated carbon fo...
File name: 2019_jbat.pdf
File size: 1.05M
Page count: 7
Word count: 3,129
Character count: 16,115
Submission date: 22-Mar-2021 11:23AM (UTC+0700)
Submission ID: 1539002447



JBAT 8(1) (2019) 52 – 58
p-ISSN 2303-0623
e-ISSN 2407-2370

Jurnal Bahan Alam Terbarukan

Terakreditasi: SK No.: 36b/E/KPT/2016
<http://journal.umnes.ac.id/index.php/jbat>

Teak Leaf-Based Activated Carbon for Phosphate Removal
Widi Astuti[✉], Luluk Siti Zulaechah, Lian Kristian
DOI 10.15294/jbat.v8i1.20169
Chemical Engineering Department, Universitas Negeri Semarang, Indonesia

Article Info	Abstract
Article history: Received: November 2018 Accepted: April 2019 Published: June 2019 Keywords: Adsorption; Adsorbent; Microwave; Isotherm; Kinetic	The use of detergent predictably causes large quantities of phosphate ion in water bodies. It is considered to trigger eutrophication, that causes a severe reduction in water quality. Adsorption using activated carbon is one of the effective methods for the removal of phosphate from wastewater. Recently, the use of microwave irradiation in activated carbon preparation is a promising alternative to replace conventional heating using a furnace. In this study, the use of microwave heating was compared to conventional heating. The result showed that pore of activated carbon was larger than that of the char and the activated carbon prepared using 30% of ZnCl ₂ had the adsorption performance higher than that of prepared using 20% of ZnCl ₂ . The optimum adsorption occurred at pH 4 and the equilibrium was reached after 180 minutes. The Langmuir equilibrium model was more appropriate than the Freundlich equilibrium model. While the kinetics model analyzed using pseudo-first-order, pseudo-second-order, internal diffusion, and external diffusion indicated that the pseudo second-order was most suitable for the adsorption of phosphate by teak leaf activated carbon.

INTRODUCTION

The use of detergent increases with the increase in laundry industries. It predictably causes large quantities of phosphate ion in water bodies. Phosphate is a necessary nutrient for the growth of plants. However, the higher phosphate content is considered to trigger eutrophication, that causes a severe reduction in water quality (Yuan et al., 2019). Numerous methods have been developed to overcome phosphate pollution in wastewaters including electrocoagulation (Hashim et al., 2019), chitosan membrane (Karthikeyan et al., 2019) and adsorption (Yuan et al., 2019). Among of them, adsorption using activated carbon was the most effective method for the removal of phosphate from wastewater due to its effectiveness, low cost, facile design, and easy to operate (Yuan et al., 2019).

On the other hand, teak leaf waste has a high content of cellulose (28.2%), lignin (29.5%) and hemicellulose (6.8%) that can be used as a precursor in the activated carbon production. The structure and characteristic of activated carbon are affected by the chemical composition of precursor and activation process, including the activating agent used. In this sense, the use of ZnCl₂ as an activating agent has been preferred due to the higher surface area obtained (Pezoti et al., 2014). Recently, the use of microwave irradiation is a promising alternative to replace conventional heating using a furnace. Microwave heating is internal and volumetric, where electromagnetic energy is converted to the thermal energy at a molecular level. As a result, it provides a shorter processing time and more uniform pore. The microwave heating has been successfully used in the preparation of activated carbon from pineapple leaf with ZnCl₂ activation (Mahamad et al., 2015). However, there has been no literature that particularly investigated the activated carbon preparation from the teak leaf.

Hence, the objective of this study was to prepare activated carbon from the teak leaf by ZnCl₂ activation. Several variables have been studied,

[✉]Corresponding author:
Chemical Engineering Department
Universitas Negeri Semarang, Indonesia
E-mail: widi_astuti@mail.umnes.ac.id

ISSN 2303-0623
e-ISSN 2407-2370

Teak leaf-based activated carbon for phosphate removal

by Widi Astuti

Submission date: 21-Mar-2021 09:23PM (UTC-0700)

Submission ID: 1539002447

File name: 2019_jbat.pdf (1.05M)

Word count: 3129

Character count: 16115



Teak Leaf-Based Activated Carbon for Phosphate Removal

Widi Astuti[✉], Luluk Siti Zulaechah, Lian Kristian

DOI 10.15294/jbat.v8i1.20169

Chemical Engineering Department, Universitas Negeri Semarang, Indonesia

Article Info

Article history:
Received
November 2018
Accepted
April 2019
Published
June 2019

Keywords :
Adsorption;
Adsorbent;
Microwave;
Isotherm;
Kinetic

Abstract

The use of detergent predictably causes large quantities of phosphate ion in water bodies. It is considered to trigger eutrophication, that creates a severe reduction in water quality. Adsorption using activated carbon is one of the effective methods for the removal of phosphate from wastewater. Recently, the use of microwave irradiation in activated carbon preparation is a promising alternative to replace conventional heating using a furnace. In this study, the use of microwave heating was compared to conventional heating. The result showed that pore of activated carbon was larger than that of the char and the activated carbon prepared using 30% of $ZnCl_2$ had the adsorption performance higher than that of prepared using 20% of $ZnCl_2$. The optimum adsorption occurred at pH 4 and the equilibrium was reached after 180 minutes. The Langmuir equilibrium model was more appropriate than the Freundlich equilibrium model. While the kinetics model analyzed using pseudo-first order, pseudo-second-order, internal diffusion, and external diffusion indicated that the pseudo second order was most suitable for the adsorption of phosphate by teak leaf activated carbon.

INTRODUCTION

The use of detergent increases with the increase in laundry industries. It predictably causes large quantities of phosphate ion in water bodies. Phosphate is a necessary nutrient for the growth of plants. However, the higher phosphate content is considered to trigger eutrophication, that causes a severe reduction in water quality (Yuan et al., 2019). Numerous methods have been developed to overcome phosphate pollution in wastewaters including electrocoagulation (Hashim et al., 2019), chitosan membrane (Karthikeyan et al., 2019) and adsorption (Yuan et al., 2019). Among of them, adsorption using activated carbon was the most effective method for the removal of phosphate from wastewater due to its effectiveness, low cost, facile design, and easy to operate (Yuan et al., 2019).

On the other hand, teak leaf waste has a high content of cellulose (28.2%), lignin (29.5%) and hemicellulose (6.8%) that can be used as a precursor in the activated carbon production. The

structure and characteristic of activated carbon are affected by the chemical composition of precursor and activation process, including the activating agent used. In this sense, the use of $ZnCl_2$ as an activating agent has been preferred due to the higher surface area obtained (Pezoti et al., 2014). Recently, the use of microwave irradiation is a promising alternative to replace conventional heating using a furnace. Microwave heating is internal and volumetric, where electromagnetic energy is converted to the thermal energy at a molecular level. As a result, it provides a shorter processing time and more uniform pore. The microwave heating has been successfully used in the preparation of activated carbon from pineapple leaf with $ZnCl_2$ activation (Mahamad et al., 2015). However, there has been no literature that particularly investigated the activated carbon preparation from the teak leaf.

Hence, the objective of this study was to prepare activated carbon from the teak leaf by $ZnCl_2$ activation. Several variables have been studied,

[✉]Corresponding author:
Chemical Engineering Department
Universitas Negeri Semarang, Indonesia
E-mail: widi_astuti@mail.unnes.ac.id

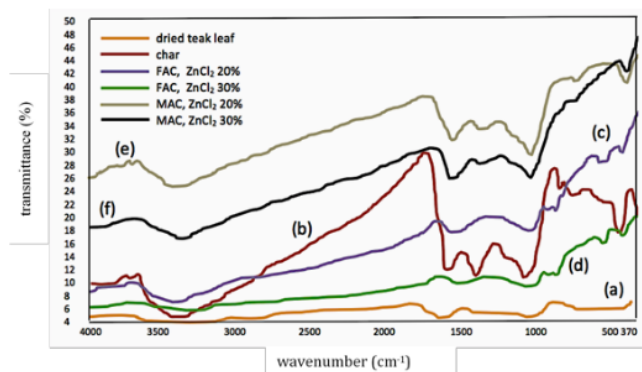


Figure 1. FTIR spectra of (a) teak leaf, (b) char, (c) FAC with $ZnCl_2$ 20%, (d) FAC with $ZnCl_2$ 30%, (e) MAC with $ZnCl_2$ 20% and (f) MAC with $ZnCl_2$ 30%

including the heating method and $ZnCl_2$ concentration. The obtained activated carbon was then evaluated for its feasibility as an adsorbent for phosphate removal in batch experiments. The effect of various contributing parameters to the adsorption performance, such as solution pH, initial concentration, and contact time have been investigated. The resulted data were further analyzed using two adsorption isotherm models (e.g. Langmuir and Freundlich) and five adsorption kinetic models (e.g. external diffusion, internal diffusion, pseudo-first-order, pseudo-second-order, and Elovich).

MATERIAL AND METHODS

Preparation of activated carbon

Teak leaf waste used in this study was obtained from Blora, Indonesia. Before any treatment, the leaf was cleaned, washed, heated at $110^\circ C$ in an oven until constant weight to remove the water content. The dried sample was then blended to a powder. The powder was entered to a furnace (Model FB1310M-33 Thermolyne, Thermo Scientific, USA) for carbonization at $500^\circ C$ for 2 hours. The sample obtained was mixed with $ZnCl_2$ as an activator agent under various concentration (20 and 30% mass), then heated using a furnace at $700^\circ C$ for 1.5 hours (FAC) or using 2.45 GHz commercial microwave oven (Model ME731K, Samsung, Malaysia) at 600 Watt for 10 minutes (namely MAC). Before microwave heating started and during the activation process, N_2 gas was flowed with a flow rate of $250\text{ cm}^3\text{ min}^{-1}$. After that, the activated carbon obtained was washed with HCl, rinsed with distilled water until the pH of the

filtrate was around 7 and heated in an oven at $110^\circ C$. Activated carbon was further analyzed the specific surface area through adsorption of N_2 at 77 K using an automated gas sorption apparatus (Quantachrome, USA) with BET (Brunauer-Emmett-Teller) method, the surface morphology using a Scanning Electron Microscope (Phenom X Desktop, UK), and the functional groups using Fourier Transform Infra-red Spectroscopy (Spectrum 100, Perkin Elmer, USA) recorded between 4000 and 400 cm^{-1} .

Batch adsorption studies

In the adsorption process, 0.05 gram of activated carbon was put into ten Erlenmeyer flasks filled with 50 mL of phosphate solution with different concentrations (10, 20, 30, 40, 50, 60, 70, 80, 90, and 100 mg/L). The degree of acidity (pH) of the solution was varied (2, 4, 6, 8, and 10) with the addition of 0.1 N HCl or 0.1 N NaOH. The mixture was then placed in the shaker and shaken at 250 rpm for 5-240 minutes. After the adsorption time was reached, the solution was filtered and the filtrate was analyzed for residual phosphate using a UV-Visible spectrophotometer (Model Genesys 10UV, Thermo Scientific, USA) at $\lambda_{\text{max}} 880\text{ nm}$.

RESULTS AND DISCUSSION

Characterization of activated carbon

The existence of functional groups in the char, MAC, and CAC was analyzed from FTIR spectra, recorded between $4000\text{--}370\text{ cm}^{-1}$ as can be seen in Figure 1. A wide absorption peak at 3426.54 cm^{-1} (Figure 1(a)) indicated the presence of -OH groups derived from cellulose and lignin (Njoku et al., 2014). The presence of $-C=O$ functional group

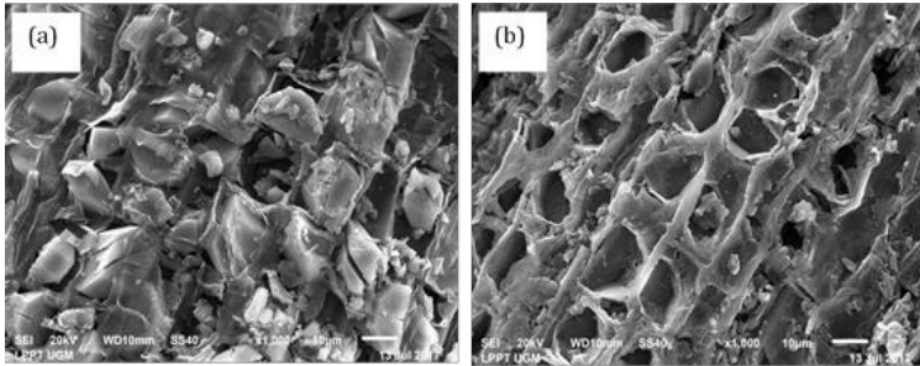


Figure 2. SEM from (a) char and (b) MAC with ZnCl₂ 30%

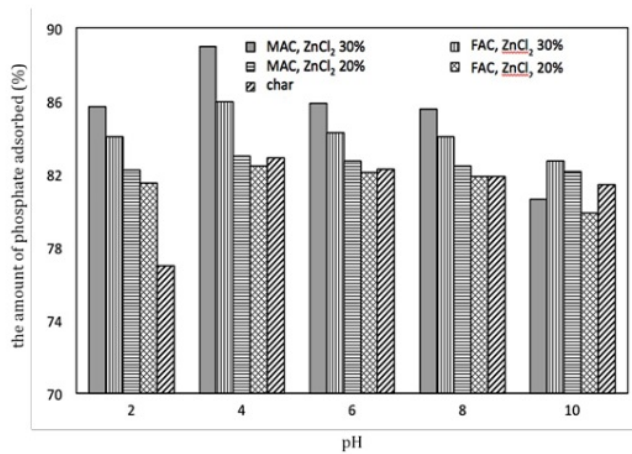


Figure 3. Effect of pH to the amount of phosphate adsorbed (time: 240 min, phosphate concentration: 100 mg/L, adsorbent dose: 0.05 gram)

derived from lignin³⁷ was indicated by an absorption peak at 1320.86 cm⁻¹ while the presence of -C-O-C groups derived from cellulose was indicated by absorption peak at 1065.04 cm⁻¹. The peak observed at 1640.07 cm⁻¹ may be attributed to the C=C group indicated the presence of carbon chains on the teak leaves before the carbonization process. After the carbonization process (Figure 1(b)), the position and intensity of some peaks being changed. Peak around 3426.54 cm⁻¹ shift to 3416.53 cm⁻¹, peak around 1065.04 cm⁻¹ shift to 871.76 cm⁻¹ and peak around 1640.07 cm⁻¹ shift to 1610.94 cm⁻¹, indicating the dissolution of several carbon bonds. It led to the formation of the new pores. Figure 1(f) shows that chemical activation process with ZnCl₂ 30% using microwave heating produced the best character compared to other treatment because it has the highest Zn-O group which can help in the adsorption process, indicated by an absorption peak at 470.58 cm⁻¹.

BET surface area of char and MAC with ZnCl₂ 30% was 6.69 m²/g and 219.79 m²/g, respectively. The larger surface area led to the higher phosphate adsorbed, so the use of microwave heating is a promising alternative.

The morphology of char and MAC with ZnCl₂ 30% was described in Figure 2. Char produced from teak leaf without activation (Figure 2(a)) had several pores, but the pore size was small and several pores were blocked by tarry substances. Whereas, MAC with ZnCl₂ 30% (Figure 2(b)) had a larger and uniform pore size.

36 Adsorption performance of activated carbon

The adsorption performance of activated carbon toward phosphate was²⁹ lied by varying pH, initial concentration, and contact time. The effect of pH on the amount of phosphate adsorbed was described in Figure 3. In a certain pH range (2-10), the amount of phosphate adsorbed increased

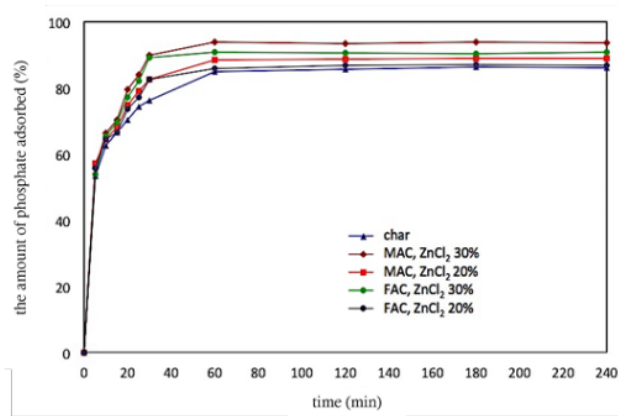


Figure 4. Effect of contact time to the amount of phosphate adsorbed (pH: 4, phosphate concentration: 100 mg/L, adsorbent dose: 0.05 gram).

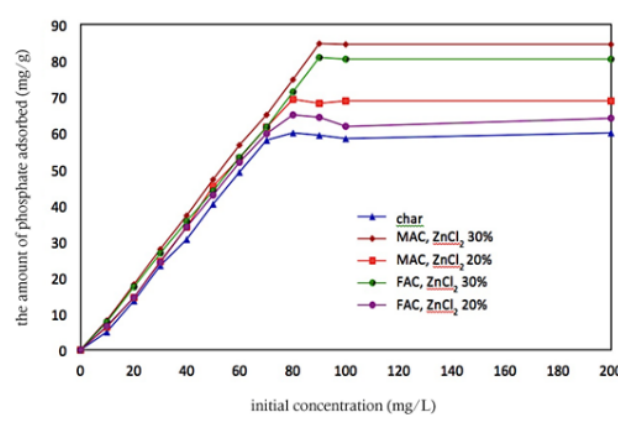


Figure 5. Effect of initial concentration to the amount of phosphate adsorbed (pH: 4, time: 240 min, adsorbent dose: 0.05 gram).

with the increasing pH up to certain pH value and then decreased with further increasing pH. The decreasing may be related to the formation of negative surface charges on the activated carbon, which was influenced by the solution pH. In the acid medium (pH 4), the positively charged species start dominating and activated carbon surface disposed to acquire positive charge while the adsorbate species (i.e. phosphate) have negatively charged. As a result, the electrostatic attraction between the active site in the adsorbent surface and phosphate molecules was dominating. The increase of solution pH led to the decrease of positively charged species and activated carbon surface disposed to acquire the negative charge. It caused the decrease of phosphate adsorbed due to electrostatic repulsive between negatively charged of activated carbon surface and negatively charged

of phosphate molecules. While the amount of phosphate adsorbed at pH 2 was lower than that of at pH 4. It may be due to in the lower pH, phosphate disposed to form phosphoric acid (H_3PO_4) having larger molecule size, so the effectiveness of the adsorption process decreased. The amount of phosphate adsorbed by MAC with $ZnCl_2$ 30% was higher than that of by $ZnCl_2$ 20% due to the greater concentration of $ZnCl_2$ used led to the larger of pores size of activated carbon.

The microwave heating technique was seen more effective than the furnace heating technique due to microwave heating was internal and volumetric so the pore size produced is more uniform. It led to the phosphate adsorbed increased.

The effect of contact time toward the amount of phosphate adsorbed describes in Figure 4. The phosphate adsorption process was rapid at

the initial stage, but it gradually slowed down until the equilibrium was reached. It may be due to a large number of vacant active sites were available for phosphate adsorption during the initial stage, and after a lapse of time, the remaining vacant surface sites were difficult to be occupied due to repulsive forces between the solute molecules on the solid and bulk phases. Once equilibrium was attained, the amount of phosphate adsorbed was constant.

The effect of initial concentration on the phosphate adsorption was investigated at pH 4 in the range of concentration 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, and 200 mg/L, as can be seen in Figure 5. The amount of phosphate adsorbed increased with the increase of initial concentration and remain constant after equilibrium reached. The initial concentration provides an important driving force to overcome all mass transfer resistance of phosphate between the aqueous and solid phase. Hence, the higher initial concentration of phosphate will enhance the adsorption process.

Adsorption isotherm

Adsorption isotherm was used to describe the adsorption mechanism of phosphate molecules on the activated carbon surface. In this study, the Langmuir and Freundlich isotherm model has been studied. The Langmuir isotherm, based on the fact that the monolayers adsorption occurs in homogeneous sites on the adsorbent surface, was given by Eq. (1) (Astuti et al., 2017).

$$C_{\mu} = \frac{C_{\mu m} K_L C_e}{1 + K_L C_e} \tag{1}$$

where K_L is the adsorption equilibrium constant (L/mg), $C_{\mu m}$ is the amount of phosphate required to form a monolayer on unit mass of adsorbent (mg/g) and C_{μ} is the amount phosphate adsorbed on unit mass of the adsorbent (mg/g) when the equilibrium concentration is C_e (mg/L) which is defined as Eq. (2) as follows (Astuti et al., 2017):

$$C_{\mu} = \frac{C_i - C_e}{m} \times V \tag{2}$$

where C_i is the initial concentration of phosphate in aqueous solution (mmol/L), C_e is the concentration of phosphate in the solution at equilibrium (mmol/L), V is the volume of phosphate solution (L) and m is the mass of activated carbon (g).

Rearrange of Eq. (1) to the linear form is given by Eq. (3) as follows (Astuti et al., 2017):

$$\frac{C_e}{C_{\mu}} = \frac{1}{C_{\mu m}} C_e + \frac{1}{K_L C_{\mu m}} \tag{3}$$

A plot of C_e/C_{μ} versus C_e should yield straight line if Langmuir isotherm is obeyed by the adsorption equilibrium data. The value of $C_{\mu m}$ and K_L can be calculated from the slope and intercept of the graphed line, respectively. In contrast to the Langmuir model, Freundlich isotherm based on the fact the presence of energetically heterogeneous adsorption sites, which is defined as Eq. (4) while the linear form is given by Eq. (5).

$$q_e = k_F C_e^{1/n} \tag{4}$$

$$\log q_e = \log K_F + 1/n \log C_e \tag{5}$$

where K_F (L/g) and n are the Freundlich equilibrium constants. The value of K_F and n can be calculated from the slope and intercept of the graphed line of Eq. (5), respectively. The value of Langmuir, and Freundlich constants and correlation coefficients on the linear regression can be seen in Table 1. Data in Table 1 shows that the Langmuir model is seen in accordance with the experimental data due to the correlation coefficient for the Langmuir isotherm is closer to unity than that of Freundlich isotherms. It is an indication of high chemical interaction between active sites on the activated carbon and phosphate molecules.

Table 1. Isotherm constants and correlation coefficient for phosphate adsorption onto activated carbon from teak leaves.

Isotherm parameter	Value
Langmuir	
$C_{\mu m}$	0.9241
K_L	24.372
R^2	0.9769
Freundlich	
K_F	1.4811
N	2.5139
R^2	0.4027

Adsorption kinetics

In this study, five kinetics models were analysed, including external diffusion, internal diffusion, pseudo-first-order, pseudo-second-order, and elovich. The linear form of the models was

Table 2. Kinetics model constants and correlation coefficient for phosphate adsorption onto Activated Carbon from Teak Leaves.

Isotherm parameter	Value
External diffusion	
A'	0.3107
k_f	1.9652×10^{-05}
R^2	0.739
Internal diffusion	
k_{id}	7.0049
R^2	0.5574
Pseudo first order	
q_e	21.301
k_1	0.0253
R^2	0.8297
Pseudo second order	
q_e	85.4701
k_2	0.0041
R^2	0.9996
Elovich	
A	65.708
B	0.0715
R^2	0.8144

expressed by Eq. (6)-(10), respectively (Astuti et al., 2017).

$$\ln \left[\left(\frac{C_t}{C_i} \right) - \left(\frac{A'}{m_s K_L} \right) \right] = \ln A' - \left(\frac{k_f S_s}{A'} \right) t \quad (6)$$

$$\log q_t = \log k_{id} + \frac{1}{2} \log t \quad (7)$$

$$\log(q_e - q_t) = \log q_e - \left(\frac{k_1}{2,303} \right) t \quad (8)$$

$$\frac{t}{q_t} = \left(\frac{1}{k_2 q_e^2} \right) + \left(\frac{1}{q_e} \right) t \quad (9)$$

$$q_t = \left(\frac{1}{\beta} \right) \ln(\alpha\beta) + \left(\frac{1}{\beta} \right) \ln t \quad (10)$$

where C_i (mmol/L) is the concentration of phosphate in aqueous solution at the time t , k_f is the external mass transfer coefficient (L/mg), m_s is the concentration of adsorbent in the liquid phase (mg/L), S_s is particle surface area (cm²), q_e and q_t are the amount of phosphate adsorbed at equilibrium (mg/g) and at time t (mg/g), respectively, k_{id} is the rate constant of intraparticle diffusion, k_1 is the rate constant of pseudo-first-order model (min⁻¹), k_2 is the rate constant of pseudo-second-order model (g/mg min), α and β are Elovich constants and t is time (min). While m_s and A' is given by Eq. (11) and (12), respectively (Astuti et al., 2017).

$$m_s = \frac{m}{V_s} \quad (11)$$

$$A' = \frac{m_s K_L}{1 + m_s K_L} \quad (12)$$

The value of the kinetic models constant can be calculated from the slope and intercept of the graphed line of Eq. (6)-(10), and the result was described in Table 2. Data in Table 2 shows that pseudo-second-order model is seen in accordance with experimental data due to the correlation coefficient is closer to unity than the others.

CONCLUSIONS

MHAC with ZnCl₂ 30% is the best characteristic, and it leads to higher adsorption performance. The optimum adsorption occurred at pH 4, and the equilibrium was reached after 180 minutes. The Langmuir equilibrium model was more appropriate than the Freundlich equilibrium model. While the kinetics model analyzed using pseudo-first-order, pseudo-second-order, internal diffusion, and external diffusion indicated that the pseudo-second-order was most suitable for the adsorption of phosphate by teak leaf activated carbon.

REFERENCES

- Astuti, W., Sulistyarningsih, T., Maksiola, M. 2017. Equilibrium and kinetics of adsorption of methyl violet from aqueous solutions using modified ceiba pentandra sawdust. *Asian Journal of Chemistry*. 29(1): 133-138.
- Hashim, K.S, Al Khaddar, R., Jasim, N., Shaw, A., Phipps, D., Kot, P., Pedrola, M.O., Alattabi, A.W., Abdulredha, M., Alawsh, R. 2019. Electrocoagulation as a green technology for phosphate removal from river water. *Separation and Purification Technology*. 210: 135-44.
- Karhikeyan, P., Banu, H.A.T., Meenakshi, S. 2019. Removal of phosphate and nitrate ions from aqueous solution using La³⁺ incorporated chitosan biopolymeric matrix membrane. *International Journal of Biological Macromolecules*. 124: 492-504.
- Mahamad, M.N., Zaini, M.A.A., Zakaria, Z.A. 2015. Preparation and characterization of activated carbon from pineapple waste biomass for dye removal. *International Biodeterioration & Biodegradation*. 102: 274-80.
- Njoku, V.O., Foo, K.Y., Asif, M., Hameed, B.H. 2014. Preparation of activated carbons from rambutan (*Nephelium Lappaceum*) peel by microwave-induced KOH activation for acid yellow 17 dye adsorption. *Chemical Engineering Journal*. 250: 198-204.
- Pezoti, O., Cazetta, A.L., Souza, I.P.A.F., Bedin, K.C., Martins, A., Silva, T.L., Almeida, V.C. 2014. Adsorption studies of methylene blue onto ZnCl₂-activated carbon produced from buriti shells (*Mauritia Flexuosa L.*). *Journal of Industrial and Engineering Chemistry*. 20: 4401-7.
- Ling, Y., Qiu, Z., Yuan, L., Tariq, M., Lu, Y., Yang, J., Li, Z., Lyu, S. 2019. Adsorption and mechanistic study for phosphate removal by magnetic Fe₃O₄-doped spent FCC catalysts adsorbent. *Chemosphere*. 219: 183-90.

Teak leaf-based activated carbon for phosphate removal

ORIGINALITY REPORT

18%

SIMILARITY INDEX

8%

INTERNET SOURCES

13%

PUBLICATIONS

8%

STUDENT PAPERS

PRIMARY SOURCES

- 1** Uheida, A.. "Sorption of palladium(II), rhodium(III), and platinum(IV) on Fe³O₄ nanoparticles", Journal of Colloid And Interface Science, 20060915 **1%**

Publication
- 2** Njoku, V.O., K.Y. Foo, M. Asif, and B.H. Hameed. "Preparation of activated carbons from rambutan (Nephelium lappaceum) peel by microwave-induced KOH activation for acid yellow 17 dye adsorption", Chemical Engineering Journal, 2014. **1%**

Publication
- 3** Maryam Mohamed, Sabeha K. Ouki. "Kinetic and Removal Mechanisms of Ethylbenzene from Contaminated Solutions by Chitin and Chitosan", Water, Air, & Soil Pollution, 2011 **1%**

Publication
- 4** www.scientific.net **1%**

Internet Source
- 5** I. Yilmaz Ipek, N. Kabay, M. Yuksel, Ö.

Kirmizisakal, M. Bryjak. "REMOVAL OF BORON FROM BALÇOVA-IZMIR GEOTHERMAL WATER BY ION EXCHANGE PROCESS: BATCH AND COLUMN STUDIES", Chemical Engineering Communications, 2008

Publication

1%

6

Submitted to Sriwijaya University

Student Paper

1%

7

microbes.scienceresearchlibrary.com

Internet Source

1%

8

Submitted to Coventry University

Student Paper

1%

9

Achmad Syafiuddin, Salmiati Salmiati, Tony Hadibarata, Ahmad Beng Hong Kueh, Mohd Razman Salim, Muhammad Abbas Ahmad Zaini. "Silver Nanoparticles in the Water Environment in Malaysia: Inspection, characterization, removal, modeling, and future perspective", Scientific Reports, 2018

Publication

1%

10

Muthanna J. Ahmed. "Application of agricultural based activated carbons by microwave and conventional activations for basic dye adsorption: Review", Journal of Environmental Chemical Engineering, 2016

Publication

1%

11	escholarship.org Internet Source	1%
12	innspub.net Internet Source	1%
13	Submitted to University of Birmingham Student Paper	1%
14	Submitted to Pandit Deendayal Petroleum University Student Paper	1%
15	Submitted to Mahidol University Student Paper	<1%
16	Submitted to SASTRA University Student Paper	<1%
17	Submitted to Sardar Vallabhbhai National Inst. of Tech.Surat Student Paper	<1%
18	Submitted to Indian School of Mines Student Paper	<1%
19	patents.justia.com Internet Source	<1%
20	Submitted to Bronx High School of Science Student Paper	<1%
21	Y Yalçinkaya, L Soysal, A Denizli, M.Y Arıca, S Bektaş, Ö Genç. "Biosorption of cadmium from	<1%

aquatic systems by carboxymethylcellulose and immobilized *Trametes versicolor*",
Hydrometallurgy, 2002

Publication

22

A Saglam, Y Yalçinkaya, A Denizli, M.Y Arica, Ö Genç, S Bektas. "Biosorption of mercury by carboxymethylcellulose and immobilized *Phanerochaete chrysosporium*", *Microchemical Journal*, 2002

<1%

Publication

23

Pascal S. Thue, Glaydson S. dos Reis, Eder C. Lima, Joseph M. Sieliechi et al. "Activated carbon obtained from sapelli wood sawdust by microwave heating for o-cresol adsorption", *Research on Chemical Intermediates*, 2016

<1%

Publication

24

Y Suma, N Pasukphun, N Eaktasang, P Laor. "Preliminary study of dye removal from aqueous solution using elephant dung activated carbon", *IOP Conference Series: Earth and Environmental Science*, 2019

<1%

Publication

25

Chang, C.F.. "Adsorption of naphthalene on zeolite from aqueous solution", *Journal of Colloid And Interface Science*, 20040901

<1%

Publication

26

Noroozifar, M.. "Adsorption behavior of Cr(VI)

on modified natural zeolite by a new bolaform
N,N,N,N',N',N'-hexamethyl-1,9-
nonanediammonium dibromide reagent",
Journal of Hazardous Materials, 20080715

Publication

<1%

27

Shaarani, F.W.. "Ammonia-modified activated
carbon for the adsorption of 2,4-dichlorophenol",
Chemical Engineering Journal, 20110501

Publication

<1%

28

Submitted to University of Wales Swansea

Student Paper

<1%

29

www.nmletters.org

Internet Source

<1%

30

Enmin Zong, Xiaohuan Liu, Jifu Wang,
Shenxiang Yang, Jinhua Jiang, Shenyuan Fu.
"Facile preparation and characterization of
lanthanum-loaded carboxylated multi-walled
carbon nanotubes and their application for the
adsorption of phosphate ions", Journal of
Materials Science, 2017

Publication

<1%

31

Genc, O.. "Uranium recovery by immobilized
and dried powdered biomass: characterization
and comparison", International Journal of
Mineral Processing, 200301

Publication

<1%

Rayane Sahmarani, Sopheak Net, Chaza

- 32 Chbib, Moomen Baroudi, Baghdad Ouddane. "Elimination of organochlorine pesticides from water by a new activated carbon prepared from Phoenix dactylifera date stones", Environmental Science and Pollution Research, 2020
Publication <1%
-
- 33 Yuli Utanto, Ghanis Putra Widhanarto, Yoris Adi Mareta. "A web-based portfolio model as the students' final assignment: Dealing with the development of higher education trend", AIP Publishing, 2017
Publication <1%
-
- 34 res.mdpi.com
Internet Source <1%
-
- 35 www.cheric.org
Internet Source <1%
-
- 36 Özgül Gerçel, H. Ferdi Gerçel. "Preparation and Characterization of Activated Carbon from Vegetable Waste by Microwave-Assisted and Conventional Heating Methods", Arabian Journal for Science and Engineering, 2015
Publication <1%
-
- 37 Sabyasachi Maiti, Somasree Ray, Balaram Mandal, Srimanta Sarkar, Biswanath Sa. "Carboxymethyl xanthan microparticles as a carrier for protein delivery", Journal of Microencapsulation, 2008 <1%

38

Yue Sun, Xinlei Feng, Weisheng Zheng.
"Nanoscale Lanthanum Carbonate Hybridized
with Polyacrylic Resin for Enhanced Phosphate
Removal from Secondary Effluent", Journal of
Chemical & Engineering Data, 2020

Publication

<1%

39

Liping Deng, Yingying Su, Hua Su, Xinting
Wang, Xiaobin Zhu. "Biosorption of copper (II)
and lead (II) from aqueous solutions by
nonliving green algae *Cladophora fascicularis*:
Equilibrium, kinetics and environmental effects",
Adsorption, 2006

Publication

<1%

Exclude quotes Off

Exclude matches Off

Exclude bibliography Off

Teak leaf-based activated carbon for phosphate removal

GRADEMARK REPORT

FINAL GRADE

/0

GENERAL COMMENTS

Instructor

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7
