2011 International Conference on Environment and Industrial Innovation
IPCBEE vol.12 (2011) © (2011) IACSIT Press, Singapore

Removal of Acid Green 25 from Aqueous Solution using Coconut Husk as Adsorbent

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Abstract. The removal of color from wastewater containing dyes requires an effective method to treat the effluent. Adsorption is quite popular due to its simplicity and effective for removal of dyes. In this paper, the removal of Acid Green 25 (AG25) from synthetic wastewater was performed by batch adsorption in which coconut husk was used as adsorbent. The comparison has been done between untreated and treated coconut husk for the effect of particle sizes of adsorbents. Two kinetic models; pseudo-first order and pseudo-second order are applied to fit the experimental kinetic data. The results indicate best fit obtained with pseudo-second order model, with the best value of k_2 was 0.258 g mg^{-1} min^{-1} for acid treated coconut husk. Surface morphology was also examined using Scanning Electron Microscopy (SEM). The acid treated coconut husk has more tendencies to remove acid dye solution as compared to untreated coconut husk.

Keywords: Wastewater treatment, Adsorption, Acid Green 25, Coconut Husks

1. Introduction

The wet processing from textile industries produce large volumes of water containing dyes which contributes to waste water generation in the textile industry. The presence of very low concentration of dyes in effluent discharged from these industries is highly visible and undesirable. Due to their chemical structure, dyes are resistant to fading when exposed to light, water and many chemicals. The discharge of dyes in the environment is worrying for both toxicological and esthetical reasons as dyes impede light penetration, damage the quality of the receiving streams and are toxic to food chain organisms [1].

Many techniques have been investigated for the removal of dyes from waste waters. Currently, the principal methods of treatment involve biological, physical and or chemical processes such as microbial degradation [2], chemical oxidation [3] and adsorption technology using activated carbon prepared from various agricultural wastes [4, 5]. Adsorption on activated carbon is one of the most effective processes but the high cost of such adsorbent has motivated many researchers to search for alternative low cost adsorbents [6].

Today, attention has been focused on the development of low-cost adsorbents as alternative adsorbent materials. The successful removal of dyes using low cost adsorbents has been carried out by Hameed and co-workers such as grass waste [6], jackfruit peel [7] chitosan/oil palm ash [8], durian peel [9], papaya seeds [10] and rattan sawdust [11]. Besides Hameed and co-workers, other researchers have developed low cost adsorbents such as coconut mesocarp [12], guava leaf powder [13, 14], almond shell [15] and chitosan bead [16].

In the present investigation, we have studied the potential of coconut husk as adsorbent to remove anionic dye from aqueous solution. In general, coconut consists of 33–35% of husk. At present, coconut husk is used as fuel for coconut processing, as a domestic fuel and as a source of fiber for rope and mats. To make better use of this cheap and abundant agricultural waste, it is proposed to use coconut husk as adsorbent. The

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acid treated and untreated coconut husk was used as adsorbents to remove the Acid Green 25 (AG25) dye from aqueous solution. Although several researchers has studied the potential of coconut husk as adsorbents [12], there are still no data reporting on the adsorption of anionic dyes using this adsorbent. The kinetic batch adsorption studies were carried out to understand the adsorption process.

2. Material and Methods

2.1 Preparation of adsorbents

2.1.1 Untreated coconut husk

The coconut husks need to be grounded and sieved to within the particle size of 125 - 710 µm. The coconut husks were washed with distilled water. The coconut husks were then dried at 55°C for a day in oven.

2.1.2 Acid treated coconut husk

The coconut husks need to be grounded and sieved to within the particle size of 125 - 710 µm. The coconut husk were washed with distilled water and were dipped in one molar (1M) solution of sulphuric acid (H_2SO_4) for 2 days and then washed with distilled water to remove any residue of acid. The coconut husks were then dried at 55°C for a day in oven.

2.2 Characterization of adsorbent

Scanning electron microscopy (SEM) (JEOL, Japan) analysis was carried out for the untreated and acid treated coconut husk to study their surface textures and the development of porosity.

2.3 Batch equilibrium studies

A 100 ml of AG25 dye solutions with initial concentration of 50 mg/L were placed in Erlenmeyer flasks. Equal mass of 100 mg of the adsorbent was added to each flask and kept in an isothermal shaker of 150 rpm at 30°C for 24 hr to reach equilibrium. After equilibrium was reached, the adsorbent was separated from the dye solution using filtration. The concentration of AG25 in filtrate was measured with UV Spectrophotometer (Thermo Spectronic) at 642 nm wavelength. Each experiment was duplicated under identical conditions.

3. Results and Discussion

3.1 Textural characterization of acid treated and untreated coconut husk

Textural characterization of acid treated and untreated coconut husk are shown in Figure 3.1. Analysis was performed using Scanning Electron Microscopy (SEM). Many large pores were clearly found on the surface of the acid treated coconut husk, as compared to the untreated coconut husk. This shows that acid sulfuric were effective in creating well-developed pores on the surface of the coconut husk.

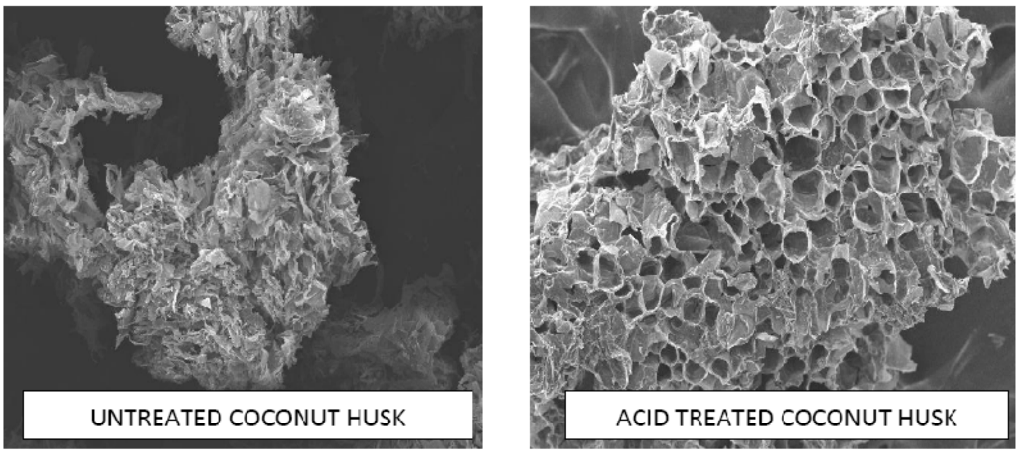

Figure 3.1: SEM image of SEM image of raw coconut husk (150x) and SEM image of acid treated coconut husk (150x).

3.2 Effect of Particle Sizes

The effect of particle sizes at 125 µm, 250 µm, 500 µm and 710 µm was studied for the adsorption of AG25 on untreated and acid treated coconut husk at temperature of 30°C. Fig. 3.2 shows the effect of particle sizes on the adsorption of AG25 dye onto acid treated and untreated coconut husk.

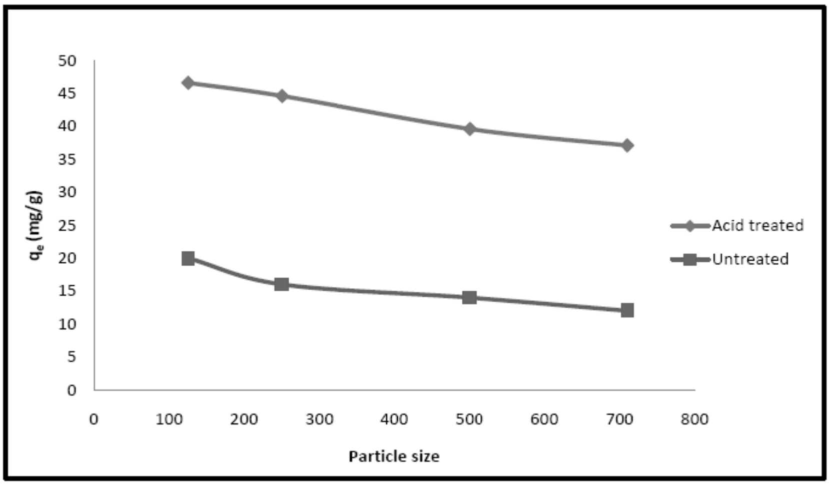

Fig. 3.2: Effect of particle sizes on the adsorption of AG25 dyes onto untreated and acid treated coconut husk.

Based on Fig. 3.2, the best adsorption capacity (q_e) for both adsorbents occurs when using 125 µm. The best adsorption capacities are 20 mg/g and 46.6 mg/g for untreated and acid treated coconut husk, respectively. The rate of dye adsorption depends on the driving force per unit area. From the observation, small particle sizes show better adsorption performance than large particle sizes. The small particles contain large external surface area that can remove dye in the initial stages of the adsorption process than the large particles. The same trend has been reported by Won *et al.*, 2006 [17].

Fig. 3.3 shows the effect of particle sizes on percentage of dye removal for untreated and acid treated coconut husks. The highest percentage removal of dye occurs at 125 µm (93.2% for acid treated and 39.6% for untreated) and the lowest percentage removal of dye occurs at 710 µm (74.2% for acid treated and 28% for untreated).

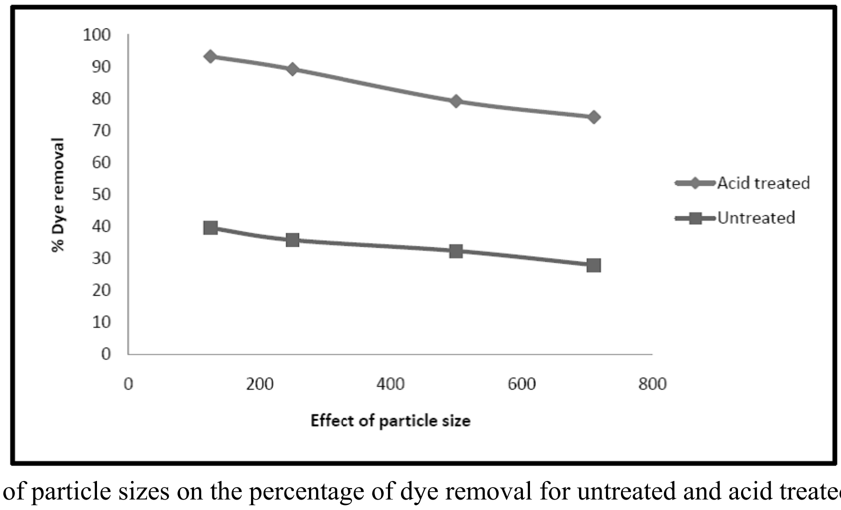

Fig. 3.3: Effect of particle sizes on the percentage of dye removal for untreated and acid treated coconut husk.

3.3 Adsorption kinetics

The efficiency of acid treated and untreated coconut husks adsorbent was evaluated by studying the adsorption kinetics of AG25 concentration in aqueous solution. The mechanisms are possible to react as pseudo-first and second-order models. The kinetic of AG25 adsorption by the adsorbents was tested with respect to first order model of Lagergren (Eq. 1 and Eq. 2) and second order model (Eq. 3 and Eq. 4) [18]:

$$q_t = q_e\left(1 - e^{-k_1 t}\right) \tag{1}$$

$$\log(q_e - q_t) = \log q_e - \frac{k_1}{2.303}t \tag{2}$$

$$q_t = \frac{q_e^2 k_2 t}{1 + q_e k_2 t} \tag{3}$$

$$\frac{t}{q_t} = \frac{1}{k_2 q_e^2} + \frac{t}{q_e} \tag{4}$$

Where q_t and q_e (mg) are total AG25 adsorption capacity at time t and at equilibrium, respectively. k_1 and k_2 are the first order and second order rate constants, respectively.

Table 3.1 shows the comparison of pseudo first order kinetic and pseudo second order kinetic models for AG25 adsorption. The values of k_1 for the pseudo-first order kinetic model and k_2 for pseudo-second order kinetic model were obtained from the slopes of the linear plots of Eqs. 2 and 4. The Lagergren second order kinetic model showed much higher R^2 value (more than 0.99) for both adsorbents. This indicates that the adsorption of AG25 onto acid treated and untreated coconut husks followed the pseudo-second order kinetic model. It can be seen that the adsorption rate of acid treated coconut husk is relatively quicker (1.6 times higher) than the untreated coconut husk adsorbent.

Table 3.1: Comparison of first and second order kinetic models for AG25 adsorption.

Adsorbent	Pseudo-first order		Pseudo-second order	
	k_1 (min^{-1})	R^2	k_2(g mg^{-1} min^{-1})	R^2
Acid Treated	0.0138	0.983	0.258	0.999
Untreated	0.0046	0.985	0.0073	0.996

4. Conclusion

Results obtained from this study showed that the acid treated coconut husk was effective in removing anionic dye (AG25) from synthetic waste water. Study on the effect of particle sizes showed that the smaller particle sizes gave the highest percentage dye removal. The experimental data fitted with the pseudo-second order kinetic model. It was concluded that the acid treated coconut husk can be used in wastewater treatment.

5. Acknowledgements

The authors would like to acknowledge the financial grant funded by Short Term Grant, Universiti Malaysia Perlis (UniMAP).

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