

ZEOLITE ADSORPTION MEASUREMENT TEST RESULTS WITH VARIOUS DATES OF CURRUMIN AS ADSORTATE

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ABSTRACT

The purpose of this study was to analyze and measure the intensity of light obtained through an LED flashlight emitted by a solution of curcumin and zeolite from the adsorption process. In addition, this study also aims to determine the appropriate isotherm model for this experiment. Variations in the dose of zeolite were taken to find out the big difference using the Lux Light Meter application. The method used is an experimental method, where the process that occurs is the light source from the sender stored in the cardboard will pass through a gap and also the bottle that has been filled with a solution of curcumin and zeolite. Then the light beam will be captured by the Lux Light Meter so that the value will be obtained. The results showed that zeolite carbon as an adsorbent was able to absorb turmeric or curcumin solution well. The equilibrium model used is Langmuir, Freundlich, Temkin, Dubinin-Radushkevich, Flory Huggins, Flower-Guggenheim, Hill-Deboer, Jovanovic, Harkin-Jura, and Halsey. The Langmuir, Freundlich, and Halsey isotherms show success in describing this adsorption process.

ABSTRAK

Tujuan dari penelitian ini adalah menganalisis dan mengukur intensitas cahaya yang diperoleh melalui senter LED yang dipancarkan melewati suatu larutan kurkumin dan zeolite dari proses adsorpsi. Selain itu penelitian ini juga bertujuan untuk mengetahui model isoterm yang tepat untuk eksperimen ini. Variasi takaran zeolite diambil untuk mengetahui perbedaan seberapa besar nilai yang dihasilkan menggunakan aplikasi Lux Light Meter. Metode yang digunakan adalah metode eksperimen, dimana proses yang terjadi yaitu sumber cahaya dari senter yang disimpan di dalam kardus akan melewati suatu celah dan juga suatu botol yang sudah terisi larutan kurkumin dan zeolite. Kemudian berkas cahaya tersebut akan ditangkap oleh Lux Light Meter sehingga akan diperoleh nilainya. Hasil penelitian menunjukkan bahwa karbon zeolite sebagai adsorban mampu menyerap larutan kunyit atau kurkumin dengan baik. Model kesetimbangan yang digunakan adalah Langmuir, Freundlich, Temkin, Dubinin-Radushkevich, Flory Huggins, Flower-Guggenheim, Hill-Deboer, Jovanovic, Harkin-Jura dan Halsey. Isoterm Langmuir, Freundlich, dan Halsey menunjukkan keberhasilan dalam menggambarkan proses adsorpsi ini.

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Introduction

Adsorption is the absorption of a substance (molecule or ion) on the surface of the adsorbent [1]. In chemical adsorption, the particles adhere to the surface by forming chemical bonds (usually covalent bonds) and tend to seek sites that maximize their

coordination number with the substrate [2]. Two terms that are often used in the adsorption process are adsorbate and adsorbent.

Adsorbate is a substance that is absorbed on the surface of other substances during the adsorption process [3] while adsorbent is a substance whose surface can absorb other

substances in the adsorption [4]. Several factors that affect adsorption are concentration, surface area, temperature, particle size, pH, and contact time [2]. The amount of substance that is absorbed depends on the concentration of the solute and the dependence of the amount of substance that is absorbed in the equilibrium concentration is called the adsorption isotherm [5].

Zeolites are hydrated aluminosilicate minerals containing alkali or alkaline earth in a 3-dimensional framework. This mineral has several interesting chemical and physical properties, including being able to absorb organic and inorganic substances, can act as a cation exchanger, and as a catalyst for various reactions [6]. Zeolite with a pore structure is widely known as a reliable adsorbent [7].

Currently, many studies use zeolite as an adsorbent in the adsorption process. Zeolite et al [6] explained that carbon zeolite is very good to be used as an adsorbent because it can absorb organic and inorganic substances, as well as a catalyst for various reactions. However, there are several problems, namely, zeolite has not had too high crystallinity, has very non-uniform pore size, has low catalytic activity, and contains a lot of impurities. Therefore it needs to be activated and modified before use.

According to research conducted by Graham et al (1997), the dealumination of zeolite can cause a decrease in zeolite crystallinity. Meanwhile, according to Setyawan (2002), immersion of natural zeolite with 1% HF can remove impurity oxides but does not damage the crystal structure of mordenite so that the crystallinity of zeolite increases [6].

This research uses zeolite as an adsorbent with various concentrations and curcumin solution as adsorbate. The purpose of this study was to determine the adsorption process of zeolite to curcumin solution and to measure the light intensity that occurred in this adsorption process. Variations in the concentration of zeolite used were 0.5; 0.75; 1.0; and 1.3 gram. This affects the adsorption results. In addition, the difference in the concentration of zeolite used would affect the

measurement of light intensity which will produce different values.

Basic Theory

The adsorption mechanism is described that the molecules will stick to the surface of the adsorbent substance [8]. There are two types of adsorption, namely Physisorption and Chemisorption. Illustration of Figures 1(a) and 1(b). Physisorption or physical adsorption in this case between hydrogen and the adsorption surface occurs Van Der Waals force [9]. So that in this adsorption no chemical reaction occurs, but only intermolecular forces or between particles, as illustrated in Figure 1(a). As for Chemisorption, the reaction occurs chemically. Where hydrogen reacts with the adsorption surface, as illustrated in Figure 1(b).

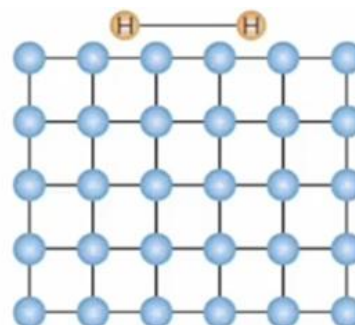


Figure 1(a). Physisorption model illustration

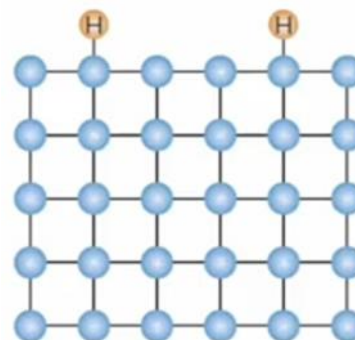


Figure 1(b). Chemisorption model illustration

Previous research explained the use of zeolite in adsorption able to obtain maximum results as in (Table 1).

Table 1. Previous Research

No.	Researcher	Theme	Strength	Weakness	Reference
1.	Fatimah, Eko Sugiharto, Karna Wijaya, Iqmal Tahir, Kamlia	Titanium Oxide Dispersed in Natural Zeolite (TiO ₂ /Zeolite)	Use many advanced tools to make research easier	There are many steps to go through	(Fatimah et al, 2006)
2.	Army Auliah	Active Clay As An Absorber Of Phosphate Ions In Water	in this study using a spectrophotometric tool where the results obtained are faster and more accurate and using two graphs so that he can compare the results he gets between the two graphs.	In this study, the optimum contact time was determined beforehand so that the research implementation time would be longer but would get optimal results.	(Army Auliah, 2009)
3.	Isna Syauqiah, Mayang Amalia, Hetty A. Kartini	Analysis of Time and Speed Variations in Process Heavy Metal Waste Adsorption With Activated Charcoal	This research helps other researchers to find the optimal stirring time and it turns out that the stirring time greatly affects the rate of entanglement of a substance in the adsorber.	At the time of letting the charcoal and waste breaker have to wait for 3 hours so that the lime breaker reacts optimally with the charcoal, but it is too long so this research takes a long time.	(Isna Syauqiah et al, 2011)
4.	Pardoyo, Listiana, Adi Darmawan	Effect of HCL Treatment On Crystallinity And Ability Natural Zeolite Adsorption Against Ca ²⁺ Ions.	In this study, HCL crystallization was carried out first to help activate the zeolite so that when adsorption was carried out the zeolite absorbed substances more quickly.	In the explanation section, the method is less detailed, so the explanation is not clear and has not been conveyed	(Pardoyo et al, 2009)

Isotherm Adsorption

Many mathematical models have been developed to quantify the isothermal adsorption process, including the distribution coefficient model or Henry model, Freundlich model, Langmuir model, and others [10].

Langmuir assumes that on the surface of the adsorbent there are active sites that are proportional to the surface area. Each of these active sites can only adsorb one molecule, so adsorption is only limited to the formation of a single layer (monolayer). The equation is:

1) Langmuir Isotherm Model

$$\frac{1}{Q_e} = \frac{1}{Q_{max}} \frac{1}{K_L C_e} + \frac{1}{Q_{max}} \quad (1)$$

Description:

Ce = equilibrium concentration of adsorbate in solution after adsorption (mg/L)
 Qe = amount of adsorbate adsorbed per adsorbent weight (mg/g)
 K = adsorption equilibrium constant (L/mg)
 Qmax = maximum adsorption capacity of adsorbent (mg/g)

2) Freundlich Isotherm Model

The Freundlich Isotherm Model uses the assumption that adsorption occurs physically and is an empirical equation, which is expressed by the equation:

$$\ln Q_e = \ln K_f + \frac{1}{n} \ln C_e \quad (2)$$

Description:

Ce = equilibrium concentration of adsorbate in solution after adsorption (mg/L)
 k = Freundlich adsorption constant
 n = empirical constant
 Q = amount of adsorbate adsorbed per adsorbent weight (mg/g)

3) Temkin Isotherm Model

The Temkin isotherm assumes three postulates, namely that the heat of adsorption decreases linearly with an increasing surface coverage of the adsorbent, the adsorption process assumes a uniform binding energy distribution on the surface of the adsorbent, and the adsorption interaction involves the interaction between the adsorbate-adsorbent [10], [11]. The equation is:

$$Q_e = B_T \ln A_T + B_T \ln C_e \quad (3)$$

4) Dubinin-Radushkevich Isotherm Model

Dubinin-Radushkevich isotherm expresses the adsorption process on adsorbents that have a pore structure or adsorbents that have a heterogeneous surface and express adsorption free energy. The equation is:

$$\ln Q_e = \ln Q_s - (\beta \varepsilon^2) \quad (4)$$

$$\text{For } = RT \ln [1 + 1 /]$$

5) Jovanovic Isotherm Model

The Jovanoic isotherm is based on the assumptions found in the Langmuir model, without allowing some mechanical contact between the adsorbate and the adsorbent [12]. The equation is.

$$\ln Q_e = \ln Q_{max} - K_I C_e \quad (5)$$

6) Halsey Isotherm Model

Halsey isotherm evaluates multi-layer adsorption systems [13], the equations are:

$$Q_e = \frac{1}{n_H} \ln K_H - \left(\frac{1}{n_H} \right) \ln C_e \quad (6)$$

Where KH and n are Halsey's model constants.

7) Harkin-Jura Isotherm Model

The Harkin-Jura isotherm describes that adsorption occurs on the surface adsorbent [12], the equation is.

$$\frac{1}{Q_e^2} = \frac{\beta H_J}{A H_J} - \left(\frac{1}{A} \right) \log C_e \quad (7)$$

Where the value of HJ is related to a certain surface area of the adsorbent and AHJ is the Harkin constant Jura is the other.

8) Fowler-Guggenheim Isotherm Model

The formula for this isotherm is:

$$\ln \left(\frac{C_e(1-\theta)}{\theta} \right) - \frac{\theta}{1-\theta} = -\ln KFG + \frac{2W\theta}{RT} \quad (8)$$

9) Flory-Huggins Isotherm Model

The equation of the Flory-Huggins model is:

$$\log \frac{\theta}{C_e} = \log KFH + n \log (1 - \theta) \quad (9)$$

Where $\theta = \left(1 + \frac{C_e}{C_o} \right)$ is the surface coverage level.

10) Hill-Deboer

The Hill-Deboer isotherm model describes cellular adsorption as well as lateral interactions between adsorbed molecules [12]. The equation is:

$$\ln [C_e (1 - \theta) \theta] - \theta 1 - \theta = -\ln K1 - \frac{K2\theta}{RT} \quad (10)$$

Materials and Methods

The materials used in this study were carbon zeolite and turmeric powder (Desaku turmeric powder) and water.

Adsorption Process

This adsorption test was carried out by adding carbon zeolite with a carbon particle size of 0.3 cm and various doses (**Figure 2**) including 0.5; 0.75; 1.0; and 1.3 gram into 76 mL of curcumin solution. Then the concentration of this solution will be measured by measuring the light source from the LED flashlight that will pass through the adsorption solution (**Figure 3**).

In this case, the researcher uses an application that can be downloaded from a smartphone, namely Lux Light Meter. The light passing through the solution will be read by the Lux Light Meter (HP Vivo Y93; Dongguan, China).



Figure 2. Zeolite carbon mass variation

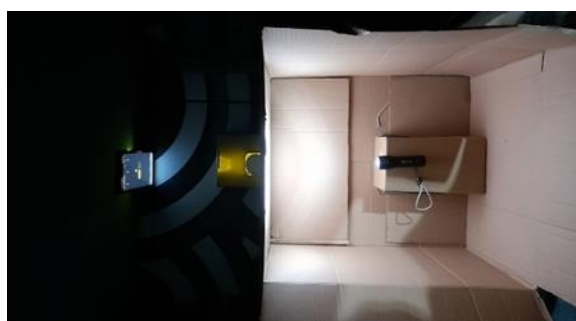


Figure 3. The process of measuring light intensity using lux light meter

There are three boxes with different sizes, where the cartons are used as supports for the variables to be tested. The LED flashlight is kept in the box and the light radiates out of the

box through a small hole. Then the light can pass through the solution to be tested, and the intensity of the light emission can be measured using the Lux Light Meter application.

Research Strategy

This study used experimental research methods. Experimental research is research that is carried out intentionally by researchers by giving certain treatments/treatments to research subjects to evoke an event/condition to be studied and what the consequences are [14].

In this experimental research method, zeolite carbon is used as an adsorbent in the adsorption of curcumin or turmeric solutions. The solution has a volume of 70 mL. The size of the zeolite used is 0.3 cm and the researchers will conduct 20 experiments with 4 variations of zeolite and 4 variations of concentration. The preparation of 4 variations of the concentration of curcumin solution was carried out for 8 hours, by making a solution with a concentration of 100 ppm first then diluted to 33.0; 25.0; 12.5; and 6.25 ppm.

The first experiment was carried out to measure the concentration of the variation of the solution first by using the spectrophotometric method. The light beam that is passed after passing through the curcumin solution without the carbon zeolite using 4 variations of concentration will be known. Then after that, each different variation of carbon, namely 0.5; 0.75; 1.0; and 1.3 gram was added to each bottle equally. Each concentration is put into 4 equal bottles, so the total number of bottles used is 16 bottles.

After adding carbon particles to the solution, the solution was left for 8 hours to get maximum results. Then after that, the experiment was carried out by shooting light rays from the LED flashlight to the sample. Then the light will be read by the Lux Light Meter application on the smartphone. In this way, the adsorption phenomenon can be seen. The adsorption study will also calculate the Langmuir equation and the Freundlich equation to determine the appropriate adsorption model in this adsorption study.

Result and Discussion

The results showed that the carbon zeolite was able to absorb the color of the curcumin solution well when the mass of carbon added was 1.3 grams. When a mass of 1.3 grams was added to each variation of the concentration of the curcumin solution from the largest to the smallest, the intensity of the light produced was, respectively, 45; 52; 70; and 75 lux. As shown in **Table 4**, the results of the adsorption measurements show that the more mass of the zeolite, the greater the measurement results

from the lux meter. This is because carbon adsorption curcumin dissolved in water so that the curcumin solution becomes clear. Thus, the more mass of zeolite mixed in the curcumin solution, the greater the light intensity measurement results. In addition to the mass of zeolite, concentration can also affect the measurement results of the lux meter.

While the results of transmittance data and calibration curves used in this experiment as shown in **Table 5(a)** and curve **(b)**.

Table 4. Lux Light Meter measurement results with different masses and concentrations

	0.5 g	0.75 g	1 g	1.3 g
33 ppm	35 lux	37 lux	41 lux	45 lux
25 ppm	33 lux	43 lux	47 lux	52 lux
12.5 ppm	53 lux	56 lux	66 lux	70 lux
6.25 ppm	64 lux	71 lux	74 lux	75 lux

Table 5 (a). Calibration Curve Data

C awal	Transmitan	absorpsi	C ₀ (ppm)
33	0,004108	2,3864	32,26797
25	0,005021	2,29925	26,57188
12,5	0,008672	2,061889	11,05809
6,25	0,010041	1,99822	6,896712

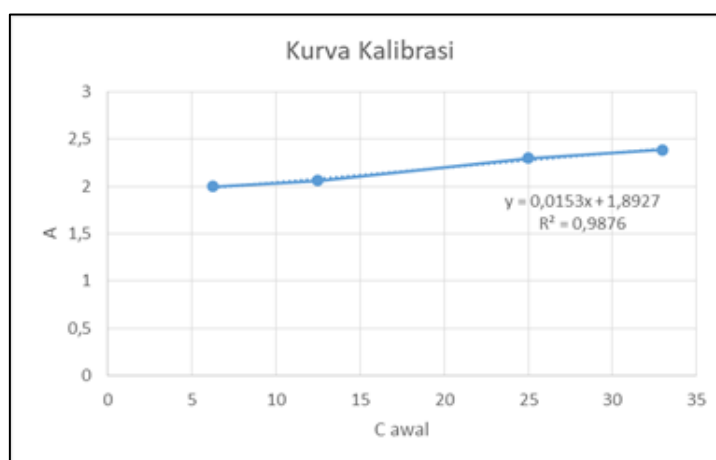


Figure 5(b). Calibration curve

Of the 16 experiments conducted using different concentrations and variations in carbon mass, data were obtained based on transmittant results as shown in **Table 6**. From

this data can be known the ability of carbon in absorbing dyes from curcumin solutions. Then this data is also used to get the right isothermic model in this experiment.

Table 6. Experimental data

Mass	Ce	Qe	1/Ce	1/Qe	ln Ce	ln Qe
0.5 gram	10,54328	1,47606	0,094847	0,677479	2,355489	0,389376
	3,17699	0,444779	0,314763	2,24831	1,155934	-0,81018
	1,111696	0,155638	0,899526	6,425187	0,105887	-1,86023
	2,303528	0,322494	0,434117	3,100834	0,834442	-1,13167
0.75 gram	12,12065	1,13126	0,082504	0,88397	2,49491	0,123332
	10,69036	0,997767	0,093542	1,002238	2,369342	-0,00224
	2,674583	0,249628	0,37389	4,005966	0,983793	-1,38778
	5,249827	0,489984	0,190482	2,040884	1,658195	-0,71338
1.0 gram	15,03451	1,052416	0,066514	0,950195	2,710348	0,051088
	13,21515	0,925061	0,075671	1,08101	2,581364	-0,0779
	7,338367	0,513686	0,13627	1,946716	1,993116	-0,66614
	6,424557	0,449719	0,155653	2,223611	1,860128	-0,79913
1.3 gram	17,67691	0,951834	0,056571	1,050604	2,872259	-0,04937
	16,08479	0,866104	0,062171	1,154595	2,777874	-0,14375
	9,00857	0,485077	0,111005	2,061529	2,198176	-0,72345
	6,805573	0,366454	0,146938	2,728856	1,917742	-1,00388

The data above shows Ce the equilibrium concentration of adsorbate in the solution after adsorption and also Qe the amount of adsorbate adsorbed per weight of adsorbent. The results of adsorption by carbon zeolite, then calculated and plotted on the graph so that the peak data will be obtained. From the graph, the extrapolation line is obtained in the form of a straight line by entering the adsorption equation from the 9 isotherm models.

Figure 7(a-i) is a plot of the analysis results based on the Langmuir, Freundlich, Temkin, Dubinin-Radushkevich, Flory Huggins, Flower-Guggenheim, Hill-Deboer, Jovanovic, Harkin-Jura and Halsey models.

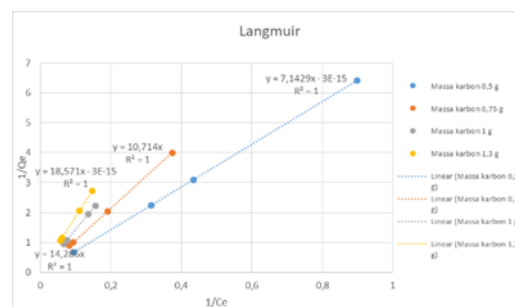


Figure 7(a). Langmuir curve

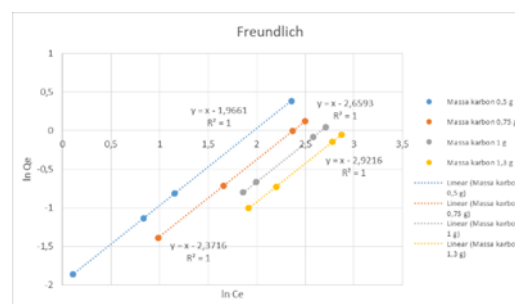


Figure 7 (b). Freundlich curve

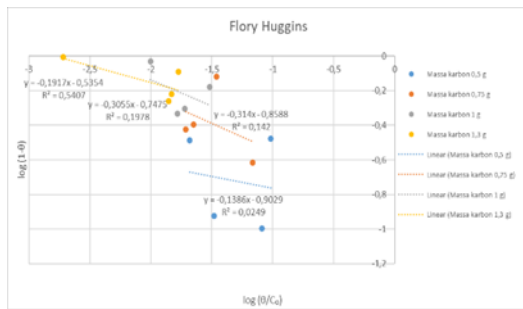


Figure 7(c). Flory Huggins Curve

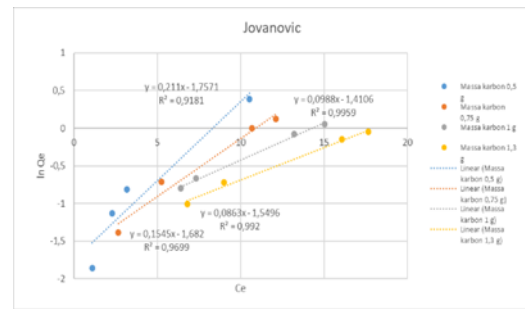


Figure 7(g). Jovanovic curve

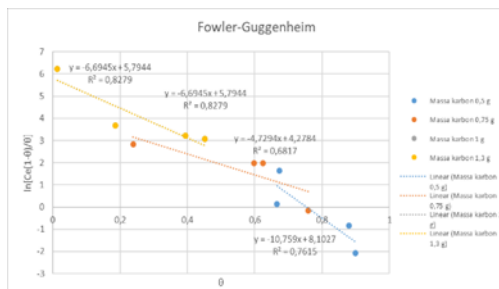


Figure 7(d). Flower-Guggenheim Curve

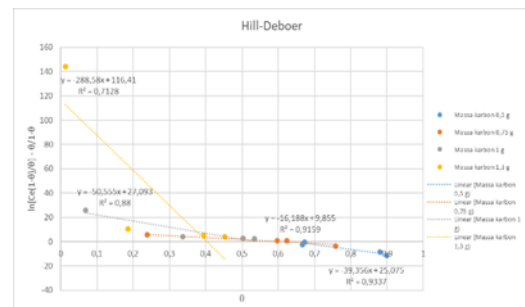


Figure 7(h). Hill-Deboer curve

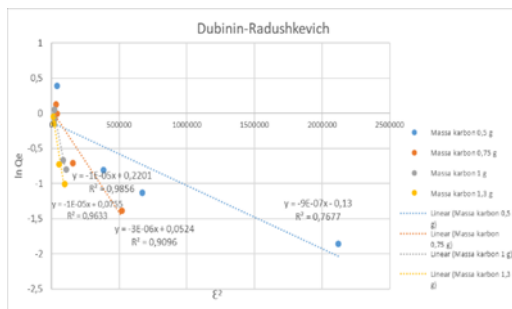


Figure 7(e). Dubinin-Radushkevich curve

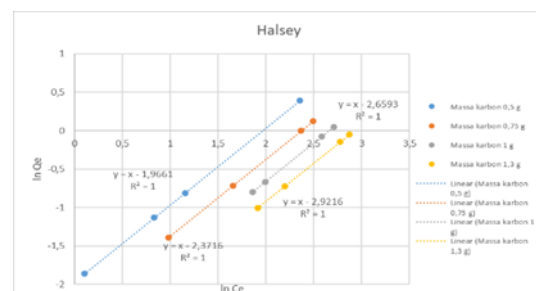


Figure 7(i). Halsey Curve

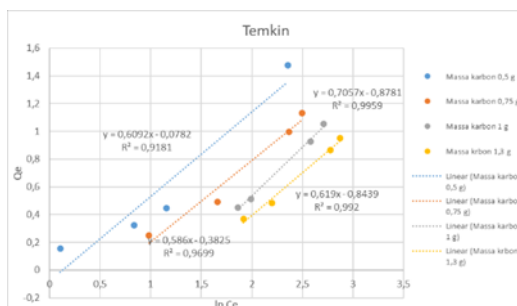


Figure 7(f). The Temkin Curve

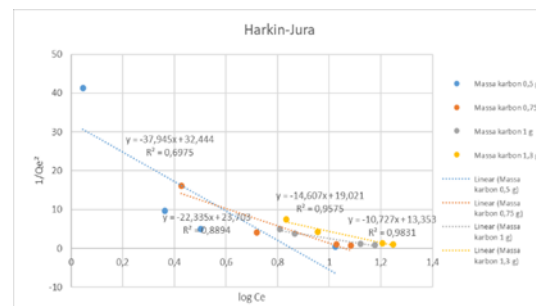


Figure 7(j). Harkin-Jura Curve

From the several types of curves above, it can be seen that the curve is by the research conducted in the curve of the Langmuir, Freundlich, and Halsey isotherm models. This appropriate curve is seen based on the most linear line compared to the curve results from other models.

Another reason is that the zeolite adsorbent adsorption system has a good correlation with these three models, one of which is the Langmuir isotherm which is indicated by the monolayer adsorption process. The adsorbate molecules are distributed on all surfaces of the adsorbent [10]. The Langmuir isotherm is obtained using the following equation:

$$\frac{1}{Q_e} = \frac{1}{Q_{max}} \frac{1}{K_L C_e} + \frac{1}{Q_{max}} \quad (1)$$

With this equation, we need to convert C_e and Q_e to the form $1/C_e$ and $1/Q_e$, which is used to fit the data. Plot analysis shows that the results have a relatively high correlation or R^2 results are more than 0.70. So the result fits the Langmuir isotherm curve.

The Freundlich isotherm model was obtained using the following equation.

$$\ln Q_e = \ln K_f + \frac{1}{n} \ln C_e \quad (2)$$

While Halsey isotherm is the same as Langmuir whose assessment is based on the reference multi-layer adsorption [13], the equation is:

$$Q_e = \frac{1}{nH} \ln KH - \left(\frac{1}{nH}\right) \ln C_e \quad (3)$$

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Conclusion

In this experiment, it can be concluded that carbon zeolite can absorb the dye on the turmeric microparticles so that the water or solvent becomes clear. Using Lux Meter will get the intensity of light from the adsorption

results. And the right isotherm model for this experiment is the Langmuir isotherm model.

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