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Utilization of Khamir (*Saccharomyces cerevisiae*) as Adsorbent of Remazol Red RB Textile Dyes

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ABSTRACT

Adsorption is considered the most efficient and simple method that requires low costs. In this study, firstly, yeast (*Saccharomyces cerevisiae*) was used to adsorption the Remazol Red RB dyes to analyze the efficiency of yeast as an adsorbent of textile dyes as well as determine the particle size, pH, and optimum contact time. Testing of the particle size parameters was done with variations of 100, 170, and 200 mesh size. The optimum condition was obtained in the particle size variation amounting to 200 mesh size with efficiency %E of 56.49%. Subsequent testing was conducted with variations in pH (5.6, 7, 8, and 9). The optimum condition was obtained at pH 6 with efficiency %E of 60.35%. The dyestuffs were conquerable with variations in time of 1, 2, 3, 4, and 5 hours, the largest %E gained was 90.01% throughout 4 hours. Secondly, the research also aimed at identifying the isotherm adsorption pattern. Adsorption in Remazol Red RB dyes fulfilled the isotherm pattern of Langmuir with a correlation coefficient R^2 of 0.9521 and the maximum capacity of the yeast adsorption of 0.07 mg/g. Further research is expected to expand the analysis variation and the type of textile dyes used which can be applied to the actual textile dyes waste.

Keywords: adsorption, yeast (*Saccharomyces cerevisiae*), remazol red RB textile dyes

INTRODUCTION

The art of *endek* fabric is believed to be the heritage of Bali's cultural art (Putri, 2015). In ancient times, the *endek* fabric was worn only by the nobility, but now it is used by all circles and often tourists bring them to their home countries for souvenirs (Dede et al. 2018; Rahayuda, 2015). It leads to a rapid growth of the *endek* fabric industry in Bali. Furthermore, the decree of Bali Governor Regulation number 47 the year 2015 that requires all civil servants wear *endek* uniforms at their workplaces (Surat Keputusan Peraturan Gubernur Bali, 2015), also causes the *endek* fabric industry increase even further.

The massive production in this textile industry increases the amount of waste textile dye as the negative impact of the dyeing process. Synthetic dyeing is widely used in the textile industry because it is cheaper and longer-lasting compared to natural dyes. For the process, Azo dyes are used the most widely, constituting about 70% because it has stable properties which do not fade easily (Sapta, 2014; Yuningrat et al., 2018).

Remazol Red RB is one of the dye substances of the azo group (monoazo) which is often used for staining fabrics red (Sastrawidana, 2011). Remazol Red RB has a molecular formula $C_{27}H_{18}ClN_7Na_4O_{16}S_5$. This textile dye is also referred to as the Reactive Red 198, having a molecular weight of 984.2 grams/mol (National Center for Biotechnology Information). The structure of Remazol Red RB is presented in Figure 1.

The waste of synthetic dyes degrades the water quality and is highly disruptive to the water biota. It is highly reactive and very easily soluble in water, so that Remazol Red RB difficult to degrade by using conventional methods (Fatimah and Gunawan, 2018).

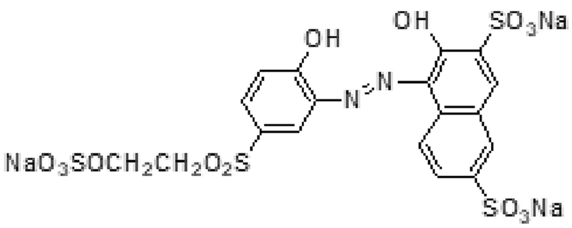

Figure 1. Structure of Remazol Red RB (Gül, 2013)

The adsorption method is considered more efficient, simple, and inexpensive than other methods to ensnare organic pollutants, such as the wastewater Red RB. In this study, Khamir (*Saccharomyces cerevisiae*) was used to absorb the Remazol Red RB dye.

MATERIALS AND METHODS

The experiments of this study were conducted in the chemistry Department of Universitas Pendidikan Ganesha, which started in January and lasted until June 2020. The devices used included glassware (Erlenmeyer flask, Beaker glass, stirrer rod, glass watch, etc.), UV-Vis spectrophotometers, shakers, analytic balances, centrifuges, ovens, and blenders.

The materials used involved yeast (*Saccharomyces cerevisiae*) for bread yeast, aquades, HCl (0.1 m), and NaOH (0.1 m) and the dyes of Remazol Red RB.

The creation of Khamir adsorbent (*Saccharomyces cerevisiae*)

Porcelain cups were placed in the oven at a temperature of 105°C for 30 minutes. Khamir of bread yeast was baked for 1.5 hours at a temperature of 105°C using an oven-based porcelain mat. Then, the yeast dried bread was ground up to the desired size using a blender. Then, it was placed in the container.

Creation of stock solution and maximum wavelength determination

The parent solution of Remazol Red RB was made of a concentration of 1000 mg/L. Furthermore, the parent solution was diluted into a concentrated solution of 500 mg/L, then 100 mg/L. Afterwards, the solution with a concentration of 100 mg/L was diluted again into a solution with a concentration of 15 mg/L, then it was reduced to about 5 mL. This stage was carried out to adjust to the size of the cuvettes, and the absorbance was measured at the wavelength range (λ) 400–800 nm. The maximum wavelength (λ_{max}) was the wavelength value that has the greatest absorbance value or has the highest peak.

Manufacturing standard solution and standard curve

The standard solution was made by diluting the raw solution 100 mg/L to a concentration variation of 5, 10, 15, 20, and 25 mg/L. The absorption of each concentration was measured at the maximum wavelength (λ_{max}). After receiving the absorbance of each variation of the concentration of the standard solution, a linear curve of the absorption of the absorbance (y) to the concentration (x) was drawn. From that curve, linear regression equation $y = ax + B$ and the value of R2 stating the linearity of the curve were obtained.

Determination of particle size, pH, and optimum contact time

Optimum particle size

Khamir of the yeast bread was crushed and then sifted with a variation of the Sieve 100, 170, and 200 mesh size. Furthermore, the result of each of the measures was taken by one gram and inserted into the Erlenmeyer flask which had been filled with a solution of Remazol Red RB in which its concentration had been measured. The solution was homogenized with a shaker for 3 hours (Elystia et al, 2018). Afterwards, it was centrifuged with a speed of 5000 rpm for 15 minutes to separate the Supernatant with Sorbent (Sastrawidana, 2011). Then, the absorbance of the dyes was measured at maximum wavelengths.

pH Optimum

The dyes of Remazol Red RB that had been measured in the previous concentrations, were prepared into variations of pH 5, 6, 7, 8, and 9 by adding HCl and NaOH then measured pH using a calibrated pH meter.

Yeast was inserted into each of the Erlenmeyer flasks with the most efficient size of the yeast absorbing the above-mentioned dye substance. It was then homogenized with a shaker for 3 hours and centrifuged at a speed of 5000 rpm for 15 minutes. The absorbance of each dyes substance was measured at maximum wavelengths. Optimum pH is a substance with the pH that has the greatest absorbance value (Setiawan et al., 2019).

Optimum contact time

The substance was added with yeast in particle size and optimum pH. The whip solution uses a shaker with time variation of 1, 2, 3, 4, and 5 hours (Elystia et al., 2018). Afterwards, it was centrifuged with a speed of 5000 rpm for 15 minutes, then the absorption of the solution of dye was measured using a UV-Visible spectrophotometer.

Data analysis

The efficiency (%E) was calculated using the following Equation (1):

$$\%E = \frac{C_0 - C_{st}}{C_0} \times 100\% \tag{1}$$

where: C_0 – the initial concentration,
C_{st} – the equilibrium concentration after adsorption.

The optimum particle size was determined by creating a link curve between the particle size times %E. The optimum pH was also determined by creating a pH linear relationship curve times %E. The optimum contact time could be determined from the contact time relationship curve to %E value.

The adsorption isotherm pattern was obtained from the adsorption data obtained from the test results and inserted into the equation of the Freundlich (2) and Langmuir (3) adsorption isotherm pattern.

$$\text{Log}\frac{X_m}{m} = \log k + \frac{1}{n}\log C_{st} \tag{2}$$

where: X_m – masses of adsorption substances (g),
m – mass adsorbent (g),
C_{st} – concentration of the substances in equilibrium (mg/L),
k – the Freundlich constant,
n – maximum capacity of adsorption (mg/g),

The value n can be calculated by creating a relationship curve between the X_m/m log times the C_{st} log.

$$\frac{m.C_{st}}{X_m} = \frac{1}{a} + \frac{b}{a}C_{st} \tag{3}$$

where: a – maximum capacity of adsorption (mg/g).

The value a can be calculated by creating a curve $(m\cdot C_{st})/X_m$ times C_{st}, linear equations will be obtained with important $1/a$ and slope b/a. (Khuluk et al., 2019).

RESULT AND DISCUSSION

The effect of pH

The obtained data was analyzed using equation (1) to obtain the percentage efficiency. Initial concentration calculation C_0, equilibrium concentration C_{st}, and percentage efficiency %E, are presented in Table 1 for particle size variation, Table 2 for pH variation and Table 3 for contact time variation.

In order to determine the particle size, pH, and optimum contact time, the relationship curve of each-each test variation to its efficiency value was created. Figures 2, 3, and 4 present the relationship curves particle size, pH, and time of contact to efficiency %E.

The calculation data above was then analyzed to determine the isotherm adsorption pattern. The Isotherm adsorption pattern of Langmuir was known by creating a C_{st} relationship curve times m.C_{st}/X_m. The curve of the isotherm adsorption pattern of Langmuir is presented in Figure 5.

Formerly, yeast (*Saccharomyces cerevisiae*) was used to adsorption metals namely; metal Cu(II) and Cr(II). Adsorption Cu(II) performed by (Setiawan et al., 2019) showed an efficiency of 55.36%. As for the adsorption of Cr(II) conducted by (Elystia et al., 2018), the highest efficiency is 54.7%. From these two studies, it can be noted that *Saccharomyces cerevisiae* is effective enough to remove heavy metals with an average percentage of about 50%.

As presented in Table 1, 2, and 3, the largest %E value of each test variation that has been performed above 50%, indicated that the use of yeast as adsorbent is quite effective in absorbing the Remazol Red RB dye. This waste, is quite hazardous to the environment, and it has to be further processed. Compared to the previous research, which also indicated %E average around 50% for the use of heavy metals, yeast is suitable for absorbing both dyes and metals. Besides, wastewater treatment using the adsorption method is more effective, simple, and relatively less inexpensive (Suarya et al., 2020). Figure 2 shows that yeast (*Saccharomyces cerevisiae*)

Table 1. Calculation results of particle size and dyes concentration.

Particle size (mesh)	C_0 (mg/L)	C_{st} (mg/L)	E (%)
100	6.648	5.409	18.64
170	6.648	5.198	21.82
200	6.648	2.892	56.49

Table 2. Calculation results of pH and dyes concentration.

pH	C_0 (mg/L)	C_{st} (mg/L)	E (%)
5	7.974	3.373	57.70
6	7.974	3.161	60.35
7	7.974	3.392	57.46
8	7.974	3.315	58.43
9	7.974	3.507	56.02

Table 3. Calculation results of dyes concentration and contact time

Contact times (hour)	C_0 (mg/L)	C_{st} (mg/L)	E (%)
1	8.954	1.480	83.47
2	8.954	0,923	89.69
3	8.954	1.019	88,62
4	8.954	0.894	90.01
5	8.954	1.038	88.40

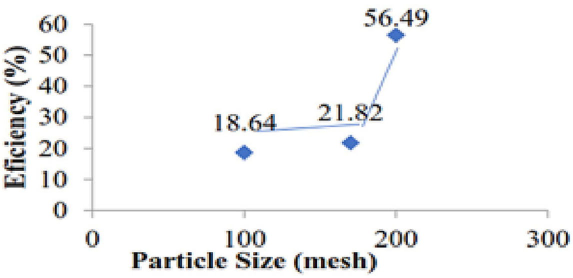

Figure 2. The particle size relationship curve to adsorption efficiency

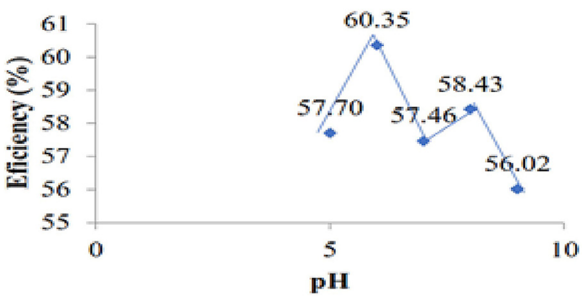

Figure 3. The pH curve towards adsorption efficiency

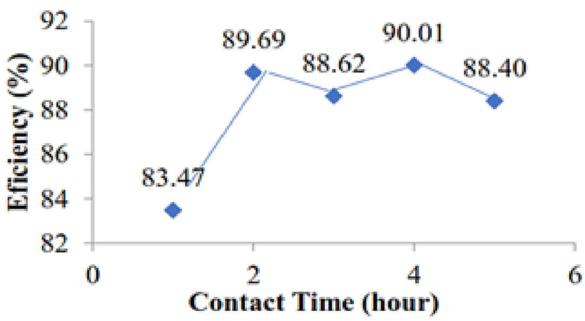

Figure 4. Contact time relation curve to adsorption efficiency

with a particle size of 200 mesh has the greatest efficiency of 56.49% because the adsorption is influenced by the surface area and particle size; the wider the surface of an adsorbent, the adsorbate is more likely to be able to maximize the adsorption process that is influenced by the surface tensile force and surface energy (Faisol and Ridha, 2008). The previous research used *Saccharomyces cerevisiae* as a biosorbent to ensnare the Cr (II) heavy metal, an effective particle size of 80 mesh size with a percentage removal efficiency of 54.7%.

On the basis of Figure 3, the optimum pH to absorb the dyes of the substance by yeast (*Saccharomyces cerevisiae*) which is pH 6 which is 60.35%. When yeast (*Saccharomyces cerevisiae*) is used to bind the Cu (II) heavy metal (Setiawan, et al., 2019), the optimum pH is pH 5 with a percentage of 54.7%. Thus, in the case of yeast (*Saccharomyces cerevisiae*) the acidic atmosphere is optimum for absorbing heavy metals as well as dyestuffs. The pH parameter influences the active

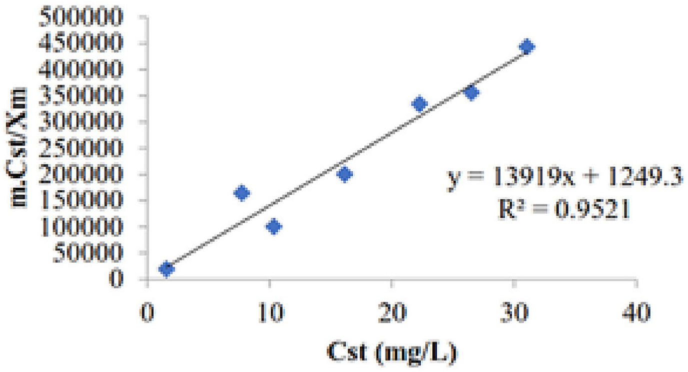

Figure 5. Pattern of isotherm adsorption Langmuir

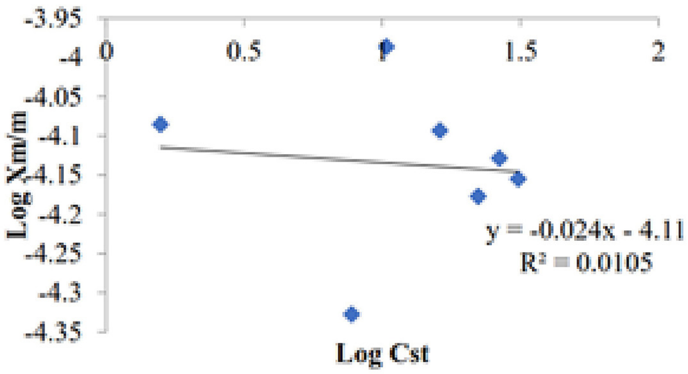

Figure 6. Pattern of isotherm adsorption Freundlich

side content of adsorbent. From pH 5 to pH 6 there is an increase in the graph, this is due to the existence of the H^+ ions in the aqueous Red RB dye solution. At pH 5, it has % E smaller than in pH 6 because the smaller the pH value, the more H^+ ions exist, so that the possibility of excess H^+ion, causing the intermolecular interactions of the substance with the active site of the yeast, is greater (Setiawan, et al., 2019). Meanwhile, after pH 6 on average decreased% E, this is due to the increasing pH; hence, the existence of the H^+ ions was reduced. Then, OH-ions increased along with the pH. The existence of OH^- ion, can lead to the formation of deposits of hydroxide reducing the level of substances that are adsorbed and affect the value of efficiency (Maghfiroh, 2016).

On the basis of the data obtained, Figure 4 showed that the dyes of Remazol Red RB were absorbed at optimum after the application of yeast for 4 hours with a percentage efficiency of 90.01%.

When the contact time is less than 4 hours, the dye is unlikely to undergo adsorption completely. As seen in the curve, indicating the chart rises, this occurs because the longer the length of the given contact, the adsorption power will be greater (Sukarta et al., 2008). Conversely, the chart decreased after a contact time of 4 hours, since yeast is no longer able to absorb dyestuffs, resulting in a release of Remazol Red (Suarya et al, 2020). The isotherm adsorption pattern was analyzed using the Langmuir prequalify by creating an relationship curve against C_{st} so that there will be a straight line equation of $y = 13919x + 1249.3$ and R^2 value of 0.9521. This means that 95.21% of the $m{\cdot}C_{st}/X_m$ value is affected by C_{st} at the time of equilibrium and is influenced by other factors by as much as 4.79%. The maximum capacity of adsorption n is obtained from the linear equation. The equation of the isotherm pattern of Langmuir has a line gradient ($1/N$) 13.919, so the value of n is 0.0000718 if it is rounded to 0.00007. Thus, 1 gram of yeast can absorb as much as 0.07 mg of the dye substance.

The Freundlich isotherm adsorption pattern of Remazol Red RB by yeast (*Saccharomyces cerevisiae*) can be determied from the analysis of test results inserted into the Freundlich equation by creating the link curve between log X_m/m against log C_{st}. From the built-in linearity curve, there is a straight-line equation of $y = -0.024x - 4.11$ and an R^2 value of 0.0105, which means it cannot meet the Freundlich equation when the R^2 value is less than 95%.

The isotherm pattern is fulfilled only from the Langmuir equation; hence, it can be assumed that the adsorbent (Khamir) has more active sites that are homogeneous than heterogeneous. The adsorption process only occurs on 1 site, molecular adsorbate (dyestuffs) only occupies 1 active site of adsorbents and further adsorption does not occur (Suarya et al, 2020). Thus, this adsorption process can be assumed to only occur on 1 side or Monolayer (Sukarta, 2020).

CONCLUSION

On the basis of the purpose of this research, it can be concluded that Khamir (*Saccharomyces cerevisiae*) is quite efficient as an adsorption of Remazol Red RB dyes with an average efficiency of 68.95% with variations in particle size, pH and contact time. The most optimum size of yeast particle (*Saccharomyces cerevisiae*) is 200 mesh size with a percentage efficiency of 56.49%. For pH test variations, the Remazol Red RB dyestuffs at pH 6 exhibits the highest %E of 60.35%. Remazol Red RB treated with yeast (*Saccharomyces cerevisiae*) for 6 hours has the greatest %E of 90.01%. The fulfilled isotherm adsorption pattern is Langmuir, with a value of R2 of 0.9521 and the maximum capacity of adsorption equal to 0.07 mg of the dye substance absorbed in 1 gram yeast (*Saccharomyces cerevisiae*).

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