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ORIGINAL RESEARCH

The removal of remazol brilliant blue dyes from liquid waste using nano montmorillonite from bentonite of Bener Meriah Aceh

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Abstract. This research focuses on the removal of Remazol Brilliant Blue Dyes from liquid waste using nano montmorillonite from Bentonite of Bener Meriah Aceh. The increasing amount of synthetic textile dyes from liquid waste such as Remazol Brilliant Blue can cause pollution and are harmful to the environment. This problem can be addressed by adsorption using nano montmorillonite. This research was conducted in several stages, first the isolation of nano montmorillonite from Aceh bentonite was done, then batch adsorption studies were carried out by varying the adsorption time, finally a pH and mass of the adsorbent and the adsorbent regeneration test was conducted. The results showed that the optimum conditions for removal of Remazol Brilliant Blue dye using nano montmorillonite occurred at a contact time of 60 minutes, with a pH of 4, and an adsorbent mass of 2 grams; The results of the regeneration test show that the nano montmorillonite adsorbent can be used repeatedly

Keywords: Bentonite, Nano montmorillonite, Adsorption, Remazol Brilliant Blue

INTRODUCTION

In recent years, the development of the textile industry in Indonesia has begun to increase; One of the reasons for this increase is is the successful reconstruction of the machinery used in the textile industry [1]. In producing a product, the textile and batik industry undergoes many processes, including the dyeing process. In the dyeing process, the textile and batik industry uses a lot of dyes, both natural and synthetic. The lack of natural dyes has caused many textile and batik industries to use synthetic dyes [2,3,4].

Synthetic dyes have many advantages, for instance, the colour is more stable, resistant to various environmental conditions, and it has a more substantial colouring power has a broader colour range. Synthetic dyes also do not fade easily, are brightly coloured, easy to obtain, and are more economical [3,5].

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The increasing usage of synthetic dyes in the textile and batik industry can cause environmental pollution. Environmental pollution by textile industry wastewater can be overcome by various means, including coagulation, filtration, electro-decolorization, and adsorption methods. The adsorption method is the absorption of a substance on the surface of another chemically and physically bonded substance. According to several previous studies, the adsorption method is widely used in textile industry wastewater treatment because this method is easy and simple, has high adsorption effectiveness and capacity, is selective, and uses relatively inexpensive materials. In addition, this adsorption method can also remove odours and reduce the levels of dyes from textile industry wastewater solutions, ideally without turning them into more dangerous compounds [6].

Several previous researchers have conducted adsorption of textile dye wastewater using different adsorbents such as zeolite, activated carbon, rice husk, bentonite, plant waste, and others [7,8,9]. Bentonite is also widely used as an adsorbent to absorb textile dyes and heavy metals in wastewater. This bentonite is one type of rock that contains montmorillonite, which has the property of expanding in water, intercalating, and having exchangeable cations [10]. Based on a previous survey, bentonite from Bener Meriah, Aceh amounted to 520,000 tons with a thickness of 1 m and an area of 20 ha [11]. Montmorillonite from Bener Meriah, Aceh was previously used as a nanocomposite filler [12].

METHODOLOGY

Isolation nano montmorillonite from bentonite of Bener Meriah Aceh

The materials used in this research were aquades, Remazol Brilliant Blue, HCl (Merck), NaOH (Merck), and nano montmorillonite isolated from bentonite from Bener Meriah, Aceh. Montmorillonite nanoparticles were obtained by preparing a 1 kg sample of bentonite and filtering it with a 100 mesh sieves; The sample was then dried in an oven at a temperature of 105 °C for 4 hours. Subsequently, the sample was fractionated. Fractionation was done with sedimentation by weighing 40 grams of 100 mesh bentonite and adding 2L aquades to form the suspension. The bentonite suspension was exposed to ultrasonic waves for 15 minutes at 750 watts at room temperature. The suspension was then left in a flat place and kept away from all vibrations. Precipitation that occurred within 15 minutes taken by pouring the suspension into another container and leaving the filtrate again. The precipitate that had formed after 3 days was filtered back and its filtratewas. The floating fraction in the filtrate was stirred again, then the filtrate was left for a week and collected when a precipitate is formed. This precipitate was dried in an oven at 105 °C for 3 hours, then crushed and sieved using a 200 mesh sieve. The fraction was stored in a desiccator [13].

Batch Adsorption Studies

Adsorption studies were conducted to study the optimum adsorption conditions by varying the contact time, pH, and adsorbent mass. The adsorption studies were carried out using the batch method by adding two g of nano montmorillonite and 50 mL of Remazol Brilliant Blue solution with a concentration of 50 mg/L to each Erlenmeyer with a pH of 4; The times varied from 10, 20, 40, 60, 80, 100, and 120 minutes. The solution was stirred using a shaker at a speed of 150 rpm. Furthermore, the solution was filtered, and the filtrate obtained was measured for absorbance using a UV-Vis spectrophotometer at the maximum wavelength of 590 nm. Adsorption studies were also carried out respectively for variations in pH which were set at 1, 2, 3, 4, 5, 6, 7, 8, and 9; then the adsorbent mass variations were 0.5, 1, 1.5, 2, 2.5, 3, and 3.5 grams.

Regeneration Process

The adsorbent of nano montmorillonite that was used was washed with distilled water to pH 7, then filtered and dried. Furthermore, the adsorbent was reused to adsorb Remazol Brilliant Blue dye at optimum conditions. The absorption efficiency was measured using a UV-Vis spectrophotometer.

RESULTS AND DISCUSSION

Isolation Nano Montmorillonite

Processing of bentonite of Bener Meriah into nano montmorillonite was carried out using sedimentation. The sedimentation method is a safe way to isolate montmorillonite without changing its physical and chemical properties [13]. The sedimentation method is carried out by dissolving bentonite in distilled water and exposing it to ultrasonic waves for 15 minutes with a power of 750 Watts, which aims to destroy aggregate of bentonite. The expected result is that the montmorillonite will become nano size. The final fraction obtained from the isolation was nano montmorillonite and characterized by Particle size Analyzer (PSA).

FTIR Characterization

The FT-IR characterization aims to determine the functional groups in montmorillonite. The presence of an OH functional group at 3624.70 cm^{-1} indicates the stretching vibrations of the hydroxyl group towards Al in the Al-Al-OH octahedral layer of montmorillonite. Absorption bands at 3709.32 cm^{-1}, 3448,79 cm^{1}, 1640.74 cm^{-1}, 1032.36 cm^{-1} and 918.12 cm-^{1} correspond to stretching vibration of Si-OH, the octahedral OH cm^{-1} to the vibration of OH bending, the stretching vibration of Si-O-Si (quartz), and the bending vibration of Al-OH-Al respectively. Furthermore, absorption bands at 751.78 cm^{-1}, 538.50 cm^{-1}, 582.50 cm^{-1} and 468.50 cm^{-1} respectively indicate the presence of Al(Mg)OH bonds, Al-O bonds, Si bonds -O-Al and Si-O-Si. This proves that the bentonite isolate is montmorillonite. The FTIR of isolated montmorillonite can be seen in the Figure 1.

PSA Characterization

Characterization using PSA aims to determine the size of montmorillonite isolated from Bener Meriah bentonite. Characterization using PSA produces percent data from the distribution of intensity, volume of distribution and number of distributions. The results of PSA characterization showed that the particle size distribution of montmorillonite isolated from Bener Meriah bentonite was 67.8 nm; This can be seen in Figure 2.

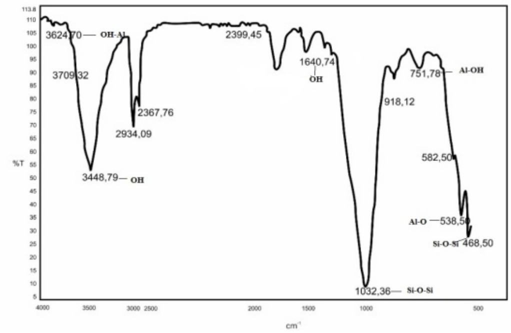

Figure 1. FTIR of montmorillonite

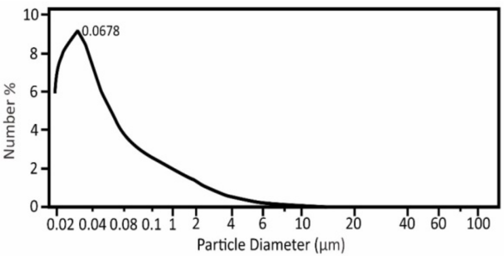

Figure 2. Particle Size of montmorillonite

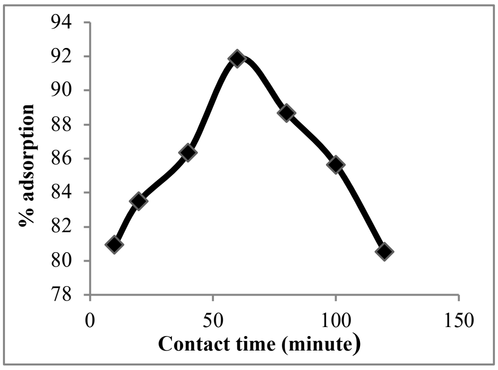

Figure 3. The relationship of percentage adsorption and contact time of Remazol Brilliant Blue dye

Optimum of contact time

Contact time is one factor that affects the adsorbent's adsorption capacity and adsorbate in the adsorption process. Determination of optimum contact time aims to determine how long it takes to achieve optimum absorption of Remazol Brilliant Blue dye by nano montmorillonite adsorbent. The percentage of absorption of Remazol Brilliant Blue dye by nano montmorillonite can be seen in Figure 3. Figure 3 shows at 10 to 40 minutes, the absorption of Remazol Brilliant Blue dye by nano montmorillonite continued to increase; This was because the adsorption process had not yet reached equilibrium. The active site of the adsorbent surface of nano montmorillonite at 10 to 40 minutes still did not bind much to the dye molecules.

Equilibrium between the adsorbent and adsorbate occurs at a contact time of 60 minutes. This is due to the active site of the adsorbent binding more with the dye molecules. The optimum absorption efficiency at the contact time of 60 minutes was 91.86%. The absorption efficiency continued to decrease at 80 to 120 min of contact time. The Remazol Brilliant Blue dye molecule has desorption from the surface of the active adsorbent site [14]. The addition of contact time above 60 minutes had no significant effect on the absorption of dye by the adsorbent because the adsorption process was in a state of equilibrium.

Several previous studies have shown that the optimum contact time varies for different adsorbents. Adsorption of Remazol Brilliant Blue dye using coconut leaf waste occurs at an optimum contact time of 15 minutes [15], adsorption of the dye using cassava pulp adsorbent occurs at a contact time of 45 minutes [16] and using Nata de Coco adsorbent occurs at a contact time of 60 minutes [9]. The difference in contact time between different adsorbents may occur because it depends on how fast or slowly the adsorbate interacts occupying the active site of the adsorbent.

Optimum pH

The pH is also a factor that affects absorption efficiency, where pH affects the intensity of the colour of the solution. The results of Remazol Brilliant Blue dye adsorption with variations in pH can be seen in Figure 4. Figure 4 explains that the optimum percentage adsorption of Remazol Brilliant Blue dye by nano montmorillonite adsorbent occurs at pH 4 with an absorption efficiency of 91.82%. A pH of 4 causes the surface of the adsorbent to be ionized by releasing H^+ ions. The surface of the adsorbent becomes negative and causes interactions between the surface of the adsorbent and the dye [17]. At a pH of 1 to 3, the absorption is relatively low due to the competition between H^+ ions and the active group of the nano montmorillonite adsorbent which is trying to bind to the dye, which then dissociates into its ions [18]. The pH factor can also be explained based on the intensity of the colour; pH 5 to 7 causes the colour of the solution to become more concentrated, and the presence of a residue will cause a decrease in absorption efficiency. The percentage of absorption at an alkaline pH also tends to decrease. Many OH^- ions result from the interaction between OH^+ ions and dyes repelling at that pH, which reduces the percentage adsorption [19]. As previously explained, the pH adjustment of the solution affects the surface charge of the adsorbent, the degree of ionization, stability, and colour intensity of the compounds in the solution [20].

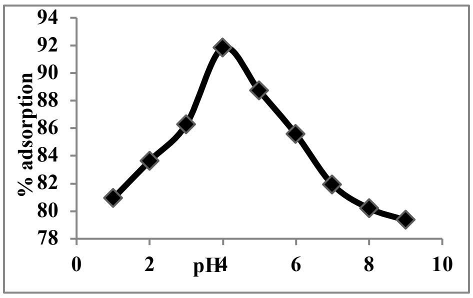

Figure 4. The relationship between percentage adsorption and pH of Remazol Brilliant Blue dye

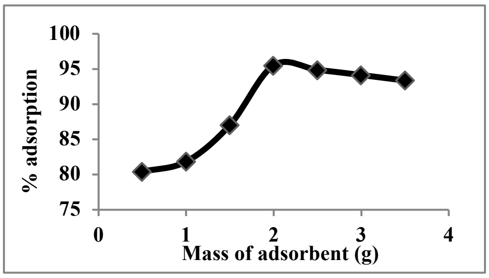

Figure 5 The relationship between the percentage adsorption and the mass of the adsorbent of Remazol Brilliant Blue dye

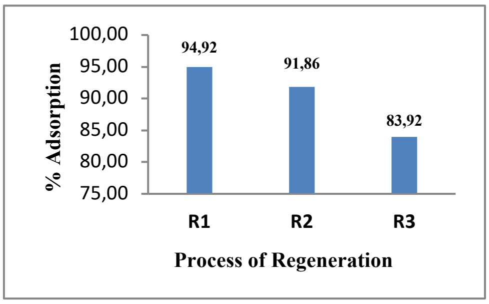

Figure 6. Percentage of adsorption of Remazol Brilliant Blue dye of regeneration nano montmorillonite adsorbent

The optimum adsorption conditions occur at different pH levels depending on the type of adsorbent. The adsorption of Remazol Brilliant Blue dye using cassava pulp occurred at an optimum pH of 1 [16], the adsorption of the dye using montmorillonite-aminosilane modified occurred at an optimum pH of 3 [21] and those using coconut leaf waste occurred at an optimum pH of 4 [15]. This shows that the pH of a solution can affect the percentage of adsorption; This is because the pH conditions in the solution affect the ionic form of the adsorbed dye, the type of adsorbate, and the charge on the surface of the adsorbent used. [22].

Optimum adsorbent mass

The effect of an adsorbent is an essential parameter in the adsorption process because it can determine the efficiency of the adsorbent to the absorption of a dye. The adsorption process for Remazol Brilliant Blue dye uses a variation of adsorbent mass from 0.5 to 3.5 grams using an optimum contact time of 60 minutes and optimum pH of 4. The results of variations in determining the optimum adsorbent mass of nano montmorillonite can be shown in Figure 5.

Figure 5 shows the increase in percentage of adsorption with the increase in the mass of the adsorbent from 0.5 grams to 1.5 grams. This increase is related to the number of active sites available on the surface of the montmorillonite nano adsorbent. The more active sites available, the more frequent the contact between the adsorbent and the adsorbate will result in greater absorption efficiency. The optimum absorption efficiency of Remazol Brilliant Blue dye reached 95.52%, which occurred at 2 grams of adsorbent. At the amount of adsorbent at 2 grams, there was an equilibrium between the amount of adsorbent and adsorbate. At the amount of adsorbent above 2 grams, the absorption efficiency of Remazol Brilliant Blue dye decreased slightly due to the number of adsorbent particles that had reached the saturation point. The decrease in absorption efficiency is suspected to be as a result of excessive adsorbent in the solution which affects the absorption of Remazol Brilliant Blue dye and will affect the readings when measuring using UV-VIS [9]. The addition of adsorbent mass causes an increase in the active adsorption site, so that the adsorption percentage will increase to the optimum condition, and the adsorption percentage will decrease with increasing adsorbent; This is due to an increasingly saturated solution [9,15,16,17].

Regeneration of Adsorbent

The adsorbent regeneration process is critical in the industrial world, especially in the textile industry, because the adsorbent can be used repeatedly, thus cutting down on dye waste which creates a more economical industry. The regeneration process of the montmorillonite nano adsorbent was carried out by washing the adsorbent using distilled water to pH 7 to remove the remaining Remazol Brilliant Blue dye attached to the adsorbent. The adsorbent, which is neutral, is then dried by aerating so that the adsorbent is not damaged.

The dried adsorbent was then reused to absorb Remazol Brilliant Blue dye at optimum conditions. The percentage adsorption can be seen in Figure 6. Based on Figure 6, the nano montmorillonite adsorbent that was regenerated and reused for Remazol Brilliant Blue dye adsorption shows that the percent of absorption is still high. The nano montmorillonite adsorbent can be used repeatedly on Remazol Brilliant Blue dye with high absorption efficiency and good adsorbent conditions.

CONCLUSION

Nano montmorillonite from Bentonite Bener Meriah, Aceh can be used as an adsorbent for Remazol Brilliant Blue Dyes waste. The optimum conditions for adsorption of Remazol Brilliant Blue dye by nano montmorillonite occurred at a contact time of 60 minutes, pH 4, and adsorbent mass of 2g with an adsorption percentage reaching 95.52%. The regenerated nano montmorillonite adsorbent can still be used for the Remazol Brilliant Blue dye adsorption process, and its absorption efficiency is still high.

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