

ADSORPTION OF RHODAMINE B DYE BY ACACIA BARK POWDER (*Acacia crassicaarpa*)

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ABSTRACT

Acacia bark powder (Acacia crassicaarpa) is a biomass containing cellulose compounds as active sites for adsorption. This study aims to optimise the adsorption parameters of Rhodamine B by acacia bark powder. The method used in this study is batch adsorption. The adsorbent is prepared in powder form with a particle size of 100–200 mesh. SEM-EDS characterisation results showed a porous surface morphology of the adsorbent, dominated by carbon (C) and oxygen (O) elements. BET analysis revealed a specific surface area of 0.460 m²/g, pore volume of 4.361×10⁻³ cc/g, and pore diameter of 379.008 Å. FTIR results indicated the presence of functional groups N-H, -OH, C-H, C=O, C=C, and C-O. Optimal adsorption conditions were obtained at an adsorbent dose of 0.5 g, pH 2, contact time of 50 minutes, stirring speed of 200 rpm, adsorbate concentration of 40 mg/L, and temperature of 50°C, with an adsorption efficiency of 99.04% and adsorption capacity of 3.9326 mg/g. The results of this study indicate that Acacia crassicaarpa bark powder has good performance in adsorbing Rhodamine B dye.

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Introduction

Acacia bark (*Acacia crassicaarpa*) can be used as an adsorbent to absorb dyes because it has lignin and cellulose content, where the cellulose content of this bark reaches 50% [1] that have the potential to bind adsorbate like dyes [2]. Availability of bark *Acacia crassicaarpa* quite abundant, especially in the industrial environment *Pulp* and paper. This acacia bark is a by-product of industrial raw materials *Pulp* and paper that is widely used as fuel, wood adhesive and handicrafts [3]. A new aspect of this research is the use of acacia bark adsorbent in raw material form because it is environmentally friendly, easily obtained, cost-efficient, and easy to use in the adsorption process. Based on its chemical composition and

abundance, acacia bark (*Acacia crassicaarpa*) has the potential to be used as an adsorbent in the adsorption process.

Rhodamine B including one of the dye waste produced by the textile industry. Its existence that exceeds the threshold and is difficult to degrade naturally in waters makes this dye harmful to living beings and the environment. Number of concentration thresholds *Rhodamine B* What is allowed in the waters is about 5–10 mg/L [4]. *Rhodamine B* including cationic dyes that have N-ethyl groups on both sides of the ring so that they are toxic and carcinogenic [5]. *Rhodamine B* may cause irritation of the skin, eyes and respiratory tract disorders in humans [6]. Therefore, it is necessary to carry out further handling to reduce the pollution of dye waste

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The adsorption method is known to be one of the effective methods for removing color in dye waste, due to its simple method and low cost [7]. Adsorption is influenced by several factors, including adsorbent dose, solution pH, contact time, stirring speed, adsorbate concentration and temperature. Increased adsorbent dosage is positively correlated with the efficiency and performance of dye removal. The pH value affects the activity of the functional group in the adsorbent, the surface charge and the surface properties of the adsorbent and adsorbate [8]. Contact time optimization is used to determine the optimum stirring time during the adsorption process, so that the adsorbent can latch the adsorbate to the maximum [9]. The stirring speed plays an important role in increasing the adsorption rate, as it helps to spread the adsorbents evenly in the solution and magnifies the adsorbate molecular interactions [10]. Adsorbate concentration optimization is important to determine the capacity of adsorbents to absorb various adsorbate concentrations [11]. Temperature plays an important role in the adsorption process because it affects the kinetic energy of the adsorbate molecule and the interaction between the adsorbate and the adsorbent [12].

Previous research has used several adsorbents such as bark *Neem Wood* (*Azadirachta indica*), jatoba bark and durian bark in adsorbing dyes *Rhodamine B* and optimum conditions were obtained at an adsorbent dose of 0.1 g, pH 6, contact time of 60 minutes, stirring speed of 200 rpm, adsorbate concentration of 30 mg/L and temperature 50°C [12], [13], [14].

The research characteristics of *Acacia crassicaarpa bark powder adsorbent* against the dye *Rhodamine B* were analyzed using *Fourier Transformed Infrared* (FTIR), *Scanning Electron Microscopy – Energy Dispersive X-Ray Spectroscopy* (SEM-EDS) and *Brunauer-Emmett-Teller* (BET).

Materials and Methods

Tools and materials

The tools used in this study are *choppers*, *grinders*, 100 and 200 mesh sieve analyses, oven (Stericell), analytical scales (Kern ABJ-

NM/ABS-N), spray bottles, stirring rods, spatulas, pH meters (Hanna), *hotplates* (Corning PC-420D), *magnetic stirrer* (IKA C-MAG MS10), *centrifuge* (IEC Centra CL2), *Scanning Electron Microscopy-Energy Dispersive X-Ray Spectroscopy* (SEM-EDS) (JEOL JBM-6510LA), *Brunauer-Emmet-Teller* (BET) (Quantachrome Quadrasorb-Evo), *Fourier Transform Infra-Red* (FTIR) Spectroscopy (IR Prestige-21, Shimadzu), UV-Vis Spectrophotometer (Agilent Cary 60 UV-Visible Spectrophotometer) and other laboratory glassware equipment according to working procedures.

The materials used in this study include *Rhodamine B* powder (C₂₈H₃₁N₂O₃Cl), acacia bark (*Acacia crassicaarpa*) samples taken from PT RAPP's Industrial Park Forest (HTI), sodium chloride (NaCl), sodium hydroxide (NaOH), hydrochloric acid (HCl), ethanol (C₂H₆O), *aqua demineralized* (H₂O), aquadest (H₂O) and aluminum foil.

Method

Adsorbent preparation

Samples of acacia bark (*Acacia crassicaarpa*) adsorbents from RAPP's Industrial Park Forest (HTI) were taken and cleaned by washing, then cut into small pieces and dried in the sun until the acacia bark dried. The sample is crushed using a grinder so that a fine powder is obtained. The obtained powder is dried in the oven for ± 2 days. Dried acacia bark powder is sifted using a sieve with a particle size of 200 < x < 100 mesh. Samples are stored inside plastic zippers.

Characterization of adsorbents

Samples of acacia bark powder (*Acacia crassicaarpa*) before and after adsorption were characterized using *Fourrier Transform Infrared* (FTIR) to determine the functional group of the adsorbent, *Scanning Electron Microscope - Energy Dispersive X-ray Spectroscopy* (SEM-EDS) was used to determine the surface morphology and chemical element composition of the adsorbent and also characterized before adsorption using the *Brunnauer-Emmett-Teller* (BET) to determine the pore surface area of the adsorbent.

Adsorbent dose optimization

The *Rhodamine B* solution is prepared at a concentration of 30 mg/L and the pH of the solution is set at pH 6 as much as 50 mL. Adsorbents with a dose variation of 0.1; 0.25; 0.5; 0.75 and 1 g are added to each solution. The mixture is stirred using a *magnetic stirrer* for 60 minutes at a stirring speed of 150 rpm at room temperature. The mixture is centrifuged for 15 minutes at a speed of 3500 rpm. Supernatant is taken and its absorbance measured using a UV-Vis spectrophotometer at the optimal wavelength. The adsorption efficiency of *Rhodamine B* in the solution and the adsorption capacity at equilibrium are calculated using **Equation 1** and **Equation 2**:

$$\text{Efisiensi adsorpsi (\%)} = \frac{C_0 - C_e}{C_0} \times 100\% \dots\dots\dots(1)$$

$$q_e = \frac{(C_0 - C_e) \times V}{m} \dots\dots\dots(2)$$

Information:

q_e = Adsorption capacity (mg/g)

C_0 = Initial concentration of adsorbate (mg/L)

C_e = Adsorbate end concentration (mg/L)

V = Solution volume (L)

m = Adsorbent mass (g)

Solution pH optimization

The *Rhodamine B* solution is prepared at a concentration of 30 mg/L as much as 50 mL and the pH of the solution is regulated at pH variations of 2, 4, 6, 8 and 10 with the addition of NaOH 0.1 M and HCl 0.1 M solutions. The mixture is stirred using a *magnetic stirrer* for 60 minutes at a stirring speed of 150 rpm at room temperature. The mixture is centrifuged for 15 minutes at a speed of 3500 rpm. Supernatant is measured for absorbance using a UV-Vis spectrophotometer at the optimal wavelength. The adsorption efficiency of *Rhodamine B* in the solution and the adsorption capacity at equilibrium are calculated using **Equation 1** and **Equation 2**.

Determination of pH_{PZC}

A solution of NaCl 0.1 M is prepared as much as 50 mL and the pH of the solution is regulated at pH 2, 4, 6, 8 and 10 using HCl 0.1 M and NaOH 0.1 M. Adsorbents are added as much as the optimal dose of 0.5 g to each solution. The mixture is stirred using a *magnetic stirrer* for 60 minutes at a stirring speed of 150

rpm. The mixture is left to sit for 24 hours then the final pH value is measured. The results of the measurements obtained made a relationship curve between the initial pH as the x-axis and the ΔpH (early-final pH) as the y-axis.

Contact time optimization

Rhodamine B solution is prepared at a concentration of 30 mg/L and an optimal pH 2 of 50 mL. The adsorbent is inserted into each solution at an optimum dose of 0.5 g. The mixture is stirred using a *magnetic stirrer* with a variation of contact time of 30, 40, 50, 60 and 70 minutes with a stirring speed of 150 rpm at room temperature. The mixture is centrifuged for 15 minutes at a speed of 3500 rpm. Supernatant is measured for absorbance using a UV-Vis spectrophotometer at the optimal wavelength. The adsorption efficiency of *Rhodamine B* in the solution and the adsorption capacity at equilibrium are calculated using **Equation 1** and **Equation 2**.

Optimization of stirring speed

Rhodamine B solution is prepared at a concentration of 30 mg/L and an optimal pH 2 of 50 mL. Adsorbents are added to each solution for an optimal dose of 0.5 g. The mixture is stirred using a *magnetic stirrer* for 50 minutes with a variation of stirring speed of 100, 150, 200, 250 and 300 rpm at room temperature. The mixture is centrifuged for 15 minutes at a speed of 3500 rpm. Supernatant is measured for absorbance using a UV-Vis spectrophotometer at the optimal wavelength. The adsorption efficiency of *Rhodamine B* in the solution and the adsorption capacity at equilibrium are calculated using **Equation 1** and **Equation 2**.

Adsorbate concentration optimization

Rhodamine B solution is prepared at concentration variations of 10, 20, 30, 40, and 50 mg/L and an optimal pH 2 of 50 mL. An adsorbent of an optimal dose of 0.5 g is added to each solution. The mixture is stirred using a *magnetic stirrer* for an optimum contact time of 50 minutes with an optimum stirring speed of 200 rpm at room temperature. The mixture is centrifuged for 15 minutes at a speed of 3500 rpm. Supernate is taken and its absorbance is measured using a UV-Vis spectrophotometer at

the optimal wavelength. The adsorption efficiency of *Rhodamine B* in the solution and the adsorption capacity at equilibrium are calculated using **Equation 1** and **Equation 2**.

Temperature optimization

Rhodamine B solution is prepared at an optimal concentration of 40 mg/L and at an optimal pH of 2 of 50 mL. Adsorbents are added to each solution at an optimal dose of 0.5 g. The mixture is stirred using a magnetic stirrer for an optimum contact time of 50 minutes with an optimum stirring speed of 200 rpm at temperature variations of 30, 40 and 50°C. The mixture is centrifuged for 15 minutes at a speed of 3500 rpm. Supernatant is measured for absorbance using a UV-Vis spectrophotometer at the optimal wavelength. The adsorption efficiency of *Rhodamine B* in the solution and the adsorption capacity at equilibrium are calculated using **Equation 1** and **Equation 2**.

Results and Discussion

Characterization of SEM-EDS

Surface morphological analysis of acacia bark powder (*Acacia crassicaarpa*) before and after adsorption was analyzed using the Scanning Electron Microscope (SEM) instrument at 5,000x magnification can be seen in **Figures 1 (a)** and **1 (b)**.

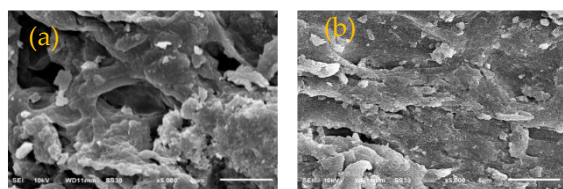


Figure 2. Surface morphology of adsorbents at 5,000x magnification (a) before adsorption and (b) after adsorption

Figure 1 (a) shows the surface shape of acacia bark powder before adsorption at 5,000x magnification. The surface morphology of the adsorbent before adsorption has open or hollow pores that will later become the place where the adsorbate is bound. The surface of acacia bark powder before adsorption appears relatively rough, this is a picture of the typical texture of woody plant fibers [14]. **Figure 1 (b)** Showing the surface shape of acacia bark powder after adsorption, it can be seen that the previously open and still empty adsorbent pores have been

filled and covered by dyes *Rhodamine B* who were seduced. This shows that the adsorption process has indeed occurred in this study.

Analysis of the chemical element composition of acacia bark powder (*Acacia crassicaarpa*) before and after adsorption was analyzed using EDS instruments. EDS spectrum results can be seen in **Figures 2 (a)** and **2 (b)**.

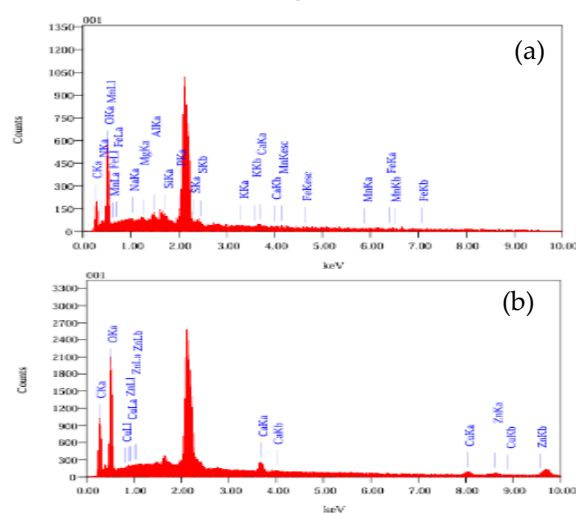


Figure 1. EDS spectrum (a) acacia bark powder before adsorption (b) acacia bark powder after adsorption

Figure 2 (a) shows the EDS spectrum of acacia bark powder before adsorption, where acacia bark powder contains mostly carbon (C) and oxygen (O) elements that indicate the cellulose contained in the adsorbent. The elements Na, Mg, Al, Ca, K and Fe are found in small amounts in adsorbents, because these elements are soil nutrients that can be absorbed by plants. Therefore, the presence of such elements in the bark is the result of natural biological processes [15].

Figure 2 (b) showed the spectrum of EDS of acacia bark powder after adsorption, where an increase in the composition of element C can be seen indicating that the dye *Rhodamine B* has been adsorbed, since most of the dyes *Rhodamine B* also consists of element C so as to increase the total number of element C after adsorption. The mineral elements Na, Mg, Al, Ca, K and Fe after adsorption are no longer detected, due to the exchange of ions between cations of the *Rhodamine B* with mineral ions on the adsorbent having the same charge, so that

these mineral ions are detached from the adsorbent surface and their intensity is lost in EDS analysis after adsorption [16]. The appearance of Cu and Zn elements in the EDS spectrum after adsorption is due to electrostatic interactions between Cu^{2+} and Zn^{2+} ions in the adsorbent with Cl^- ions and COO^- from *Rhodamine B* during adsorption [17].

BET Characterization

Analysis of surface area, volume and pore diameter of acacia bark powder adsorbent (*Acacia crassicaarpa*) was analyzed using the BET instrument which can be seen in Table 2.

Surface Area (m^2/g)	Pore Volume (cc/g)	Average Pore diameter ($\text{\AA}$)
0.460	4.361×10^{-3}	3.790×10^2

Table 1. The results of the analysis of the surface area, volume, and pore diameter of acacia bark powder adsorbents (*Acacia crassicaarpa*)

Surface area and pore volume of adsorbent are $0.460 \text{ m}^2/\text{g}$ and $4.361 \times 10^{-3} \text{ cc/g}$, the value is relatively small due to the use of adsorbents in the form of *Raw* material without activation either physically or chemically. The average diameter of the pore of an adsorbent is $379.008 \text{ \AA}$ or equivalent to 37.9008 nm which is included in the size of mesopori, because according to IUPAC materials classified as mesopores have a diameter between 2 to 50 nm. The mesopore structure provides a large enough space that allows adsorbate molecules to easily diffuse into the adsorbent pores and improves adsorption efficiency [18].

FTIR Characterization

The analysis of the functional clusters of acacia bark powder (*Acacia crassicaarpa*) before and after adsorption was analyzed using the Fourier Transformed Infrared (FTIR) instrument which can be seen in Figure 3.

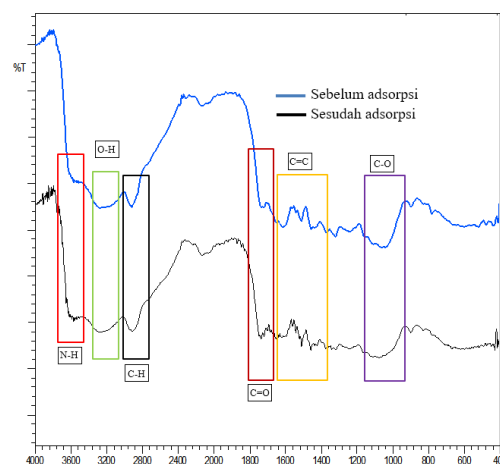


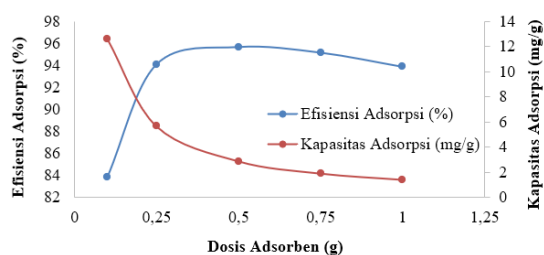
Figure 3. Spectrum FTIR of acacia bark powder (*Acacia crassicaarpa*) before and after adsorption

Peak absorption at wave number $3574.25 - 3605.11 \text{ cm}^{-1}$ shows the presence of a functional group of N-H amines both derived from organic compounds in acacia bark and from amine groups in dyes *Rhodamine B* after adsorption [19]. Peak at wave number $3284.57 - 3275.27 \text{ cm}^{-1}$ indicates the presence of -OH vibrations or hydroxyl groups of alcohols, phenols and carboxylic acids found in acacia bark adsorbents or dyes *Rhodamine B* [20]. Absorption at wave number $2917.46 - 2903.96 \text{ cm}^{-1}$ arises from the presence of many organic compounds in the biomass of acacia bark, such as lignin cellulose and hemicellulose, which are rich in aliphatic alkyl and methylene (CH_2) group and represents the C-H bond stretch vibration [14].

The peak that appears at wave number $1743.72 - 1736.01$ indicates the vibration of the C=O bond or carbonyl group of carboxylic acid compounds, aldehydes, ketones and esters cm^{-1} [21]. The peak of the wave number $1617.38 - 1457.28$ indicates the presence of a C=C bond in the aromatic ring of the compound found in both adsorbents and adsorbates. cm^{-1} [22]. The peaks that appear at wave numbers $1077.29 - 1042.57$ indicate the presence of C-O bond vibrations from ester groups, alcohols, ethers, carboxylic acids and phenols cm^{-1} [23].

Adsorbent dose optimization

The effect of adsorbent dose on the adsorption of *Rhodamine B* dye was obtained with an optimal adsorbent dose of 0.5 g with an adsorption efficiency of 95.65% and an adsorption capacity of 2.8728 mg/g as shown in

Figure 4.**Figure 4.** Graph of the relationship between adsorbent dose and adsorption efficiency and adsorption capacity *Rhodamine B*

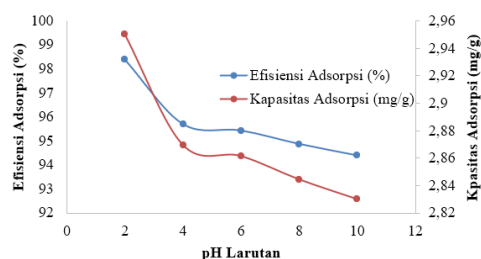
Dose optimization of acacia bark powder adsorbents (*Acacia crassicaarpa*) in absorbing dyes *Rhodamine B* studied at a dose variation of 0.1; 0.25; 0.5; 0.75 and 1 g. **Figure 4** showed an increase in the dose of adsorbents from 0.1 g to 0.5 g, so that the adsorption efficiency also increased from 83.86% to 95.65%. This is due to the increase in the dose of the adsorbent, the surface area will also increase, so that the active side of the adsorbent will also increase to bind the adsorbate which causes the adsorption efficiency to increase. However, after reaching optimum as the adsorbent dose increases from 0.5 g to 1 g, it decreases the adsorption efficiency from 95.65% to 93.86%. This is because a larger dose of adsorbent will cause overlap or aggregation of the adsorption site resulting in a decrease in the total surface area of the adsorbent and the adsorption efficiency [24].

Adsorption capacity decreases further as the adsorbent dose increases as shown in **Figure 4**. The adsorption capacity decreased from 2.8728 mg/g to 1.4096 mg/g as the adsorbent dose increased. This decrease in adsorption capacity is caused by The mass factor of the adsorbent is inversely proportional to the adsorption capacity [25]. Thus, the adsorption capacity per gram decreases due to too many adsorbents and too many active sites for the number of adsorbents available, so the number of adsorbate bound in each gram of adsorbent becomes less.

Solution pH optimization

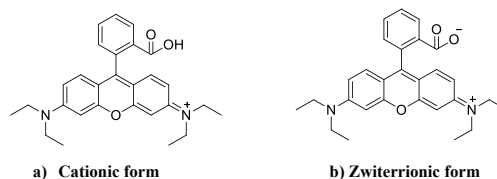
The study of the effect of pH of *Rhodamine B* dye solution in adsorption obtained the best pH at pH 2 with an adsorption efficiency of

98.39% and an adsorption capacity of 2.9500 mg/g shown in **Figure 5**.

**Figure 5.** Graph of the relationship between the pH of the solution and the adsorption efficiency and adsorption capacity *Rhodamine B*

pH optimization is studied at pH 2, 4, 6, 8 and 10. In general, in electrostatic interactions, the increase in adsorption efficiency occurs at a higher pH or alkaline pH because *Rhodamine B* is a cationic dye. However, in this study, the increase in adsorption efficiency occurred at a lower pH or acidic pH. This can be explained by the presence of a change in the shape of the *Rhodamine B* molecule which depends on the pH of the solution.

Molecular shape changes *Rhodamine B* is influenced by the pKa value of the dye, where the pKa value *Rhodamine B* is 3.7 [26]. If the pH of the solution is lower than the pKa value, then the molecule *Rhodamine B* has a cationic form as shown in **Figure 6(a)**. However, if the pH of the solution is greater than the pKa value, then the aromatic carboxyl group will be deprotonated and negatively charged, resulting in a molecular shape known as *Whitening* ions such as in

**Figure 6(b)** [27].**Picture 6.** Molecular structure *Rhodamine B*
(a) cationik (b) zwitter ion

The adsorption efficiency is highest at pH 2 because at that pH it is pH below the pKa value so that the molecule *Rhodamine B* cationic in form. The shape is a monomer *Rhodamine B* which has a molecular size of 1.8 nm so that it can easily penetrate the porous structure of the adsorbent. In addition, at a pH higher than pKa,

namely at pH 4, 6, 8 and 10, *Rhodamine B* deformed into *Whitening* ion. This shape increases the aggregation of dyes which leads to the formation of larger dye molecules making it harder to enter the pores of the adsorbent and reducing the efficiency of adsorption [28]. The adsorption capacity also decreased as the pH of the solution increased, from 2.9500 mg/g to 2.8299 mg/g. It is also caused by changes in the shape of molecules *Rhodamine B* which depends on the pH of the solution.

Determination of pH_{pzc}

The pH value of acacia bark powder (*Acacia crassicaarpa*) was determined by the pH variation of the NaCl solution of 0.1 M at pH 2, 4, 6, 8 and 10. The pH pH_{pzc} acacia bark powder (*Acacia crassicaarpa*) is at pH 4.3. A graph of the relationship between the initial pH and the ΔpH (early pH-final pH) as well as the pH_{pzc} point is shown in Figure 7.

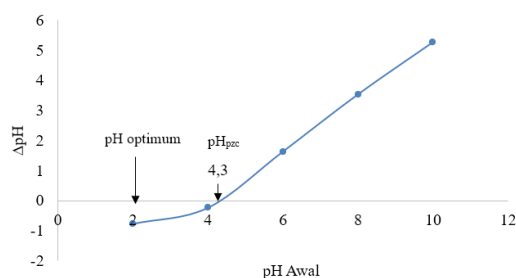


Figure 7. Graph of pH_{pzc} value adsorbent of acacia bark powder (*Acacia crassicaarpa*)

Determination of pH_{pzc} It is carried out to obtain a pH condition that makes the surface of the adsorbent neutrally charged. If the pH of the solution $> pH_{pzc}$ then the surface of the adsorbent will be negatively charged and vice versa if the pH of the solution is $< pH_{pzc}$ then the surface of the adsorbent will be positively charged [29]. pH value pH_{pzc} of adsorbents) in this study is 4.3.

Based on the general concept of pH_{pzc} Adsorption *Rhodamine B* will be more beneficial at a higher pH_{pzc} , which is above pH_{pzc} 4.3 because at that pH the adsorbent will be negatively charged, causing electrostatic interaction with dyes *Rhodamine B* which are cationic or positively charged. However, the results of this study are not in accordance with the concept of pH_{pzc} where more favorable

adsorption occurs at low pH or below pH_{pzc} . This indicates that the pH is below the pH_{pzc} as in optimum pH 2 there is a possibility of other interactions such as hydrogen bonds, hydrophobic-hydrophobic interactions or π - π interactions and van der Waals forces that are more dominant than electrostatic interactions [28], [30].

Several interactions can occur between *Rhodamine B* with active groups in acacia bark powder adsorbents including hydrogen bonds, electrostatic interactions and π - π (hydrophobic-hydrophobic) interactions or van der Waals forces [29]. Hydrogen bonding occurs when the hydrogen atom of a molecule bonds with more electronegative elements such as oxygen and nitrogen present in other molecules. Electrostatic interactions occur between N^+ ions in molecules *Rhodamine B* with negatively charged adsorbent groups such as COO^- groups. The π - π interactions occur in benzene rings *Rhodamine B* with a benzene ring present in the adsorbent of acacia bark powder which causes the van der Waals style.

Contact time optimization

The effect of the variation in the adsorption contact time of *Rhodamine B* dye was obtained with an optimal contact time of 50 minutes with an adsorption efficiency of 98.37% and an adsorption capacity of 2.9478 mg/g as shown in Figure 8.

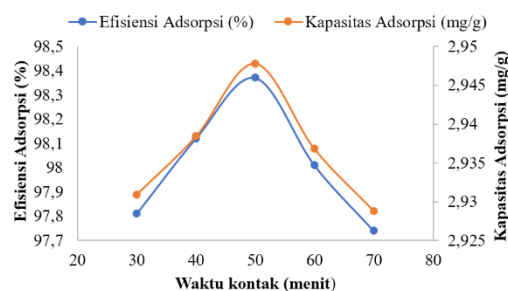


Figure 8. Graph of the relationship between contact time and adsorption efficiency and adsorption capacity of *Rhodamine B*

Effect of contact time on adsorption *Rhodamine B* Using acacia bark powder adsorbent (*Acacia crassicaarpa*) was studied at a variation of contact time of 30, 40, 50, 60 and 70

minutes. The efficiency and adsorption capacity increase at 30 minutes to 50 minutes, but at 60 and 70 minutes efficiency and capacity decrease, as shown in **Figure 8**. The longer the contact time, the more adsorbate is adsorbed. This is because more adsorbent particles come into contact with the adsorbate, so that many adsorbs are bound in the pores of the adsorbent particles. However, if the contact time lasts too long, the number of active surfaces available in the adsorbent will be reduced, resulting in the efficiency and capacity of the adsorbent in adsorbing the dye molecules *Rhodamine B* Decreased[31].

The optimal contact time reached at 50 minutes indicates that the equilibrium of the reaction has been achieved and the maximum adsorption process is experienced, where the adsorption time is less than 50 minutes there are still many active sites from the adsorbent that have not bound to the dye *Rhodamine B* So that there is an increase in efficiency and adsorption capacity. Meanwhile, adsorption of more than 50 minutes does not increase in efficiency and adsorption capacity because the active site of the adsorbent has been met by dyes *Rhodamine B* and has reached a saturated state. Saturation condition is achieved when the adsorbent is no longer able to absorb the adsorbate [32].

Optimization of stirring speed

The effect of the adsorption stirring speed of *Rhodamine B* dye was obtained at 200 rpm with an adsorption efficiency of 98.78% and an adsorption capacity of 2.9564 mg/g as shown in **Figure 9**.

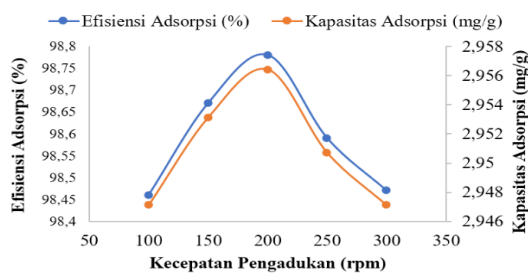


Figure 9. Graph of the relationship between stirring speed and adsorption efficiency and adsorption capacity of *Rhodamine B*

Variation in stirring speed in dye adsorption *Rhodamine B* It is studied with stirring speeds of 100, 150, 200, 250 and 300 rpm. By **Figure 9**, optimum stirring speed at 200 rpm

with an adsorption efficiency of 98.78% and an adsorption capacity of 2.9564 mg/g. If the stirring speed rate is too slow, then the adsorption process runs slowly so that the interaction and distribution of adsorbate in the adsorbent is not optimal [10].

The efficiency and adsorption capacity increase with the increase in stirring speed from 100 to 200 rpm. The greater the stirring speed, the greater the capacity and efficiency of adsorption, this is because the fast stirring rate causes greater contact between the adsorbate and the adsorbent, so that the adsorbent adsorbent can work optimally. However, at stirring speeds that are too high at 250 to 300 rpm, there is a decrease in efficiency and adsorption capacity, this is because the stirring speed affects the adsorbent structure so that the adsorption process is less than optimal. Molecule *Rhodamine B* adsorbent pores can be released again due to high stirring speeds. After reaching the equilibrium point, the increase in stirring speed no longer increases the efficiency and adsorption capacity [33].

Adsorbate Concentration Optimization

The study on the effect of the adsorbate concentration of *Rhodamine B* dye obtained an optimal adsorbate concentration of 40 mg/L with an adsorption efficiency of 98.42% and an adsorption capacity of 3.9358 mg/g as shown in **Figure 10**.

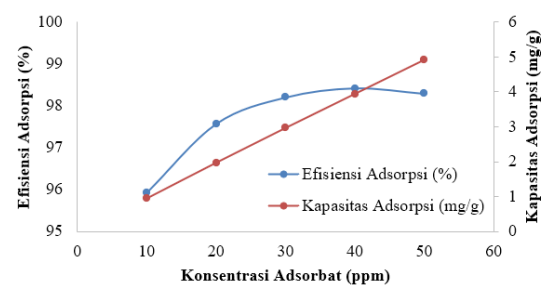


Figure 10. Graph of the relationship between the concentration of the adsorbate and the adsorption efficiency and the adsorption capacity of *Rhodamine B*

Adsorbate concentration optimization was studied at concentration variations of 10, 20, 30, 40 and 50 mg/L. Based on the data presented in **Figure 10**, the optimal adsorbate concentration

is 40 mg/L with an adsorption efficiency of 98.42% and an adsorption capacity of 3.9358 mg/g. A graph of the relationship between adsorbate concentration and adsorption efficiency and capacity can be seen in **Figure 10**.

The adsorption efficiency increased from 10 to 40 mg/L, from 95.93% to 98.42%. This increase in adsorption efficiency is due to the greater the concentration of adsorbate in the solution the greater the number of adsorbate molecules available and can be absorbed by the adsorbent surface [34]. After reaching the optimum concentration at 40 mg/L, the addition of a higher concentration at 50 mg/L led to a decrease in adsorption efficiency to 98.29%. This is because after the equilibrium is achieved, the active site of the adsorbent will become saturated because the amount of adsorbate in the solution is not proportional to the number of adsorbent particles available so that the adsorbent is no longer able to adsorb *Rhodamine B* and the adsorption efficiency will decrease [35].

Temperature Optimization

The effect of temperature variation of the adsorption of *Rhodamine B* dye is obtained as the temperature increases, the efficiency and adsorption capacity increase by 99.04% and 3.9326 mg/g as shown in **Figure 11**.

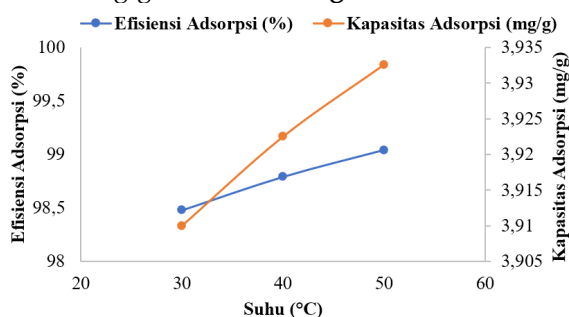


Figure 11. Graph of the relationship between temperature and adsorption efficiency and adsorption capacity of *Rhodamine B*

Temperature optimization in the adsorption process was studied at temperature variations of 30°, 40°, and 50°C. Based on **Figure 11**, that increasing temperature increases the efficiency and adsorption capacity. The efficiency and adsorption capacity obtained were 99.04% and 3.9326 mg/g, respectively. The increase in temperature from 30°C to 50°C

increases the percentage of *Rhodamine B* dye removal so that the capacity and efficiency of adsorption increases as the temperature increases.

An increase in temperature causes the efficiency and capacity of adsorption to increase, which indicates that the adsorption process is chemical and takes place endothermically. So that in the chemical adsorption process, the adsorption rate increases with increasing temperature. Higher temperatures increase the adsorbent's ability to attract and bind dyestuffs. This is also due to the increased mobility of dye molecules in the adsorption process. On the other hand, if the adsorption capacity decreases with increasing temperature, then the adsorption process is exothermic [36]. Temperature affects the adsorption process because it can increase the rate of displacement of material to be adsorbed into the pores of the adsorbent surface.

Conclusion

Acacia bark powder adsorbent (*Acacia crassicaarpa*) has porous and relatively rough surface morphological characteristics. The composition of adsorbent elements is mostly composed of carbon (C) and oxygen (O). The characteristics of BET indicate adsorbents including mesoporous materials. FTIR analysis showed that the adsorbent function groups included N-H, -OH, C-H, C=O, C=C and C-O. Adsorption of *Rhodamine B* using acacia bark powder (*Acacia crassicaarpa*) obtained optimal conditions at a dose of 0.5 g, pH 2, contact time of 50 minutes, stirring speed of 200 rpm, adsorbate concentration of 40 mg/L and temperature of 50°C with an adsorption efficiency of 99.04% and an adsorption capacity of 3.9326 mg/g.

Bibliography

- [1] M. X. T. Nong *et al.*, "Fabrication of activated carbon from *Acacia Crassicaarpa* bark by carbothermal functionalization for adsorptive removal the dyes in aqueous solution," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 1278, no. 1, 2023, doi: [10.1088/1755-1315/1278/1/012039](https://doi.org/10.1088/1755-1315/1278/1/012039).
- [2] S. K. Yadav, K. M. Subhedar, S. R.

- Dhakate, and B. P. Singh, "Synthesis of high surface area activated carbon from eucalyptus bark for the removal of methylene blue," *Indian J. Eng. Mater. Sci.*, vol. 27, no. 6, pp. 1059–1066, 2020, [doi: 10.56042/ijems.v27i6.46844](https://doi.org/10.56042/ijems.v27i6.46844).
- [3] Asfarizal. 2020. *Optimalisasi Pembuatan Papan Partikel Berbahan Dasar Tandan Kosong Kelapa Sawit Dengan Kulit Kayu Akasia*. Disertasi. Padang: Universitas Andalas.
- [4] A. Ulya, E. Nasra, A. Amran, and D. Kurniawati, "Adsorpsi Zat Warna Rhodamine B Dengan Karbon Aktif Kulit Durian sebagai Adsorben," *J. Period. Jur. Kim. UNP*, vol. 11, no. 2, p. 74, 2022, [doi: 10.24036/p.v11i2.113371](https://doi.org/10.24036/p.v11i2.113371).
- [5] M. Danish, W. A. Khanday, R. Hashim, N. S. B. Sulaiman, M. N. Akhtar, and M. Nizami, "Application of optimized large surface area date stone (Phoenix dactylifera) activated carbon for rhodamine B removal from aqueous solution: Box-Behnken design approach," *Ecotoxicol. Environ. Saf.*, vol. 139, no. December 2016, pp. 280–290, 2017, [doi: 10.1016/j.ecoenv.2017.02.001](https://doi.org/10.1016/j.ecoenv.2017.02.001).
- [6] T. O. Ajiboye, O. A. Oyewo, and D. C. Onwudiwe, "Adsorption and photocatalytic removal of Rhodamine B from wastewater using carbon-based materials," *FlatChem*, vol. 29, no. June, p. 100277, 2021, [doi: 10.1016/j.flatc.2021.100277](https://doi.org/10.1016/j.flatc.2021.100277).
- [7] A. Fitriansyah, H. Amir, and E. Elvinawati. 2021. "karakterisasi adsorben karbon aktif dari sabut pinang (areca catechu) terhadap kapasitas adsorpsi zat warna indigosol blue 04-B," *Alotrop*, vol. 5, no. 1, pp. 42–54, [doi: 10.33369/atp.v5i1.16485](https://doi.org/10.33369/atp.v5i1.16485).
- [8] E. Rápó and S. Tonk, "Factors affecting synthetic dye adsorption; desorption studies: A review of results from the last five years (2017–2021)," *Molecules*, vol. 26, no. 17, 2021, [doi: 10.3390/molecules26175419](https://doi.org/10.3390/molecules26175419).
- [9] A. Febriani, S. A. Umara, E. Nursa'adah, and M. L. Firdaus, "Kapasitas Adsorpsi Zat Warna Malachite Green Dan Violet Dye Menggunakan Metal Organic Frameworks (Fe-BDC)," *J. Kependidikan Kim.*, vol. 10, no. 2, pp. 61–72, 2022, [Online]. [Available: http://ojs.undikma.ac.id/index.php/hydrrogen/](http://ojs.undikma.ac.id/index.php/hydrrogen/)
- [10] R. Septiana, S. Benti Etika, and E. Nasra, "Adsorpsi Zat Warna Rhodamin B Menggunakan Senyawa C-Sinamalkaliks[4]Resorsinarena (CSKR) dengan Metoda Batch," *Periodic*, vol. 9, no. 1, pp. 17–23, 2020, [Online]. Available: <https://ejournal.unp.ac.id/index.php/kimia/article/view/108808> doi.org/10.24036/p.v9i1.108808
- [11] C. Irawan, "Pengaruh Konsentrasi Adsorbat Terhadap Efektivitas Penurunan Logam Fe dengan Menggunakan Fly Ash sebagai Adsorben," *Seminastika*, vol. 1, no. 1, pp. 291–293, 2018.
- [12] A. jafar Ahmed, V. Balakrishnan, and S. Arivoli, "Kinetic and equilibrium studies of Rhodamine B adsorption by low cost activated carbon A.," *Arch. Appl. Sci. Res.*, vol. 3, no. 3, pp. 154–166, 2011.
- [13] C. A. Demarchi, A. Debrassi, and C. A. Rodrigues, "The use of Jatobá bark for removal of cationic dyes," *Color. Technol.*, vol. 128, no. 3, pp. 208–217, 2012, [doi: 10.1111/j.1478-4408.2012.00365.x](https://doi.org/10.1111/j.1478-4408.2012.00365.x).
- [14] P. Yang *et al.*, "Effective removal of methylene blue and crystal violet by low-cost biomass derived from eucalyptus: Characterization, experiments, and mechanism investigation," *Environ. Technol. Innov.*, vol. 33, no. November 2023, p. 103459, 2024, [doi: 10.1016/j.eti.2023.103459](https://doi.org/10.1016/j.eti.2023.103459).
- [15] Y. Rusmanta, "dan Mg," vol. 2, pp. 10–14, 2021.
- [16] I. Levchuk, J. J. Rueda Márquez, and M. Sillanpää, "Removal of natural organic matter (NOM) from water by ion exchange – A review," *Chemosphere*, vol. 192, pp. 90–104, 2018, [doi: 10.1016/j.chemosphere.2017.10.101](https://doi.org/10.1016/j.chemosphere.2017.10.101).
- [17] A. Shofiyani, Y. Rahmiyati, and Ti. Anita, "Nanosilika Berbahan Dasar Batu

- [Padas sebagai Adsorben Zat Warna Sintetis Phodamin B,” *Indones. J. Chem. Sci.*, vol. 9, no. 3, pp. 188–193, 2020, \[Online\]. Available: <http://journal.unnes.ac.id/sju/index.php/ijcs>](#)
- [18] [I. Jimmy, D. H. Susanti, A. Roesyadi, and S. Suprpto, “Pembuatan HZSM-5 Mesopori: Pengaruh Agen Desilikasi Sodium Hidroksida dan Potasium Hidroksida,” *Pros. SENIATI*, pp. 273–279, 2019, \[Online\].](#)
- [19] [P. Saharan, G. R. Chaudhary, S. Lata, S. K. Mehta, and S. Mor, “Ultra fast and effective treatment of dyes from water with the synergistic effect of Ni doped ZnO nanoparticles and ultrasonication,” *Ultrason. Sonochem.*, vol. 22, pp. 317–325, 2015, doi: \[10.1016/j.ultsonch.2014.07.004\]\(https://doi.org/10.1016/j.ultsonch.2014.07.004\).](#)
- [20] [Ikram, F. Hidayat, R. Sunartaty, L. Fitriyana, C. AR, and D. E. Puspita, “Effect of Chemical Solutions and Soaking Time on the Characteristics of Kluwih Seed Starch,” *Serambi J. Agric. Technol.*, vol. 5, no. 2, pp. 110–116, 2023, \[Online\].](#)
- [21] [D. Luthfiana, A. Roosdiana, and Sutrisno, “Esterifikasi Gliserol dengan Asam Oleat Menggunakan Lipase yang Diamobilisasi dalam Karagenan,” *BULLET J. Multidisiplin Ilmu*, vol. 1, no. 2, pp. 85–94, 2022.](#)
- [22] [V. A. Tiwow, M. J. Rampe, H. L. Rampe, and A. Apita, “Pola Inframerah Arang Tempurung Kelapa Hasil Pemurnian Menggunakan Asam,” *Chem. Prog.*, vol. 14, no. 2, p. 116, 2021, doi: \[10.35799/cp.14.2.2021.37191\]\(https://doi.org/10.35799/cp.14.2.2021.37191\).](#)
- [23] [Y. Subba Reddy, N. K. Rotte, S. Hussain, V. V. S. S. Srikanth, and M. R. Chandra, “Sustainable mesoporous graphitic activated carbon as biosorbent for efficient adsorption of acidic and basic dyes from wastewater: Equilibrium, kinetics and thermodynamic studies,” *J. Hazard. Mater. Adv.*, vol. 9, no. November 2022, p. 100214, 2023, doi: \[10.1016/j.hazadv.2022.100214\]\(https://doi.org/10.1016/j.hazadv.2022.100214\).](#)
- [24] [H. A. Pramitasari, W. D. Arianti, and L. U. Widodo, “Penyerapan Zat Warna Remazol Red menggunakan Adsorben Arang Aktif Batang Ubi Kayu,” *Chempro*, vol. 3, no. 1, pp. 14–19, 2023, doi: \[10.33005/chempro.v3i1.128\]\(https://doi.org/10.33005/chempro.v3i1.128\).](#)
- [25] [D. Frandica, M. Masrullita, R. Ulfa, S. Suryati, and S. Sulhatun, “Adsorpsi Rhodamin B Menggunakan Adsorben Karbon Aktif Dari Daun Ketapang \(Terminalia Catappa,” *Chem. Eng. J. Storage*, vol. 4, no. 3, p. 423, 2024, doi: \[10.29103/cejs.v4i3.15141\]\(https://doi.org/10.29103/cejs.v4i3.15141\).](#)
- [26] [H. Du, Y. Zhang, H. Jiang, and H. Wang, “Adsorption of rhodamine B on polyvinyl chloride, polystyrene, and polyethylene terephthalate microplastics in aqueous environments,” *Environ. Technol. Innov.*, vol. 27, p. 102495, 2022, doi: \[10.1016/j.eti.2022.102495\]\(https://doi.org/10.1016/j.eti.2022.102495\).](#)
- [27] [I. M. Boukerzaza, B. Boulhouchet, B. Kebabi, and A. Mennour, “Adsorption of Rhodamine B Onto Olive Pomace: Isotherms, Kinetics and Infrared Studies,” *Environ. Eng. Manag. J.*, vol. 20, no. 12, pp. 1963–1971, 2021, doi: \[10.30638/eemj.2021.183\]\(https://doi.org/10.30638/eemj.2021.183\).](#)
- [28] [N. Kaya, “Removal of Congo Red and Rhodamine B dyes from aqueous solution using unmodified and NH₃/HCl-modified wood charcoal: a kinetic and thermodynamic study,” *Fullerenes Nanotub. Carbon Nanostructures*, vol. 29, no. 3, pp. 183–195, 2020, doi: \[10.1080/1536383X.2020.1825952\]\(https://doi.org/10.1080/1536383X.2020.1825952\).](#)
- [29] [K. Kuśmierk, J. Fronczyk, and A. Świątkowski, “Adsorptive Removal of Rhodamine B Dye from Aqueous Solutions Using Mineral Materials as Low-Cost Adsorbents,” *Water. Air. Soil Pollut.*, vol. 234, no. 8, 2023, doi: \[10.1007/s11270-023-06511-5\]\(https://doi.org/10.1007/s11270-023-06511-5\).](#)
- [30] [T. S. Vo, M. M. Hossain, and K. Kim, “Natural bamboo powder and coffee ground as low-cost green adsorbents for the removal of rhodamine B and their recycling performance,” *Sci. Rep.*, vol. 13, no. 1, pp. 1–15, 2023, doi: \[10.1038/s41598-023-48354-4\]\(https://doi.org/10.1038/s41598-023-48354-4\).](#)
- [31] [A. Sugiharto, I. Hoyali, A. F. A. Ghifari, and T. H. Nabilla, “Effect of Contact Time of Rice Husk Ash and Poly](#)

- Aluminum Chloride to Reduce the Concentration of Rhodamin B Dyes Using the Adsorption-Fluidization Method," *Chem. J. Tek. Kim.*, vol. 7, no. 1, p. 77, 2020, doi: [10.26555/chemica.v7i1.16529](https://doi.org/10.26555/chemica.v7i1.16529). (<http://creativecommons.org/licenses/by/4.0/>).
- [32] R. F. Sam, T. Wirawan, and A. Aziz, "ADSORPSI ZAT WARNA RHODAMINE B MENGGUNAKAN SERBUK KULIT BUAH LAI (*Durio kutejensis* (Hassk.) Becc.) SEBAGAI ADSORBEN," *J. At.*, vol. 9, no. 2, pp. 96–104, 2024.
- [33] I. Syafrianda, E. Yenier, and S. Daud, "Pengaruh Waktu Kontak dan Laju Pengadukan Terhadap Adsorpsi Zat Warna Pada Air Gambut Menggunakan Adsorben Limbah Biosolid Land Application Industri Minyak Kelapa Sawit," *J. Jom FTEKNIK*, vol. 4, no. 2, pp. 1–6, 2017.
- [34] Y. Putri and A. Hasna Oktaviana, "Adsorpsi Zat Warna Remazol Brilliant Blue R Pada Limbah Industri Batik Menggunakan Adsorben dari Mahkota Buah Nanas Adsorption of Remazol Brilliant Blue R Dye on Batik Industry Waste Using Pineapple Crown Adsorbent," *J. Ilm. Tek. Kim.*, vol. 21, no. 1, pp. 2460–8203, 2024.
- [35] M. D. Arif and Mawardi, "Pengaruh Konsentrasi Awal Larutan Terhadap Penyerapan Ion Logam Cr+6 Menggunakan Biomassa Alga Hijau *Mougeotia* Sp yang Diimobilisasi Dengan Natrium Silika," *Chem. J. Univ. Negeri Padang*, vol. 9, no. 2, pp. 50–54, 2020.
- [36] M. T. Yagub, T. K. Sen, S. Afroze, and H. M. Ang, "Dye and its removal from aqueous solution by adsorption: A review," *Adv. Colloid Interface Sci.*, vol. 209, pp. 172–184, 2014, doi: [10.1016/j.cis.2014.04.002](https://doi.org/10.1016/j.cis.2014.04.002).

