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Efficiency of activated carbon and white charcoal from textile dyeing industry in synthetic wastewater

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Abstract

The experiment aimed on the treatment of synthetic wastewater of disperse dye and reactive dye with activated carbon and white charcoal by wastewater shell that flow through the column. It contained small pellet of charcoal, having thickness 20, 40 and 60 cm, respectively and measured the treatment efficiency of dye color every hours and chemical oxygen demand (COD) before and after treatment. The study observed the efficiency of white charcoal treatment through that synthetic wastewater treatment of disperse dye having thickness of 20, 40 and 60 cm. The efficiency was 62.97%, 50.18% and 89.22%, respectively and activated carbon was 36.88%, 40.77% and 62.38%, respectively. While in case of reactive dye the efficiency of white charcoal was 14.85%, 42.47% and 99.94%, respectively and activated carbon was 13.12%, 35.46% and 53.78%, respectively. The treatment of COD found that white charcoal and activated carbon were 71.09% and 58.79%, respectively. Efficiency of both dye color and COD treatment increased with increase in the thickness of charcoal. The thickness of 60 cm was better than 40 and 20 cm.

Keywords: Adsorption, activated carbon, white charcoal, disperse dye, reactive dye

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1. Introduction

The textile industry plays a significant role in Thailand's economic development. It is an industry with an export value of 3.40% of total domestic products. The average amount obtained from textile and garment exports is more than 150,000 million baht per year and employ more than 1 million people, accounting about 20% of all employment in the manufacturing sector in Thailand [1]. The process of dyeing is an important step in the textile industry and it is important to make the fabric and yarn colorful, durable to the environment and should be comfortable to the wearers. Therefore, it is important to examine the dyeing process of textile industry. The dyeing industry use chemicals and dyes to alter the properties of fibers in the dyeing process and these processes often rely on water as an intermediary for almost every step. Tanning industry is an industry that requires large amounts of water. In addition, wastewater after dyeing process will be contaminated by chemicals since manufacturing process use chemicals, such as cleaning agents, dyes, dyestuffs. The properties of wastewater generated by each dyeing industry, or even the same type of dyeing, differ at different stages. There are many differences in the characteristics of waste water depending on the type of production and selection of chemicals [2]. Most of the effluent is composed of colored-organic matter with variety of pH value, thereby affecting the organism in natural water sources. It also destroyed the scenic beauty and is offensive to the environment. Some dyes cannot be treated by physical and chemical methods such as reactive dye, acid dye, basic dye and direct dye. Therefore, wastewater treatment from the textile industry is adopted as a means to meet the effluent standards and to prevent pollution problem [3]. There are many ways to remove colorants in industrial wastewater, including membrane filtration treatment, coagulation and flocculation process with alum and calcium hydroxide and ozone treatment. This method is a highly effective method of treatment. However, there are limitation on the flow rate, pH and water temperature [4]. The adsorption method is simple and can be used in a variety of ways. Materials used are silica gel, activates - alumina, zeolite, activated carbon and white char-

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coal [5]. Activated carbon and white charcoal are suitable materials for wastewater treatment from dye, due to the very porous surface (300-700 m^2/g). The adsorbent commonly used is activated carbon, a form of raw materials consisting of carbon-based organic substance. This carbon is activated by heating or burning in a confined furnace at a high temperature so as to create porosity. Then, it is compressed with steam to increase the absorbent surface area. White charcoal is a charcoal with a production process, very different from general black charcoal production, having luster and it looks like metal. White charcoal are denser than other charcoal. It can also be reused after treatment through a regeneration process. Therefore, the efficiency of activated carbon and white activated carbon should be studied in color treatment in synthetic wastewater as well as studying the appropriate thickness of the charcoal layer. This increases the choice of using absorbent materials in the textile dyeing industry so as to be able to treat color in wastewater efficiently and suitable for wastewater.

Sun et al. [6] studied three types of reactive dyestuffs such as Reactive Red 23, Reactive Blue 171 and Reactive Blue 4, with activated carbon being produced from green algae. The study found that activated carbon has a dye adsorption capacity of 59.88, 71.94 and 131.93 mg/g, respectively. Similarly, Palanisamy et al. [7] found the activated carbon that is made from *Euphorbia tirucalli Linn.* has a dye adsorption capacity of Reactive Red and Reactive Blue, 217.39 and 200 mg/g, respectively. While El-Sayed et al. [8] found adsorbed dyestuffs with activated carbon that is made from sugar cane stalks can remove more than 50% in an hour.

2. Research Objectives

This research aimed at studying the synthetic wastewater treatment of disperse dye and reactive dye with activated carbon and white charcoal using a Column Adsorption Process. It also discusses the factors influencing the adsorption process. The following are the objectives:

- To study the efficiency of dye treatment from synthetic wastewater by activated carbon and white charcoal
- To find out the efficiency of the COD treatment
- To analyze the life cycle of charcoal

3. Methodology

3.1. Preparation of materials and synthetic wastewater

Synthetic wastewater was prepared from Red Disperse and Red Reactive dye as shown in Fig. 1. The adsorbents used were activated carbon obtained from C. Gigantic Carbon Co., Ltd. and white charcoal from Charcoal Home Co., Ltd.. The two types of charcoals were used to grind and separate through a sieve having a size of 0.85-2 mm, then it was washed with distilled water to remove debris and contaminants. After that, it was dried in the sun and stored for experimental use.

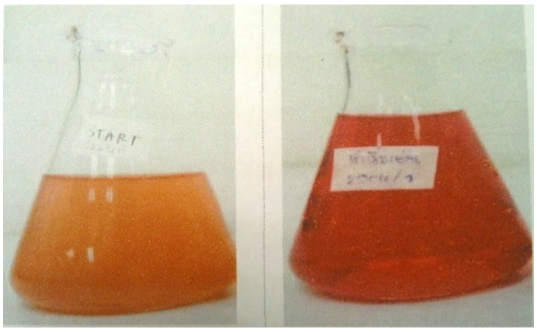

Figure 1: Synthetic wastewater, Red Disperse and Red Reactive dye.

Figure 2: The column with 20 cm. of charcoal.

3.2. Study on dye and COD efficiency with activated carbon and white charcoal

Activated carbon and white charcoal were placed in columns with a diameter of 4.30 cm, giving the charcoal layer a thickness of 20 cm, as shown in Fig. 2, and feeding the disposable and disposable synthetic wastewater. Column analysis of synthetic wastewater concentration before and after it passes column each hour with UV-VIS Spectrophotometer at the maximum wavelength of synthetic wastewater. The reflux method was used to determine the COD value by using the method of Standard Methods for the Examination of Water and Wastewater [9]. The experiment was repeated but the thickness of charcoal was changed to 40 and 60 cm order.

3.3. Study on the efficiency of dye treatment and COD from synthetic wastewater by activated carbon and white charcoal

Filled activated carbon and white charcoal in a column with a diameter of 4.30 cm, the charcoal layer

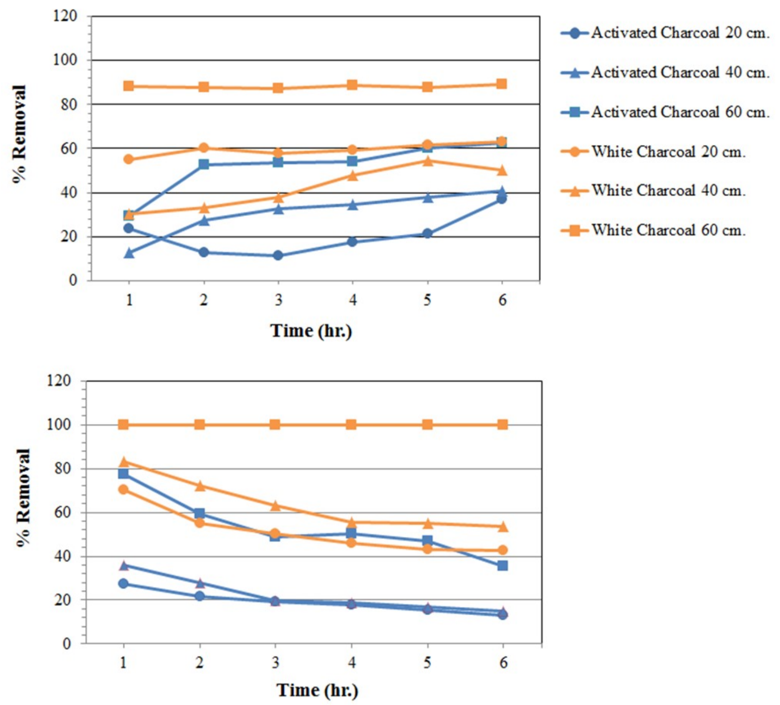

Figure 3: The efficiency of dye treatment by activated carbon and white charcoal; (A) is disperse dye and (B) is reactive dye.

is 20 cm thick as shown in Fig. 2 and filled with disperse wastewater and reactive wastewater in column and analysis were done s of the concentration of synthetic wastewater before column and after column passes every 1 hour with UV-VIS Spectrophotometer at the maximum wavelength of synthetic wastewater. Used the Close reflux method to determine the COD value by using the method of Standard Methods for the Examination of Water and Wastewater [9]. Then, the experiment was repeated with the thickness of the charcoal layer of 40 and 60 cm, respectively.

3.4. Study of life cycle of activated carbon and white charcoal

Life cycle is the lifetime of the activated carbon and white charcoal until eventually the activated carbon must be replaced. Activated carbon and white charcoal were added in the column to a thickness of 20 cm. Thereafter, the synthetic wastewater was filled into the column and the concentration of synthetic wastewater that passed through the column were analyzed every 1 to 6 hours, followed by every 2 to 12 hours and consequently analyzed every 4 hours until the synthetic wastewater that passed through the column was similar to the wastewater before passing to the column.

4. Results and Discussion

4.1. The efficiency of dye treatment from synthetic wastewater by activated carbon and white charcoal

The results of dye treatment from synthetic wastewater have shown that: the efficiency of Red disperse of activated carbon was at 20, 40 and 60 cm. A high proportion, of 36.98%, 40.77%, and 62.38%, respectively was found to be having efficiencies in white charcoal with thickness of 20, 40 and 60 cm, respectively. Similarly, in the case of 62.97%, 50.18% and 89.22%, respectively, the efficiency was decreased in the 1st hour and increased at 4th hour and remained constant until the 6th hour as shown in Fig. 3(A). While in the case of Red Reactive activated carbon, the efficiency was at 20, 40 and 60 cm thickness with proportion. Another 13.12%, 35.46%, and 53.78%, respectively were having efficiencies. Similarly, another 14.85%, 42.47% and 99.94%, respectively white charcoal were having efficiencies with thicknesses of 20, 40 and 60 cm, respectively. The efficiency of the two types of charcoal was the highest in the first hour and gradually decreased over the time period as shown in Fig. 3(B). It can be seen that the Red Disperse dye tends to increase the efficiency of dye treatment when the system duration increases. This is because the rate of water flowing out of the system is less, synthetic wastewater has a longer contact with charcoal and the property factor of the dye with large particles, dissolve into colloidal particles causing more clogging in the space between the charcoal particles, making the space smaller

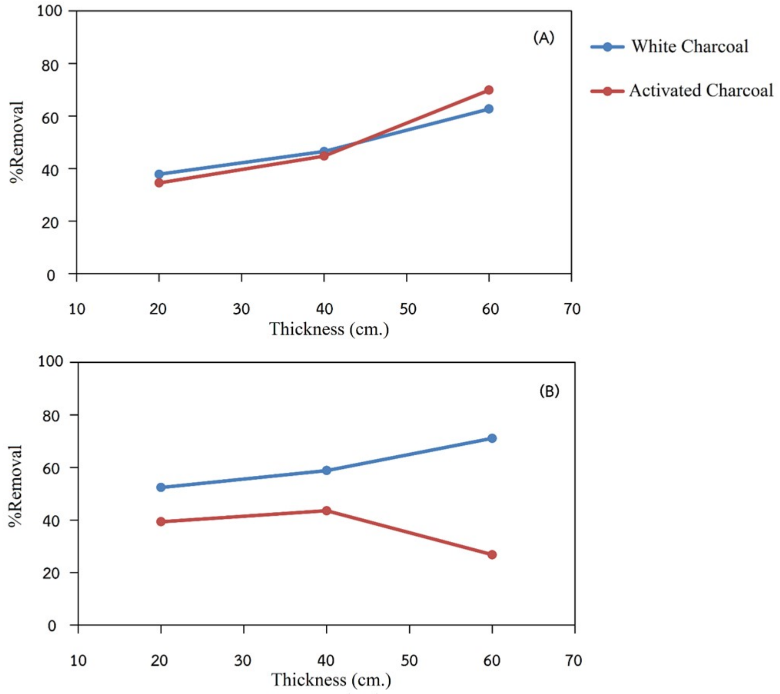

Figure 4: The efficiency of COD treatment by activated carbon and white charcoal; (A) is disperse dye and (B) is reactive dye.

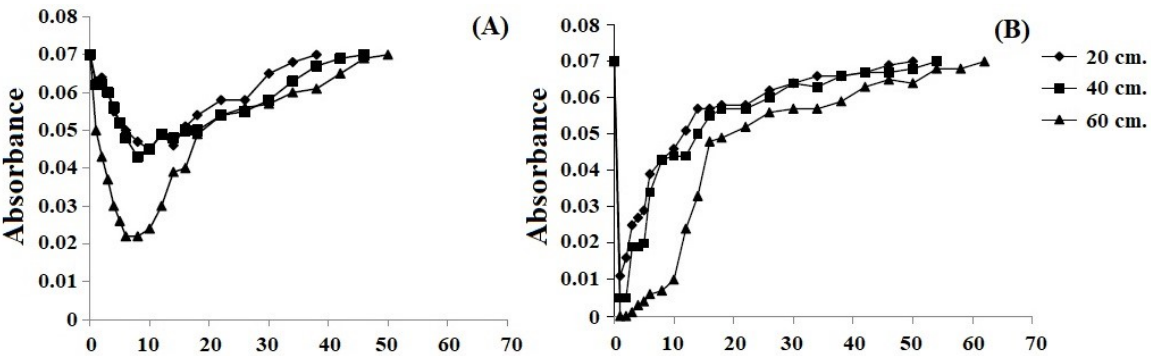

Figure 5: The life cycle of both types of charcoal; (A) is activated carbon and (B) is white charcoal.

Less passed synthetic wastewater. Therefore, increasing the resistance time is a factor that makes the treated wastewater to have better efficiency. In part of Red Reactive, it can be seen that there is a tendency for the effectiveness of dye treatment to decrease when the system duration increases. Due to the qualification factors of this type of dye, it has a fine texture and dissolves well. Resulting in waste water in the form of a solution, and over time the solution particles are absorbed more on the charcoal particles. Causing the surface area of the charcoal to be less adsorbed and the treatment efficiency in the later hours tends to decrease from the first hour.

Furthermore, Sinsangkaew et al. [10] found powdered soybean meal that pretreatment by washing with distilled water, dried at 90 °C for 2 hours, sift through the sieve 30-40 mesh, 1 hour in adjusted with 0.5 M NaOH, washing with distilled water then dried at 60 °C for 24 hours. The adsorption of reactive dye and basic of cationic dye was 100%, and 67.5%, respectively. However, findings of Ahmad and Hameed [11] who found active carbon prepared form bamboo waste by chemical activation method can reduce color of 91.84%.

From the Table 1, it was found that F_1 = 44.844. It can be concluded that the average of thickness with each level were different at P-value < 0.0009. Pairwise comparisons revealed that: the average of absorbance of thickness of 60 cm was lower than the thickness of 20 and 40 cm while the average of absorbance of thickness of 20 and 40 cm was not different.

For F_2 = 88.067, it can be concluded that the average of each type of charcoal were different at P-value < 0.0009. It was found the average of activated carbon

Table 1. Results of Analysis of Variance of removing disperse dye.

Data Sources	Sum of Squares	df	Mean of Squares	F	P-value
Thickness level	0.010	2	0.005	44.844	< 0.0009
Type of charcoal	0.010	1	0.010	88.067	< 0.0009
Thickness * type of charcoal	0.002	2	0.001	8.956	< 0.0009
Deviations	0.011	102	0.00001078		
Total	**0.033**	**107**			

Table 2. Results of Analysis of Variance of removing reactive dye.

Data Sources	Sum of Squares	df	Mean of Squares	F	P-value
Thickness level	20.505	2	10.253	107.793	< 0.0009
Type of charcoal	1.071	1	1.071	11.256	0.001
Thickness * type of charcoal	1.966	2	0.983	10.335	< 0.0009
Deviations	9.702	102	0.095		
Total	**0.033**	**107**			

was higher than white charcoal. And F_3 = 8.956, it can be concluded that there is a relationship between the thickness level and type of charcoal at P-value < 0.0009. While lower average absorbance values indicate high performance of removing dye.

From the Table 2, it was found that F_1 = 107.793. It can be concluded that the average of thickness with each level was different at P-value < 0.0009. Pairwise comparisons revealed that: the average of absorbance of thickness of 60 cm was lower than the thickness of 20 and 40 cm while the average of absorbance of thickness of 20 cm was higher than thickness of 40 cm.

For F_2 = 11.256, it can be concluded that the average of each type of charcoal was different at P-value < 0.0009. It was found the average of activated carbon was higher than white charcoal. And F_3 = 11.335, it can be concluded that there is a relationship between the thickness level and type of charcoal at P-value < 0.0009. While lower average absorbance values indicate high performance of removing dye.

4.2. The efficiency of dye treatment from synthetic wastewater by activated carbon and white charcoal

The results of COD treatment from synthetic wastewater have shown that a high proportion of 34.54%, 44.77% and 69.87%, respectively were having efficiency of disperse dye of activated carbon at 20, 40 and 60 cm thickness respectively. Similarly, 37.83%, 46.51% and 62.69%, respectively were having maximum COD treatment efficiency. The efficiency was increased by thicknesses as shown in Fig. 4(A). While the efficiency of reactive dye of activated carbon varies at 20, 40 and 60 cm thickness having COD treatment efficiency with a large proportion of 39.33%, 43.53% and 58.79%, respectively. And the COD treatment efficiency of White Charcoal was found to be increased with thickness (52.38%, 58.82% and 71.09%, respectively) as shown in Fig. 4(B). It can be seen that the trend of COD treatment efficiency increases when the thickness of the charcoal layer increases. Because there is more charcoal taken in the treatment and the water flowing out from the system has a longer time to contact the charcoal. While Jain and Sikarwar [12] investigated adsorption methods from waste material sawdust as adsorbent, it can reduce COD of 73.5 mg/L when the particle size is not over than 106 BSS mesh. Furthermore, Ahmad and Hameed [11] found active carbon that prepared form bamboo waste by chemical activation method. It can reduce COD of 75.21%.

From the Table 3, it was found that F_1 = 43.583. It can be concluded that the average of thickness with each level was different at P-value < 0.0009. Pairwise comparisons revealed that: the average of %removing COD of thickness of 60 cm was higher than the thickness of 20 and 40 cm while the average of absorbance of thickness of 20 and 40 cm was not different.

For F_2 = 79.668, it can be concluded that the average of each type of charcoal was different at P-value < 0.0009. It was found the average of white charcoal was higher than activated carbon. And F_3 = 7.351, it can be concluded that there is a relationship between the thickness level and type of charcoal at P-value < 0.0009.

From the Table 4, it was found that F1 = 104.330. It can be concluded that the average of thickness with each level was different at P-value < 0.0009. Pairwise comparisons revealed that: the average of absorbance of thickness of 60 cm was lower than the thickness of 20 and 40 cm while the average of absorbance of thickness of 20 cm was lower than thickness of 40 cm.

For F_2 = 13.021, it can be concluded that the aver-

Table 3. Results of Analysis of Variance of COD treatment from synthetic wastewater of disperse dye.

Data Sources	Sum of Squares	df	Mean of Squares	F	P-value
Thickness level	24,447.419	2	12,223.710	43.583	< 0.0009
Type of charcoal	22,344.508	1	22,344.508	79.668	< 0.0009
Thickness * type of charcoal	4,123.381	2	2,061.691	7.51	0.001
Deviations	28,608.093	102	280.472		
Total	**79,523.402**	**107**			

Table 4. Results of Analysis of Variance of removing reactive dye.

Data Sources	Sum of Squares	df	Mean of Squares	F	P-value
Thickness level	67,384.293	2	33,692.147	104.330	< 0.0009
Type of charcoal	4,204.886	1	4,204.886	13.021	< 0.0009
Thickness * type of charcoal	7,612.885	2	3,806.442	11.787	< 0.0009
Deviations	32,939.589	102	322.937		
Total	**112,141.653**	**107**			

age of each type of charcoal was different at P-value < 0.0009. It was found the average of white charcoal was higher than activated carbon. And $F_3 = 11.787$, it can be concluded that there is a relationship between the thickness level and type of charcoal at P-value < 0.0009.

4.3. Life cycle analysis of Charcoal

At the start of the system, the absorbance of synthetic wastewater was reduced rapidly. Until the saturation point, the absorbance value was increased. Demonstrated reduced efficacy or the end of life cycle. In this study, the charcoal layer a thickness of 20, 40 and 60 cm in length, respectively. It was found the life cycle of a white charcoal was 50, 54 and 60 hours, respectively. While the life cycle of an activated carbon was 38 and 40 and 48 hours, respectively. The life cycle of both types of charcoal. It showed that the life cycle is longer than the use of charcoal in the treatment of synthetic wastewater. So, both types of charcoal can be reused in the experiment as shown in Fig. 5.

5. Conclusions

It can be concluded that the treatment synthetic wastewater of disperse dye and reactive dye, white charcoals had treatment efficiency of dye color and COD higher than activated carbon. The production process of the white charcoal produced by using high temperature, it made white charcoal to have more porous than activated carbon. It caused the white charcoal to have more area to absorb. The efficiency of dye treatment from synthetic wastewater by activated carbon and white charcoal varies with thickness. The higher the thickness is, the higher the proportion of efficiency of disperse dye treatment of activated carbon and white charcoal treatment. Setha [13] and Iampee [14] found that activated carbon can be used to remove color, suspend solids, BOD and COD. Furthermore, the increased thickness of the charcoal layer increases the efficiency of the treatment.

This research is to use white charcoal as an alternative absorbent. At present, there are no white charcoal that has appropriate appearance and has not been sold widely in the market. White charcoal is more effective adsorption than activated carbon. And with price per unit of charcoal is high, it should be used to treat or absorb important pollutants in order to be more economical

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