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NaOH TREATED SPENT BLEACHING EARTH

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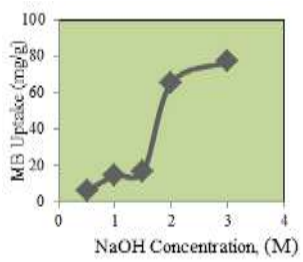
Graphical abstract



Abstract

Spent bleaching earth (SBE) was treated with sodium hydroxide (NaOH) and used for the removal of methylene blue (MB). Adsorption test of treated SBE was carried out to evaluate the removal efficiency of MB. It showed that the maximum uptake of MB was at 76.9 mg/g using SBE treated with 3.0 M NaOH which is equivalent to 76% removal of MB. The effect of increasing initial concentration on the removal of MB showed that higher initial concentration leads to higher surface loading which reduces its removal potential. The effect of SBE dosage on the removal of MB pointed to the maximum removal percentage of 95% at 100 mg SBE dosage.

Keywords: Adsorption, spent bleaching earth, color removal, methylene blue

Abstrak

Tanah peluntur terpakai (SBE) telah dirawat dengan natrium hidroksida (NaOH) dan digunakan untuk penyingkiran metilena biru (MB). Ujian penjerapan bagi SBE yang dirawat telah dijalankan untuk menilai kecekapan penyingkiran MB. Ia menunjukkan bahawa pengambilan maksimum MB adalah 76.9 mg/g menggunakan SBE yang dirawat dengan 3.0 M NaOH yang bersamaan dengan penyingkiran 76% MB. Kesan peningkatan kepekatan awal pada penyingkiran MB menunjukkan bahawa kepekatan awal yang lebih tinggi membawa kepada beban permukaan yang lebih tinggi yang mengurangkan potensi penyingkiran. Kesan dos SBE ke atas penyingkiran MB menunjukkan kepada penyingkiran peratusan maksimum sebanyak 95% pada 100 mg dos SBE.

Kata kunci: Penjerapan, tanah peluntur terpakai, penyingkiran warna, metilena biru

1.0 INTRODUCTION

Dyes are categorized as basic dye, acid dye and reactive dye. It is widely used in textiles, pulp mills, leather, dye synthesis, printing, food and plastics manufacturing industries. The liquid effluent from these industries needs to be treated as it possesses toxic organic dyestuff [1-4]. Commercially, methods for dye removal in liquid effluent include coagulation, chemical oxidation, membrane separation, electro-chemical process and adsorption techniques [5]. The adsorption method using activated carbon has been used extensively, but the operating cost is high in a long run. Alternatively, adsorbents made from low cost materials such as from biomass waste, industrial sludge waste and clay based geo-materials have been suggested [6-11]. Adsorption method by using low cost materials are the most potential technique for textile liquid effluent treatment due to their efficiency

in removing of pollutants and economic considerations [12]. Spent bleaching earth (SBE) which is a clay-based material is seen as a viable option as a low cost adsorbent for dye removal. Bleaching earth (BE) is used extensively in edible oil processing facility as an adsorbent but creates major disposal problems. The regeneration and reuse of SBE has attracted considerable interest among researchers in recent years [13].

It is therefore, the aim of this study is to evaluate the adsorption characteristics of regenerated SBE as an adsorbent in the removal of methylene blue (MB). SBE was reactivated by alkaline treatment with sodium hydroxide (NaOH) as alkaline activator. MB was used as the target contaminant to characterize the adsorptive properties of the regenerated adsorbent. Adsorption influencing factors such as MB concentration and adsorbent dosage were investigated.

2.0 EXPERIMENTAL

2.1 Materials

Methylene Blue (MB) was used as the basic dye which was purchased from Ajax Chemical. The stock solutions of different MB concentrations were prepared by diluting the weighed dye with distilled water. The spent bleaching earth (SBE) was obtained from crude palm oil processing in Pasir Gudang, Johor, Malaysia. SBE is typically clay and contains a small amount of residual oil, which is not removed by filter pressing[13].

2.2 SBE Treatment

SBE is normally treated with NaOH for the removal of residual oil in a process known as saponification reaction which results in the formation of fatty acid sodium salts. It is later removed by washing with water[13]. In this experiment, the SBE sample was treated with NaOH solution (solid/solution ratio: 1/5 w/w) and heated at 105°C for 24 hours. The concentration of NaOH was varied from 0.5M, 1.0M, 1.5M, 2.0M and 3.0M. Low concentration of NaOH was selected to reduce the treatment cost. The treated spent bleaching earth (TSBE) was then washed with distilled water, filtered and dried at 105°C for 24 hours and crushed into powder form.

2.3 Adsorption Studies

Initial studies were conducted by mixing 25 mg of TSBE with 50 ml of methylene blue (MB) of different concentrations in 250mL conical flasks and the solution was then stirred at 150 rpm at room temperature. The concentration of MB for the adsorption studies was as follows; 10 mg/L, 25 mg/L, 50 mg/L, 75 mg/L, 100 mg/L, 125 mg/L, 150 mg/L, 175 mg/L, 200 mg/L, 225 mg/L and 250 mg/L. Each test was conducted for 24 hours and the solution was then filtered. The supernatant was analyzed by UV-Visible spectrophotometry with a wavelength of 660 nm. It was repeated 3 times for the average reading. Further tests were performed to investigate the effect of different TSBE dosage and contact time on the removal of MB. The dosage was varied (25mg, 50 mg, 75 mg, 100 mg) and the experiment was carried out at a room temperature using 50 ml MB solution with a concentration of 100 mg/L. The effect contact time on the removal of MB was investigated using 50 mg of TSBE. The uptake (q_e) and percentage removal of dye were calculated, respectively, as follows:

$$q_e = (C_o - C_e) \times \frac{V}{m} \quad (1)$$

$$\% \text{ removal} = \frac{(C_o - C_e)}{C_o} \times 100\% \quad (2)$$

where; q_e is the amount of dye adsorbed on adsorbent at equilibrium (mg/g), C_o and C_e are the initial and equilibrium of dye concentration (mg/L) in solution, respectively, v is the volume of solution (L), and m is the weight of adsorbent (g).

3.0 RESULTS AND DISCUSSIONS

3.1 Removal of MB by SBE treated NaOH

Adsorption test of SBE treated with different molar of NaOH solution was carried out to evaluate the removal efficiency of MB. The increasing trend of MB uptake by SBE treated at different concentration of NaOH is shown in Figure 1. It shows that the maximum uptake of MB was at 76.9 mg/g when SBE was treated with 3.0 M NaOH concentration. It is equivalent to 76% removal of MB.

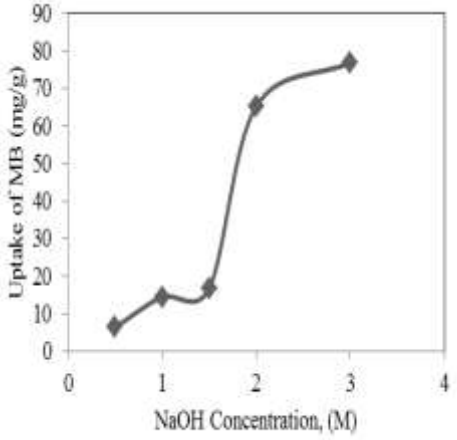


Figure 1: MB uptake by SBE treated with different molar of NaOH solution

3.2 Effect of Initial Concentration of Methylene Blue

Adsorption is a process that is dependent on the initial concentration. The concentration of MB in solution provides an important driving force in overcoming mass transfer resistance between the aqueous and the solid phases. The effect of increasing initial concentration on the removal of MB is shown in Figure 2. It is believed that higher initial concentration leads to higher surface loading thus reducing its removal potential. In a fixed surface adsorption sites, it leads to greater competition of MB ions, thus, resulting in a less removal efficiency. Similar results were observed by Han et al. (2005) for the adsorption of copper (II) and lead (II) on chaff [14]. Ahmad Zaini et al. (2014) reported that at higher initial concentrations, the presence of adsorbate molecules are higher than the availability of the surface sites, thus decreasing the percent removal [15]

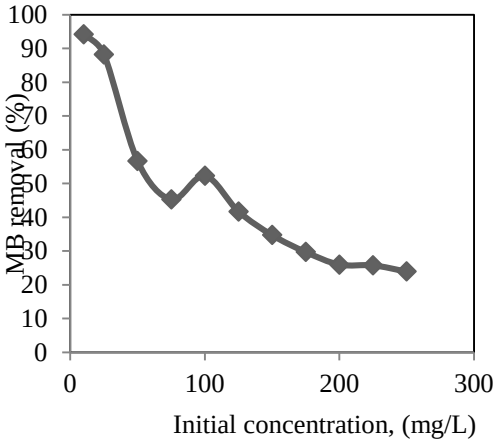


Figure 2: Percentage removal of MB (50 mg TSBE in 50mL solution MB)

3.3 Effect of Adsorbent Dosage on MB Removal

The effect of TSBE dosage on MB adsorption at a contact time of 150 min was studied by varying the TSBE dosage from 25 to 100 mg in a 100 mg/L MB solution. The effect of TSBE dosage on the removal of MB is shown in Figure 3. It shows increasing percentage of MB removal as the adsorbent dosage was increased from 25 mg to 100 mg. The maximum removal percentage was 95% at 100 mg TSBE dosage. It is attributed to the enhanced active site which is caused by an increment in the amount of the adsorbent, thereby resulting in the increased percentage of MB removal from the solution. Similar finding were reported by Ngadi et al. (2013) in their study of to determine the potential of eggshell powder as an adsorbent for methylene blue removal [16]. The adsorption efficiency increased with adsorbent dosage because there were plenty of surface area and more adsorption sites available to interact with the dye molecules provided by the increased adsorbent dosage.

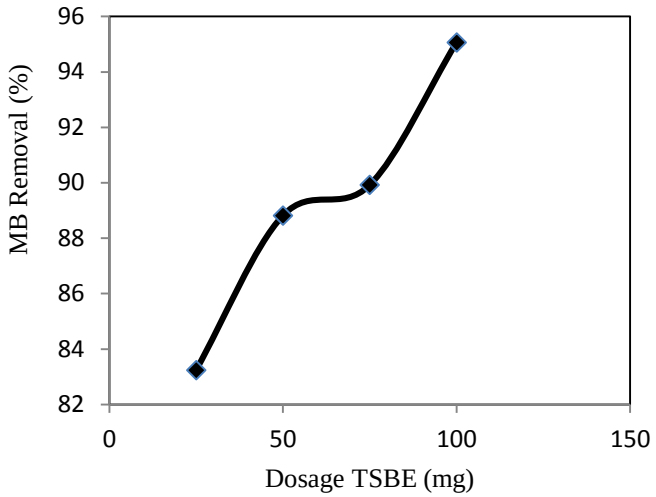


Figure 3: Results on the removal of MB with different TSBE dosage (50mL with concentration of100 mg/L)

3.4 Effect of contact time on MB Removal

Contact time is also an important factor affecting removal. These experiments have been carried out at different contact time (0–250 minutes). The effect of contact time on the adsorption of MB onto TSBE and the percentage of MB removal is shown in Figure 4. The percentage removal increased rapidly at the beginning of the adsorption process, but later showed a slow increment until it reached the equilibrium state. It showed that the sorption equilibrium was reached after 100 mins with the adsorption capacity of 168 mg/g. Similar results were reported by Ngadi et al. (2013) which revealed that the rate of percent dye removal was higher at the beginning [16]. This was probably due to larger surface area of the adsorbent being available at the beginning for the adsorption of dye ions.

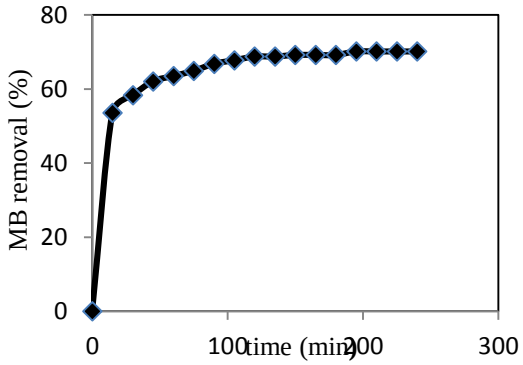


Figure 4: Percentage removal of MB against time (50mL MB solution with concentration of 100 mg/L, 50 mg TSBE)

4.0 CONCLUSION

The treatment of spent bleaching earth using sodium hydroxide solution has led to the development of an efficient sorbent for the removal of MB from aqueous solutions. The removal efficiency of MB has increased with the increasing concentration of NaOH. It was also found that the uptake of MB increases with the increasing initial MB concentration up to its saturation point. The effect of increasing initial concentration on the removal of MB has shown that higher initial concentration leads to higher surface loading which reduces its removal potential. The effect of TSBE dosage on the removal of MB pointed to the maximum removal percentage of 95% at 100 mg TSBE dosage. A contact time of less than 100 min was sufficient for sorption equilibrium.

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