

# C.2a.1.3-An insight into the adsorption behavior of malachite green on DABCO (1,4-.pdf

*By* Risfidian Mohadi

3

## An insight into the adsorption behavior of malachite green on DABCO (1,4-diazabicyclo[2.2.2]octane) modified bentonite

Tarmizi Taher, Lavini Indwi Saputri, Riza Antini, Afifah Rahma Dian, Risfidian Mohadi, and Aldes Lesbani

Citation: *AIP Conference Proceedings* **2026**, 020010 (2018); doi: 10.1063/1.5064970

View online: <https://doi.org/10.1063/1.5064970>

View Table of Contents: <http://aip.scitation.org/toc/apc/2026/1>

Published by the *American Institute of Physics*

---

---

**AIP** | Conference Proceedings

Get **30% off** all  
print proceedings!

Enter Promotion Code **PDF30** at checkout



# An Insight Into The Adsorption Behavior of Malachite Green on DABCO (1,4-diazabicyclo[2.2.2]octane) Modified Bentonite

Tarmizi Taher<sup>1)</sup>, Lavini Indwi Saputri<sup>2)</sup>, Riza Antini<sup>2)</sup>, Afifah Rahma Dian<sup>2)</sup>,  
Risfidian Mohadi<sup>2)</sup>, and Aldes Lesbani<sup>1,2,a)</sup>

<sup>1</sup>Department of Environmental Sciences, Graduate School of Sriwijaya University, Jl. Padang Selasa, No. 524, Bukit Besar, Palembang, South Sumatra, Indonesia

<sup>2</sup>Department of Chemistry, Faculty of Mathematics and Natural Sciences, Sriwijaya University, Jl. Palembang-Prabumulih, Km. 32, North Indralaya, South Sumatra, Indonesia

<sup>a)</sup>Corresponding author: [aldeslesbani@pps.unsri.ac.id](mailto:aldeslesbani@pps.unsri.ac.id)

**Abstract.** Organo modified bentonite was synthesized by replacing the exchangeable cation in the interlamellar space of bentonite with 1,4-diazabicyclo[2.2.2]octane (DABCO). The modified bentonite product was systematically studied for its adsorption behavior for removal of Malachite Green (MG) dye from aqueous solution. The change of bentonite nature, before and after modification was characterized with X-Ray diffraction analysis and FT-IR spectroscopy technique. The behavior of MG adsorption on the adsorbent was investigated in batch experiment method. Some effect of the operational parameters, including adsorbent dosage, contact time, and initial dye concentration were investigated. The result indicated that the removal of MG on the modified bentonite occurred in fast process in which the adsorption equilibrium time was achieved only within 10 to 20 min. The kinetics adsorption study was conducted by employing two kinetics models named pseudo-first order and pseudo-second order kinetics model. The results showed that the adsorption kinetics of MG was well defined by using pseudo-second order model rather than the pseudo-first order model. The adsorption equilibrium of MG was also explored according to the Langmuir and Freundlich adsorption isotherm model. The employed data indicated that adsorption of MG on DABCO modified bentonite was better defined by Langmuir isotherm model.

## INTRODUCTION

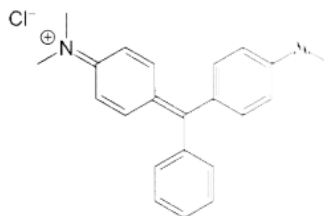
Textile products and their derivatives are one of the fundamental needs which are increased yearly by increasing the human population worldwide [1]. However, most of the textile products were made by using synthetic organic dyes and various auxiliary chemicals that produce environmentally hazardous and toxic discharge [2]. Based on the work reported by Jiang et al.[3], textile wastewater discharge poses a toxic, carcinogenic and even mutagen to the living creatures and human life. Therefore, the release of the dyes molecule in the environment has become major environmental issues in the recent decades.

Malachite Green (MG) with IUPAC name 4-[4-(Dimethylamino)phenyl](phenyl)methylidene-*N,N*-dimethyl cyclohexane-2,5-diene-1-iminium chloride, a cationic dye (Fig. 1), has been widely used in the textile industry and various fields such as paper production, leather, fungicide, and aquaculture [4]. However, in case of its contamination to the aquatic environment, MG disrupted the path of the light penetration and impeded the photosynthesis activities of the aquatic plants. Moreover, MG is chemically stable and hardly degraded by nature, and its toxicity can be increased due to the capability to chelate various metal ions [5]. Hence, the removal of MG from wastewater is necessary before it could be directly discharged to the environment.

For last decades, various technical methods have been developed in order to eliminate the presence of hazardous chemical like dyes in the wastewater [6]. Among of them, membrane separation, electrochemical oxidation, coagulation, and adsorption were considered as the most widely used methods [7]. The utilization of electrochemical oxidation process was reported has a significant performance for reducing various organic molecule in the wastewater [8]. However, this method may produce a highly toxic substance as a byproduct of

the oxidation reaction. Treatment of wastewater by using membrane separation is highly efficient for dyes molecule removal. On the other hand, this process requires high cost and the recovery of the membrane material is limited.

Adsorption is considered as the most efficient method due to its economic and feasible properties in dyes contamination removal [9]. Nowadays, various cheap and environmental friendly adsorbent materials have been developed from numerous synthetic and abundant natural materials such as activated carbon [10], biochar [11], and natural clay [7, 12]. Recently, bentonite as one of the most abundant clay materials has garnered high concern in the wastewater treatment. It was widely applied as an efficient adsorbent for removal of various organic contamination [13, 14, 15]. Basically, bentonite is layered material of montmorillonite that comprised of two main structure, i.e., a layer constructed by two silica tetrahedral and one alumina octahedral sheet with negative surface charge and some kinds of cation that lied in the interlamellar space of the layered structure called as the counter ion such as  $\text{Na}^+$ , and  $\text{Ca}^{2+}$  [16]. As a counter ion, the presence of these cations in the interlayer space of montmorillonite structure is unstable and easily replaced by other cations. This nature gained the possibility of bentonite to adsorb ionic contaminant by cation exchange mechanism.



8

FIGURE 1. Chemical structure of malachite green

In order to increase the adsorption capacity of bentonite, various modification methods have been developed based on its cation exchange capacity (CEC) property by replacing the small interlayer cation and inserting another inorganic or organic cation into the interlayer space. As conducted by Hou et al. [17], insertion of polyhydroxy iron into interlamellar space of bentonite has increased its surface area from 7.5 to 36.8  $\text{m}^2/\text{g}$  and raised up its adsorption efficiency onto Rhodamine B from 19 to more than 99%. Huang et al. [7] have studied the possibilities of organic cation to be inserted into the bentonite interlayer space by using cetyltrimethylammonium bromide (CTAB) to replace  $\text{Na}^+$  cation. The obtained result described that this modification has successfully increased its adsorption capacity on Rhodamine B and Acid red 1 up to 173.5  $\text{mg}/\text{g}$  and 157.4  $\text{mg}/\text{g}$ , respectively. Numerous researchers also reported that organic and inorganic modification of natural bentonite had ameliorated its adsorption behavior [18, 19, 20].

In this current work, natural bentonite collected from local bentonite deposit has been successfully modified by intercalating organic cation 1,4-diazabicyclo[2.2.2]octane (DABCO) into the interlamellar space of montmorillonite mineral according to the ion exchange technique. The modified bentonite product then applied to adsorb Malachite Green (MG) dye from aqueous solution. The obtained data on the adsorption experiment were subjected to some adsorption parameter, including adsorption kinetics, adsorption equilibrium, and adsorption thermodynamic, in order to get an understanding on the adsorption behavior of MG on DABCO modified bentonite.

## EXPERIMENTAL SECTION

### Materials

Bentonite used in this research was obtained from Sarolangun bentonite deposit with technical quality. Further purification was conducted based on our previous work [21]. DABCO (1,4-diazabicyclo[2.2.2]octane) was purchased from Kanto chemical Co, Japan.  $\text{H}_2\text{SO}_4$  and  $\text{NaOH}$  as pH adjuster was obtained from Merck KGaA, Singapore. Malachite green with molar mass 364.911  $\text{g}/\text{mol}$  and chemical formula  $[\text{C}_6\text{H}_3\text{C}(\text{C}_6\text{H}_4\text{N}(\text{CH}_3)_2)_2]\text{Cl}$  as dye effluent model was purchased from Merck Millipore in analytical grade quality. The de-ionized water used during all the adsorption experiment and dye solution preparation was provided by Purite<sup>®</sup> instrument with outlet water quality 18M $\Omega$ .

## PREPARATION OF ADSORBENT

DABCO modified bentonite adsorbent used in this work was prepared through ion exchange procedure as conducted in our previous work [22]. The bentonite suspension was firstly prepared by adding 5 g of bentonite powder into 200 mL of distilled water under vigorous stirring for 8 hours. The DABCO<sup>1+</sup> solution was prepared by dissolving solid DABCO with distilled water at pH 6 ( $K_1 = 10^{8.19}$ ). The DABCO<sup>1+</sup> solution (0.5 mol/L) of 100 mL was added drop wisely into the prepared bentonite suspension followed by stirring for additional 8 hours. After finished, the modified bentonite suspension was rinsed with distilled water for several times to remove the excess of DABCO solution. The precipitate then was separated by centrifugation and was dried at 80 °C. The obtained sample then assigned as D-Bent.

## CHARACTERIZATION

The chemical analysis of the natural bentonite and D-Bent sample was conducted by X-ray powder diffraction technique using XRD Rigaku Miniflex 600 equipped with CuK $\alpha$  irradiation at 30 kV and 10 mA. All the samples were scanned from  $2\theta$  ranging from 2° to 60° under scanning speed of 5°/min. The functional group of the both samples was investigated using Fourier Transform Infrared (FT-IR) technique using Shimadzu Prestige-21 FTIR by KBr pellet method. The spectra of the both natural and D-Bent was recorded at wavenumber ranging from 400 cm<sup>-1</sup> to 4000 cm<sup>-1</sup>.

## PREPARATION OF MG SOLUTION

The stock solution of MG was prepared by weighing 1 g of MG for further dissolved with 1000 mL of distilled water to produce 1000 mg/L MG stock solution. The MG standard solution and working solution were prepared by diluting the MG stock solution with distilled water into the desired concentration.

## ADSORPTION EXPERIMENT

The whole adsorption experiments in this work were conducted in the batch method. Typically, the prepared adsorbent was contacted with 50 mL of MG working solution then shaken in horizontal shaker for predetermined time. After finished, the mixture of the adsorbent and the dye solution was separated by centrifugation for 5 min at 4000 rpm. The remaining concentration of dye after the adsorption process was measured with UV-Vis spectrophotometer at maximum wavelength 616 nm. Some effect of the operational parameter on the MG adsorption behavior, including adsorbent dosage, contact time, initial dye concentration, and temperature, were systematically studied. The kinetics, equilibrium, and thermodynamic nature of the adsorption process were investigated according to the established model. The adsorption performance of MG on D-Bent in term of percent removal and adsorption capacity was determined based on the following equation, respectively.

$$\% \text{Removal} = \frac{C_0 - C_t}{C_0} \cdot 100 \quad (1)$$

$$q_e = \frac{C_0 - C_e}{m} \cdot V \quad (2)$$

$$q_t = \frac{C_0 - C_t}{m} \cdot V \quad (3)$$

Where  $C_0$  (mg L<sup>-1</sup>) is the initial concentration of MG solution,  $C_t$  (mg L<sup>-1</sup>) is MG concentration after the adsorption for  $t$  time,  $C_e$  (mg L<sup>-1</sup>) is the remaining MG concentration at equilibrium time.  $q_e$  and  $q_t$  (mg g<sup>-1</sup>) are the adsorption capacity at equilibrium and at any time  $t$ .  $m$  is the amount of adsorbent (g) and  $V$  is the volume of the dye solution (L). The adsorption kinetics was studied based on the pseudo-first order model and the pseudo-second order model. The adsorption equilibrium was studied based on the data of the effect of the initial dye concentration according to the Langmuir and Freundlich adsorption isotherm model.

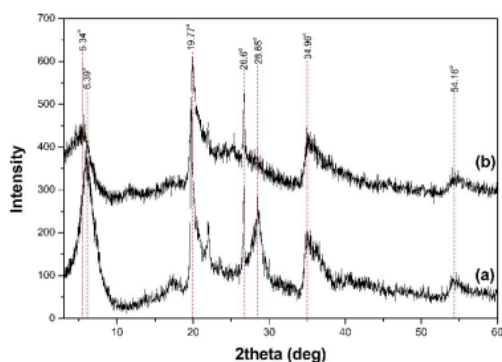


FIGURE 2. XRD patterns of (a) natural bentonite, and (b) D-bent

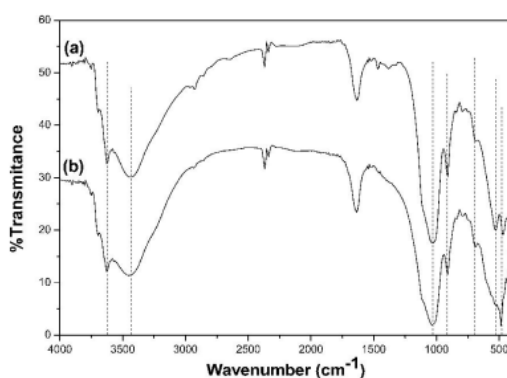


FIGURE 3. FT-IR spectra of D-Bent (a), and natural bentonite (b)

## RESULTS AND DISCUSSION

### Adsorbent Characterization

Investigation on the change of bentonite structure due to the DABCO modification was intensively conducted with X-Ray diffraction analysis. The result of this analysis, in form of XRD pattern was then used to identify the change of the distance between the layers before and after the DABCO modification. The XRD pattern of natural bentonite and D-Bent sample are presented in Fig. 2. It can be shown from the result that the basal spacing of  $d_{001}$  as the typical XRD pattern of natural bentonite was recorded at  $2\theta$  about  $6.39^\circ$  with basal spacing value 1.38 nm. After modified using DABCO, the typical basal spacing peak,  $d_{001}$ , was shifted to the lower  $2\theta$  value which is recorded at  $2\theta$  value about  $5.34^\circ$  with the basal spacing distance was increased to 1.65 nm. The shifting of  $d_{001}$  peak was correspond to the opening of the interlayer space due to the entrance of the DABCO ionic molecule by changing the native small cation of the natural bentonite. This finding indicated that the interlamellar spacing of natural bentonite increased which then increased the adsorption possibility for organic molecule removal.

In order to study the effect of DABCO modification on the change of the functional group of natural bentonite, FT-IR analysis was carried out at wavenumber range 4000 to 400  $\text{cm}^{-1}$ . The FT-IR spectra of natural bentonite and D-Bent are presented in Fig 3. As can be seen at the figure, the result of FT-IR spectra of both sample exhibited no much differences and roughly has the same peak characteristic. This finding is an indication that the main structure of bentonite was not changed due to the modification process.

13

### EFFECT OF ADSORBENT DOSAGE

Study on the effect of the amount of the adsorbent to the adsorption performance was conducted in various different amount of the adsorbent weight. The other variables of the experiments, like contact time, dye concentration, and shaking speed, were constantly predetermined. The result of effect of the adsorbent dosage variation on the removal efficiency is presented in Fig. 4. The obtained data indicated that by increasing adsorbent amount from 0.02 g to 0.03 g, the removal efficiency increased rapidly. However, by increasing the adsorbent amount more than 0.03 g, the adsorption efficiency increased gradually and even tent to constant.

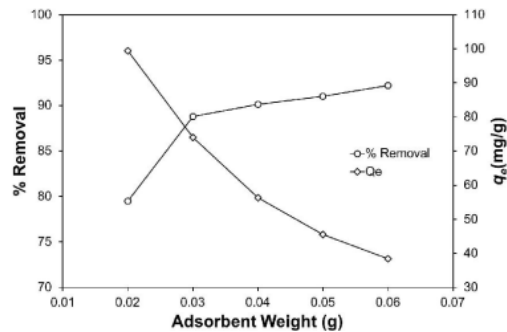


FIGURE 4. Effect of adsorbent amount on the percent of MG removal and adsorption capacity

12

### EFFECT OF CONTACT TIME

Study on the effect of contact time on MG adsorption capacity on the D-Bent was conducted by varying the duration of the contact time between MG and the adsorbent. In this work, the contact time was set up ranging from 0 to 80 min. During the adsorption process, the other variables like temperature, agitation speed, and adsorbent amount was set constant. The result of this investigation is showed in the Fig. 5. As can be seen in the figure, the adsorption of MG onto D-Bent was done in relatively fast mechanism. In the first 10 min, the adsorption process exhibited significant uptake of MG to the D-Bent. However, after more than 20 min, the uptake of MG was occurred in constant speed. This finding indicated that in the beginning of the adsorption process, the affinity of D-Bent is high. By increasing contact time, the available site of D-Bent reduced, hence, the affinity of D-Bent gradually decreased.

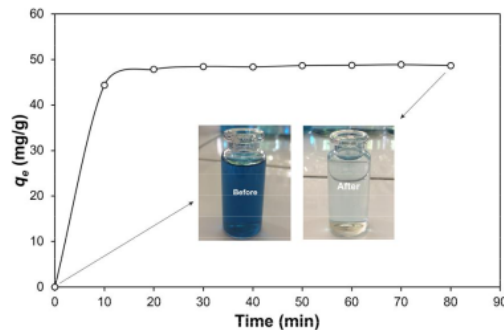


FIGURE 5. Chemical structure of malachite green

## ADSORPTION KINETICS

Further investigation on the dependency of the adsorption performance on the contact time was followed by the adsorption kinetics investigation. In this work, the adsorption data was employed to the pseudo-first order and pseudo-second order kinetics model. The linear form of the Lagergren pseudo-first order equation is presented in the following equation.

$$\log(q_e - q_t) = \log q_e - \frac{k_1}{2.303} t \quad (4)$$

While the Lagergren pseudo-second order model can be described by the following linearized form as follow:

$$\frac{t}{q_t} = \frac{1}{k_2 q_e^2} + \frac{1}{q_e} t \quad (5)$$

Where  $k_1$  is the constant of pseudo-first order model ( $\text{min}^{-1}$ ),  $k_2$  is the constant for pseudo-second order model ( $\text{g mg}^{-1} \text{min}^{-1}$ ). The values of  $k_1$  and  $q_e$  from the pseudo-first order model were calculated based on the linear plots of  $\log(q_e - q_t)$  against  $t$ . The values of  $k_2$  and  $q_e$  were measured from the value of slope and intercept of the linear plot of  $t/q_t$  versus  $t$  [23]. The plot of pseudo-first order model and pseudo-second order kinetics model are presented in Fig. 6. The adsorption kinetics parameters according to the pseudo-first order and pseudo-second order kinetics model are tabulated in the Table 1. According to the magnitude of correlation coefficient ( $R^2$ ) of the both model, it can be clearly seen that the adsorption of MG on D-Bent followed the pseudo-second order kinetics model rather than the pseudo-first kinetics model.

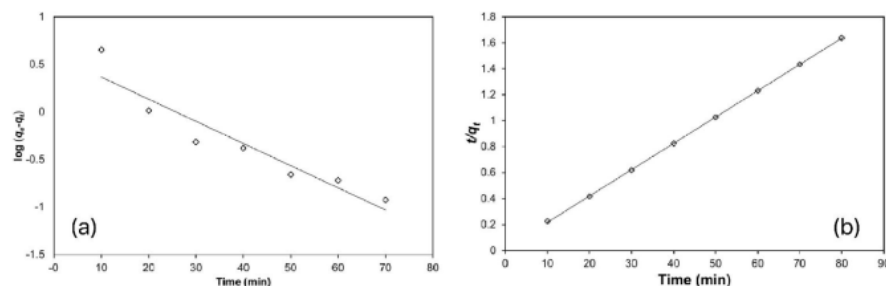


FIGURE 6. Plot of (a)  $\log(q_e - q_t)$  versus  $t$  for the pseudo-first order kinetics model, and (b)  $t/q_t$  versus  $t$  for the pseudo-second order kinetics model

TABLE 1. Adsorption kinetics parameters of MG based on the pseudo-first and pseudo-second order model

	Pseudo-first order	Pseudo-second order	
$R^2$	0.8982	0.9999	
$k_1$ ( $\text{min}^{-1}$ )	0.0537	$k_2$ ( $\text{g mg}^{-1} \text{min}^{-1}$ )	0.0247
$q_{e,exp}$ ( $\text{mg g}^{-1}$ )	48.8702	$q_{e,exp}$ ( $\text{mg g}^{-1}$ )	48.8702
$q_{e,cal}$ ( $\text{mg g}^{-1}$ )	4.0045	$q_{e,cal}$ ( $\text{mg g}^{-1}$ )	49.3844

## EFFECT OF INITIAL CONCENTRATION AND ADSORPTION ISOTHERM

The relationship of the adsorbent and adsorbate in term of equilibrium is assigned by the adsorption isotherm. In this study, this relation was presented in Fig. 7 as the function of the adsorption capacity towards the equilibrium concentration. The obtained data were fitted with the Langmuir and Freundlich adsorption isotherm model as described in the equation 6 and 7, respectively.



$$\frac{C_e}{q_e} = \frac{1}{q_m k_L} + (1/n) \ln C_e \quad (6)$$

$$\ln q_e = \ln k_F + (1/n) \ln C_e \quad (7)$$

Where  $C_e$  is the concentration of MG remaining after the adsorption at equilibrium ( $\text{mgL}^{-1}$ ),  $q_e$  is the equilibrium adsorption capacity ( $\text{mgg}^{-1}$ ),  $q_m$  is the maximum adsorption capacity based on the theoretical Langmuir model ( $\text{mgg}^{-1}$ ),  $k_L$  is Langmuir constant related to the adsorbent affinity on the solute ( $\text{L/mg}$ ),  $k_F$  and  $n$  are Freundlich constant based on the adsorption capacity and adsorption intensity, respectively.

The equilibrium adsorption isotherm of MG on D-Bent is presented in Fig. 7 and its linearized isotherm based on Langmuir and Freundlich model is shown in Fig. 8. The value of adsorption isotherm parameters including  $q_m$ ,  $k_L$ ,  $n$ ,  $k_F$ , and  $R^2$  are presented in Table 2. According to the magnitude of  $R^2$  value of the both Langmuir and Freundlich model, it can be concluded that Langmuir isotherm model is better in describing the adsorption process rather than Freundlich model with  $R^2 > 0.9$ . This finding is an indication that D-Bent adsorbent has specific homogeneous active site in its surface, hence the adsorption of MG on D-Bent following the mono-layer adsorption process.

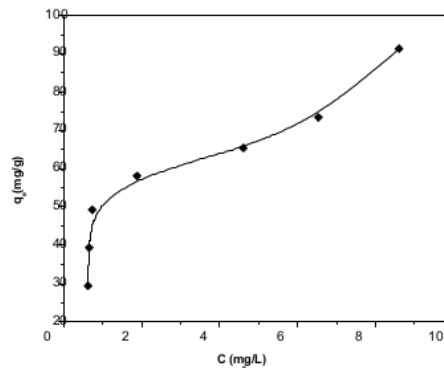


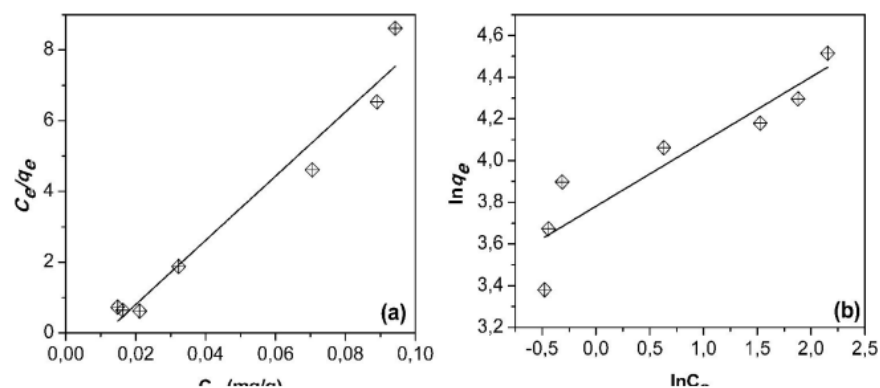
FIGURE 7. Plot of adsorption isotherm of MG on D-Bent

TABLE 2. Equilibrium isotherm model parameters of MG on D-Bent

Langmuir		Freundlich	
$R^2$	0.9636	$R^2$	0.8518
$q_m$ (mg/g)	94.1989	$n$	3.2261
$k_L$ (L/mg)	0.8495	$k_F$ (L/g)	43.8682

## CONCLUSION

Modified bentonite prepared by DABCO<sup>1+</sup> ion exchange with DABCO<sup>1+</sup>: Bentonite ratio  $1 \text{ mmol g}^{-1}$  was systematically applied for Malachite Green dye removal from aqueous solution. The DABCO bentonite sample characterization indicated that the DABCO ion molecule have successfully inserted into the interlayer space of the bentonite. Study on the effect of the adsorbent weight on the adsorption capacity and adsorption efficiency showed that MG adsorption was highly influenced by the adsorbent amount. The adsorption kinetics study revealed that the adsorption process followed the pseudo-second order kinetics model. While for the adsorption equilibrium, the obtained adsorption data were well defined by Langmuir adsorption isotherm model.



**FIGURE 8.** Plot of (a)  $C_e$  versus  $C_e/q_e$  for Langmuir isotherm model, and (b)  $\ln C_e$  versus  $\ln q_e$  for Freundlich adsorption isotherm model

### ACKNOWLEDGEMENTS

1 Profoundly, TT thanks to the Ministry of Research, Technology, and Higher Education of Republic Indonesia, for financially supporting this research through "Program Magister Menuju Doktor untuk Sarjana Unggul" (PMDSU) grant with contract number 468/UN9.3/LT/2017 and 326/SP2H/LT/DRPM/IX/2016. The authors also thanked to the Integrated Research Laboratory of Graduate Program of Sriwijaya University for the technical supporting this re- search.

### REFERENCES

1. F. Li, J. Huang, Q. Xia, M. Lou, B. Yang, Q. Tian, and Y. Liu, *Sep. Purif. Technol.* **195**, 83–91 (2018).
2. J. Liang, X. an Ning, M. Kong, D. Liu, G. Wang, H. Cai, J. Sun, Y. Zhang, X. Lu, and Y. Yuan, *Environ. Pollut.* **231**, 115–122 (2017).
3. F. Jiang, D. M. Dinh, and Y.-L. Hsieh, *Carbohydr. Polym.* **173**, 286–294 (2017).
4. F. Zhang, Z. Wei, W. Zhang, and H. Cui, *Spectrochim. Acta. A. Mol. Biomol. Spectrosc.* **182**, 116–122 (2017).
5. F. Naseeruteen, N. S. A. Hamid, F. B. M. Suah, W. S. W. Ngah, and F. S. Mehamod, *Int. J. Biol. Macromol.* **107**, 1270–1277 (2018).
6. F. Bouaziz, M. Koubaa, F. Kallel, R. E. Ghorbel, and S. E. Chaabouni, *Int. J. Biol. Macromol.* **105**, 56–65 (2017).
7. Z. Huang, Y. Li, W. Chen, J. Shi, N. Zhang, X. Wang, Z. Li, L. Gao, and Y. Zhang, *Mater. Chem. Phys.* **202**, 266–276 (2017).
8. L. Bilińska, M. Gmurek, and S. Ledakowicz, *Process. Saf. Environ.* **109**, 420–428 (2017).
9. S. Mousavi, F. Deuber, S. Petrozzi, L. Federer, M. Aliabadi, F. Shahraki, and C. Adlhart, *Colloids. Surf. A. Physicochem. Eng. Asp.* **547**, 117–125 (2018).
10. M. N. Mahamad, M. A. A. Zaini, and Z. A. Zakaria, *Int. Biodeterior. Biodegradation.* **102**, 274–280 (2015).
11. M. A. Zazycki, M. Godinho, D. Perondi, E. L. Foletto, G. C. Collazzo, and G. L. Dotto, *J. Clean. Prod.* **171**, 57–65 (2018).
12. K. Rida, S. Bouraoui, and S. Hadrine, *App. Clay Sci.* **83-84**, 99–105 (2013).
13. J. Lin, B. Jiang, and Y. Zhan, *J. Environ. Manage.* **217**, 183–195 (2018).
14. E. Derakhshani and A. Naghizadeh, *J. Mol. Liq.* **259**, 76–81 (2018).
15. S. Du, L. Wang, N. Xue, M. Pei, W. Sui, and W. Guo, *J. Solid. State. Chem.* **252**, 152–157 (2017).
16. Z. Yang, O. Xiao, B. Chen, L. Zhang, H. Zhang, X. Niu, and S. Zhou, *Chem. Eng. J.* **223**, 31–39 (2013).
17. M.-F. Hou, C.-X. Ma, W.-D. Zhang, X.-Y. Tang, Y.-N. Fan, and H.-F. Wan, *J. Hazard Mater.* **186**, 1118–1123 (2011).
18. A.-M. Georgescu, F. Nardou, V. Zichil, and I. D. Nistor, *App. Clay Sci.* **152**, 44–50 (2018).
19. R. Huang, L. Zhang, P. Hu, and J. Wang, *Int. J. Biol. Macromol.* **86**, 496–504 (2016).

20. P. Banković, A. Milutinović-Nikolić, Z. Mojović, N. Jović-Jovičić, M. Perović, V. Spasojević, and D. Jovanović, *Microporous Mesoporous Mater.* **165**, 247–256 (2013).
21. T. Taher, R. Mohadi, D. Rohendi, and A. Lesbani, *AIP Conference Proceeding: International Conference on Chemistry, Chemical Process and Engineering* (2017), 10.1063/1.4978101.
22. T. Taher, D. Rohendi, R. Mohadi, and A. Lesbani, *IOP Conference Series: Materials Science and Engineering* **299**, pp. 012055 (2018).
23. W. Konicki, A. Hełminiak, W. Arabczyk, and E. Mijowska, *Chem. Eng. Res. Des.* **129**, 259–270 (2018).
24. B. Çağlar, O. Cubuk, E. Demir, F. Coldur, M. Catir, C. Topcu, and A. Tabak, *J. Mol. Struc.* **1089**, 59–65 (2015).

# C.2a.1.3-An insight into the adsorption behavior of malachite green on DABCO (1,4-.pdf

---

ORIGINALITY REPORT

---

# 18%

SIMILARITY INDEX

---

## PRIMARY SOURCES

---

1	<a href="http://media.neliti.com">media.neliti.com</a> Internet	84 words — 3%
2	<a href="http://www.researchgate.net">www.researchgate.net</a> Internet	76 words — 2%
3	<a href="http://www.pms.unsri.ac.id">www.pms.unsri.ac.id</a> Internet	62 words — 2%
4	<a href="http://pubs.rsc.org">pubs.rsc.org</a> Internet	49 words — 2%
5	<a href="http://sciencetechindonesia.com">sciencetechindonesia.com</a> Internet	47 words — 1%
6	<a href="http://www.omicsonline.org">www.omicsonline.org</a> Internet	39 words — 1%
7	<a href="http://mafiadoc.com">mafiadoc.com</a> Internet	30 words — 1%
8	<a href="http://medcraveonline.com">medcraveonline.com</a> Internet	23 words — 1%
9	<a href="http://acta.bibl.u-szeged.hu">acta.bibl.u-szeged.hu</a> Internet	22 words — 1%

---

10	<a href="http://iopscience.iop.org">iopscience.iop.org</a> Internet	22 words — 1%
11	<a href="http://pak.uui.ac.id">pak.uui.ac.id</a> Internet	21 words — 1%
12	<a href="http://ujcontent.uj.ac.za">ujcontent.uj.ac.za</a> Internet	21 words — 1%
13	<a href="http://jwrd.iwaponline.com">jwrd.iwaponline.com</a> Internet	20 words — 1%
14	<a href="http://www.mdpi.com">www.mdpi.com</a> Internet	19 words — 1%
15	<a href="http://onlinelibrary.wiley.com">onlinelibrary.wiley.com</a> Internet	18 words — 1%
16	<a href="http://www.jmst.org">www.jmst.org</a> Internet	18 words — 1%
17	<a href="http://scholars.cityu.edu.hk">scholars.cityu.edu.hk</a> Internet	17 words — 1%

---

EXCLUDE QUOTES      OFF  
EXCLUDE BIBLIOGRAPHY      ON

EXCLUDE MATCHES      < 1%