Synthesis of Adsorbent Materials from Vetiver Grass for Wastewater Treatment

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***Abstract* – Vetiver grass has been widely used for soil erosion control and runoff protection. The present work provided an alternative application of vetiver grass as adsorbent materials for wastewater treatment. The adsorbent materials was synthesised in two different methods. The absorbent 1 was synthesized by heating the vetiver grass at 300°C. In the meanwhile, the adsorbent 2 was synthesized by heating at 750°C and adding some chemicals (such as TPABr and NaOH). The XRD patterns suggested that the adsorbent 1 could be activated carbon. On the other hands, the adsorbent 2 was unidentified materials. Both adsorbents were able to treat dye wastewater with >99% of effectively. This performance is greater than using a commercial activated carbon. However, at the highest wastewater concentration, the adsorbent 1 obtained the better efficiency rather than the adsorbent 2.**

Keywords – Vetiver Grass, Activated Carbon, Adsorbent Materials, Dye Wastewater Treatment.

1. INTRODUCTION

Vetiver grass is a tropical plant and grows naturally. The clump diameter and height are around 30 cm and 50 to 150 cm. The leaves are erect with 75 cm of length and 8 mm of width. Its significant characteristic is a deep thick root system and spreads vertically. The vetiver grass is widely used for soil erosion control and water conversion in several countries such as Thailand and Nigeria [1, 2]. Recently, the vetiver grass has been introduced for soil remediation, called as phytoremediation process. The contaminants (*i.e.*, pesticides and heavy metals) are uptake, store and/or degrade within the grass' tissue. However, this removal process requires a longer period than other processes, especially adsorption.

Adsorption is one of effective processes for contaminants removal from soil and water. The contaminants are adsorbed into adsorbents' surface by physical and/or chemical forces. The advantages of this process are the ability to remove many contaminants effectively and the capacity to reactivate and reuse. Recently, the most well-known adsorbents are activated carbon and zeolite, which can be synthesised from agricultural waste such as rice husk ash and palm shells [3, 4]. The intentions of the present work were to 1) synthesise adsorbent materials from vetiver grass and 2) investigate the performance to treat dye wastewater comparing to a commercial activated carbon.

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2. MATERIALS AND METHODS

2.1 Materials Synthesis

The vetiver grass was synthesised using two methods;

Method 1: The fresh leaves were shredded into small pieces and heated at 300°C for 12 hours in air to eliminate moisture and undesirable compounds. The char (adsorbent 1) was ground and characterised using X-Ray Diffraction (XRD) technique.

Method 2: The fresh leaves were shredded into small pieces and heated at 750°C for 12 hours in air to eliminate carbon compounds. The ash was used as raw material for further adsorbent synthesis. The ash was characterised using X-Ray Florescence (XRF) technique. The ash 3.01 g was predispersed in distilled water 25 mL containing NaOH 2.50 g. The mixture was introduced in an oil bath at temperature of 110°C for 24 hours, and then added a structure directing substrate of tetrepropylammonium bromide (TPABr) solution). The TPABr solution was prepared separately by mixing TPABr 2.33 g and distilled water 25 mL. The whole mixture was continued at 110°C for 10 days with stirring. At the end, the mixture was centrifuged and the solid phase was washed several with distilled water and dried at 110°C for 12 hours. The obtained material (adsorbent 2) was heated at 550°C for 5 days [3] and characterised using X-Ray Diffraction (XRD) technique.

2.2 Wastewater Treatment Performance

The standard concentration of dye wastewater was prepared by dissolving methylene blue 0.032 g in distilled water 10 L. For the treatment batch tests, four batches of the 50 mL dye wastewater were prepared.

Added 1.00 g of the adsorbent 1, adsorbent 2 and commercial activated carbon in each batch, and the last was controlled batch (no adsorbents were added). During the batch tests, the pH was around 7-8, and temperature was around 25-30°C. The four batch solutions were stirred at 200 rpm for 15 min, and then filtered. The filtered solution was measured using UV-Vis spectrophotometer (scanning wavelength from 400-800 nm in adsorption mode).

Other concentrations of dye wastewater were prepared (see in Table 1) to measure the treatment ability of adsorbents.

Table 1. Preparation of synthetic dye wastewater

Concentration	Methylene Blue (g)	H_2O (L)
Standard	0.032	10
2 times	0.064	10
5 times	0.160	10
8 times	0.256	10
10 times	0.320	10

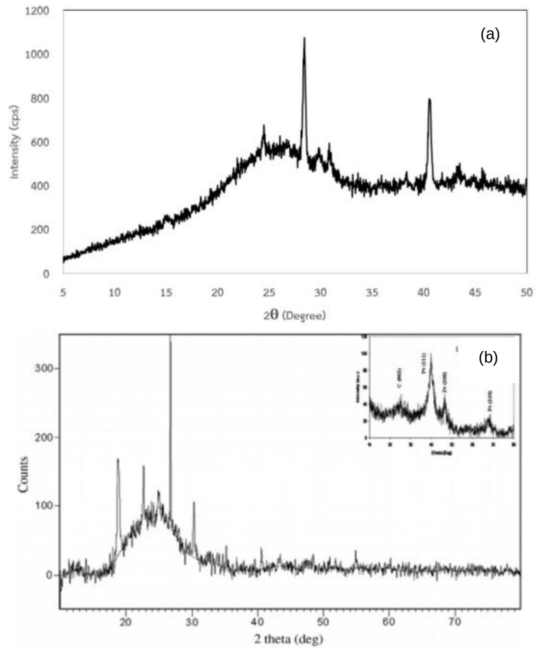

Figure 1 XRD pattern of (a) adsorbent 1 and (b) synthesised activated carbon [4].

3. Results and Discussion

3.1 Adsorbents Characterization

The adsorbent 1 was formed as black powder with approximate size of 0.3 mm. The X-ray diffractogram of adsorbent 1 is shown in Figure 1(a). A broad peak around 24° indicated the presence of microporous carbon and its structure was amorphous phase. Moreover, the strong peaks in the humps suggest that a crystalline structure existed in the amorphous carbon. The appearance of strong peaks was the same as the activated carbon mentioned in previous studies (Figure 1(b)) [4, 5]. It can be summarised that the adsorbent 1 which was synthesized in this research could be an activated carbon. The yield was 34.7% which was higher than the synthesised activated carbon from palm shells [6].

The X-ray diffractogram of the ash which was raw material for synthesising the adsorbent 2 is presented in Figure 2(a). Figures 1(a) and 2(a) reveal that there was different in the samples' structures after heating at 300°C and 750°C. At 750°C, the disappearance of broad peak around 24° and the occurrence of many sharp peaks indicate that no carbon was remained and the molecules were rearranged in crystalline structure. According to the result of X-Ray Fluorescence (XRF) analysis, the ash contained very high K and no C (Table 2). The strong peaks at 28.4° and 40.2° in Figure 2a represents KCl, and the peaks at 32.3° and 35.9° represents $KClO_4$ [7].

The adsorbent 2 became white powder with approximate size of 0.2 mm and its X-ray diffractogram is shown in Figure 2(b). The analysis of patterns show that the crystalline phase was changed; the strong peaks at 21.8° and 40.2° were disappeared. The adsorbent 2 presents the diffraction peaks at 26.7°, 28.0°, 31.4° and 34.6°, which the further analysis is required to identify the specific type of the adsorbent 2.

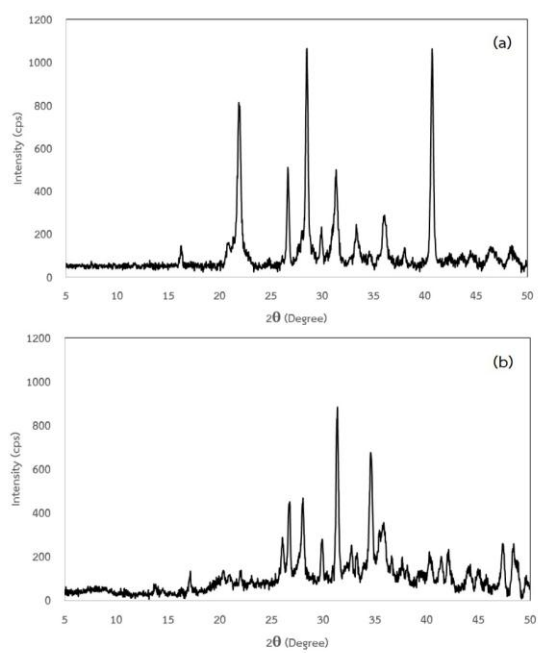

Figure 2 XRD pattern of (a) ash (heated at 750°C) and (b) adsorbent 2

Table 2 XRF result of ash (heated at 750°C)

Elements	%w/w
Mg	2.32
Si	27.21
P	10.67
S	3.75
Cl	2.08
K	44.89
Ca	7.84
Mn	0.47
Fe	0.76

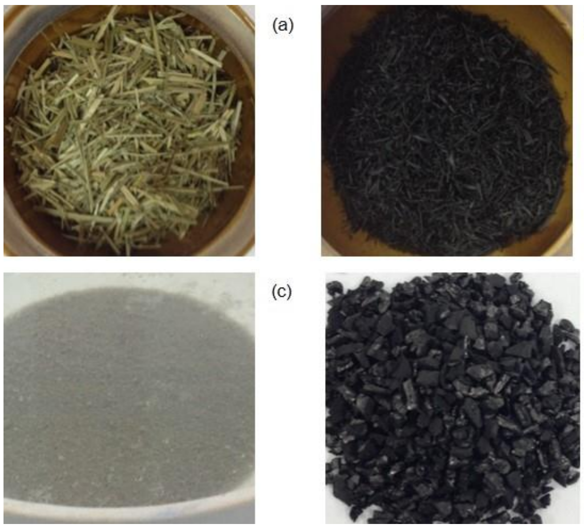

Figure 3 (a) Vetiver leave, (b) adsorbent 1, (c) adsorbent 2, and (d) commercial activated carbon.

3.2 Wastewater Treatment

The ability of adsorbents 1 and 2 for treating dye wastewater was discussed in this section, and compared to that of commercial activated carbon. The standard dye wastewater (untreated) was blue colour and obtained the highest absorbance of 0.52 at 664 nm. Therefore, the reduction of 664 nm absorbance can indicate the colour removal efficiency of each adsorbent. For the control batch (no adsorbent), no colour removal was found and the absorbance pattern was the same as the untreated wastewater (shown in Figure 4). The 664 nm absorbance of the treated wastewater by adsorbents 1 and 2 was decreased to less than 0.01, and both treated wastewater was clear and colourless. In the meantime, the colour of treated wastewater by commercial activated carbon still had light blue with the 664 nm absorbance of 0.22. The synthesized adsorbents from vetiver grass were able to achieve excellent removal efficiency, and their adsorption abilities were much better than the commercial activated carbon.

The adsorption ability of adsorbents was investigated at higher concentrations of dye wastewater. When the concentrations were increased to 2, 5, 8 and 10 times of the standard, the adsorbent 1 can achieve excellent removal efficiency of >99% (see in Figure 5). The adsorbent 2 also achieve high removal efficiency at high concentrations, however the removal efficiency was decreased to approximately 58% at the highest concentration. For the commercial activated carbon, its removal efficiency was gradually decreasing from 53% to 2% when the concentrations were increasing. Moreover, no removal efficiency was found in the control batch.

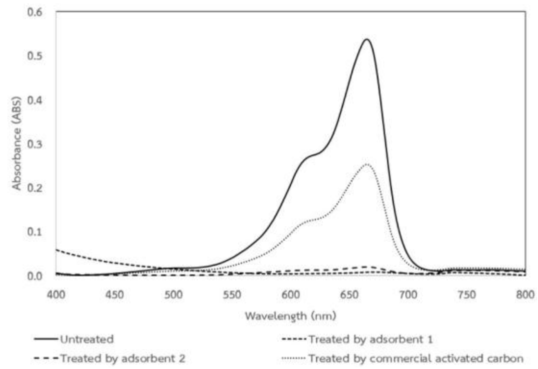

Figure 4 Absorbance value of wastewater treated by adsorbent 1, 2 and commercial activated carbon

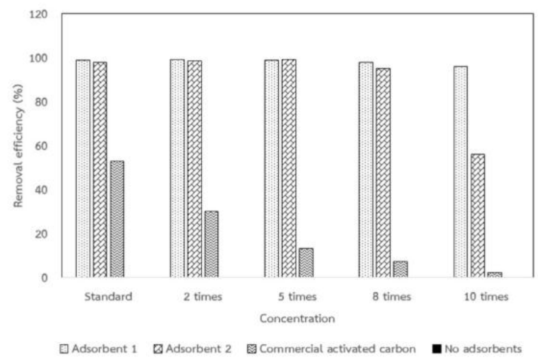

Figure 5 Treatment efficiency of adsorbents at various wastewater concentrations

4. CONCLUSION

The vetiver grass can use as raw material to synthesis excellent adsorbent materials. The first synthesized adsorbent (adsorbent 1) was activated carbon and had very high adsorption ability for wastewater treatment. Although the specific type of the second synthesized adsorbent (adsorbent 2) cannot be identified in this research, its ability was relatively high. Significantly, both adsorbents provided a better colour removal efficiency than the commercial activated carbon.

5. REFERENCES

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