Investigated on Removal of Residual Dyestuff in Effluent from Dyeing Process: Physical Method

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Abstract

This study was investigated the pretreatment of dye effluent from dyeing process by activated carbon. The study parameters were color strength, operating time, and types of dyestuff such as direct dye, reactive dye, acid dye, basic dye, and disperse dye. The results found, the activated carbon was achieved to adsorb the colorant. The pretreatment process used 100 – 200 gram activated carbon to one liter of dye effluent. The contact time was 2 hours at room temperature. The dyeing conditions had an influent for pretreatment process. The acidic condition was favored than neutral and basic condition. In addition, the dye removal efficiency was basic dye > acid dye > disperse dye > direct dye > reactive dye.

Keywords: dye effluent, activated carbon, color strength, dyestuff

Introduction

Since the establishedment of the synthetic dye industry with Perkin's synthesis of mauvein in 1856, generations of chemists have applied their minds to the challenge of designing dyes for an ever-widening range of fiber substrates and application methods. The large number of dyes in use today bears witness to their creativity and innovation in successfully meeting this challenge and satisfying the dyer's demands for sample, reproducible application processes, and the consumer's need for quality products of reasonable price. At the present time, textile activities are in constant expansion showing a high pollutant potential. They have long been a large and important group of industrial chemicals, and are used in many products such as paper, leather, and foodstuffs. Thus, dye effluents are extremely variable in composition, due to the large number of dyes and other chemicals used in dyeing processes. Dyes often receive the most attention from researchers interested in textile effluents treatment process because of their colour, as well as the toxicity of the raw materials used to synthesize dyes.

From this impact of dye effluent emerging from dyeing processes on the environment mentioned earlier, it is found that this problem is difficult to solve. Treatment of wastewater to remove dyestuff in effluents using many methods have been attempted, however the cost of treatment is still high and at present there are many types of dyes and treatment differs on the type of dye used. Pretreatment process in the textile dyeing industry are generally designed to remove colour from the wastewater that are physical method [1,2,3], chemical method [4,5,6] and biological method [4,7]. Dye effluents often receive the most attention from researchers interested in Textile wastewater treatment processes because of their colour, as well as the toxicity of some of the raw materials used to synthesize dyes e.g. certain aromatic amines used to produce azo dyes.

This study preferred inphysical method using adsorption pretreatment by activated carbon. Activated carbon was the favorite adsorbents that are highly crystalline form and extensively developed internal pore structure. A wide variety of activated carbon products is available exhibiting markedly different characteristics depending upon the raw material and activation technique used in their production. In selecting an activated carbon, it is importanct to have some understanding of its characteristics. Many natural substances of base materials are used to make activated carbon. The most common of these are wood, coal, lignite, and coconut shell. Thus activation gives carbon its unique filtering characteristics. The carbon product may be supplied as granular activated carbon, powdered activated carbon, or in pelleted form. Activated carbon works by attracting and holding certain chemicals as water passes through it. It is an extremely high surface area for contaminant adsorption. The equivalent surface area of 1 pound of activated carbon ranges from 60 to 150 acres. The adsorption process depends on the following factors: 1) physical properties of the activated carbon, such as pore size distribution and surface area; 2) the chemical nature of the carbon source, or the amount of oxygen and hydrogen associated with it; 3) chemical composition and concentration of the contaminant; 4) the temperature and pH of the water; and 5) the flow rate or time exposure of water to activated carbon.

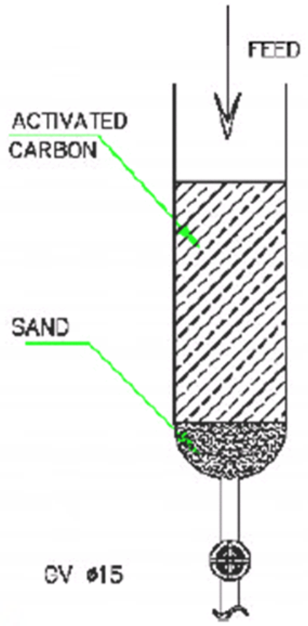
Physical pretreatment was the other method employed to reduce the colour strength of the effluent from dyeing processes. This was achieved by using activated carbon to adsorb the colour.

2. Material

Dyes were used in this research as direct dye, reactive dye, acid dye, basic dye, and disperse dye. All of them were prepared at concentration of 0.5%, 1.0%, and 2.0% of weight fabric (% shade) in a particular condition. The residual dye solutions were established for this experiment.

Firstly, the calibration curves for each dye were prepared in distilled water. Almost dyes were prepared as 0.001, 0.002, 0.003, 0.004, and 0.005%w/v in distilled water accepted basic dye. Basic dye has high brightness so that the preparation concentrations were 0.00025, 0.00050, 0.00075, 0.0010, and 0.00125 %w/v, respectively. However, the dye absorbance would be less than 2.5%w/v for acceptance. The dye solution absorbencies were measured using a UV-Vis spectrophotometer Model 160A (Shimadzu).

In the study, physical pretreatment was performed in the batch apparatus shown in Figure 1, activated carbon was used as the adsorbent. For a fixed effluent volume of 1 liter, the amount of activated carbon was varied at 100 gram, 200 gram, 300 gram, and 400 gram, respectively. The samples were kept and measured from 1 hour to 8 hour.



Remark : GV ∅ 15 was gate valve, sand was used for water filtration

Figure 1 Scheme of physical pretreatment

When all the essential data of various dyes to be used in our study are known, pretreatment could be performed via physical means. The main objective of pretreatment was to reduce the colour strength of the dye effluent. Factors studied were dye type, colour strength, and condition.

3. Results and Discussions

3.1 Relationship between dyestuff and pretreatment condition

Most dyes can be adsorbed with activated carbon. The degree of adsorption depends on the amount of activated carbon in the column. Results of dye adsorption are summarized in Table 1.

Table 1 Relationship between dyestuff and pretreatment condition

Dye stuff	Conc. (% shade)	Mass (g)	Time (hr)
Direct Dye	0.5	64.37	1
	1.0	128.74	3
	2.0	257.48	6
Reactive Dye	0.5	128.74	5
	1.0	257.48	2
	2.0	257.48	4
Disperse Dye	0.5	193.11	3
	1.0	128.74	4
	2.0	193.11	5
Acid Dye	0.5	N/A	N/A
	1.0	N/A	N/A
	2.0	257.48	1
Basic Dye	0.5	64.37	1
	1.0	64.37	1
	2.0	64.37	1

Remark: N/A = no report

In physical pretreatment, it was found that activated carbon can absorb all types of dye, but the degree of adsorption depended on the characteristics of individual dye effluent, the amount of adsorbent, and contacting time [8]. The results were followed: the direct dye was the high degree of adsorption thus the less of adsorbent consumption at the lower contact time. This effect was apparently unrelated to the number of sulphonic acid groups in its structure. This colour was dyed in natural condition. The reactive dye was very low degree of adsorption by meaning as the greatest adsorbent consumption at the long time contacting. Which, it was, apparently unaffected by the degree of sulphonation or ease of hydrolysis. Thus, the reactive dye was added onto substrate in basic state. In the other dye was dyed in acidic condition. The acidic condition could arrange as disperse dye, acid dye, and basic dye. The disperse dyes was a colloidal substrate so the particle was attracted into the activated pore molecule. The degree of adsorption was medium to high degree. The acid dye was also high solubility leads to low adsorption as the direct dye. Which it was appeared to depend on the degree of sulphonation. In the other, the basic dye was dyed in acidic condition so that the ions were powerful to adsorb into the adsorbent medias.

Classification of dye for good adsorption are basic > acid > disperse > direct > reactive, respectively.

3.2 Effect of color strength

As can be seen from the table above, height of activated carbon vary on colour strength. The factors of adsorbtion on activated carbon are summarize in Table 2.

Table 2 Relationship between color strength and physical condition

Conc. (%w/v)	Mass (g)	Time (hr)
0.0002 - 0.0004	100	1
0.0005 - 0.0013	100	3
0.0014 - 0.0017	200	5
0.0023-0.0032	300	3
0.0032-0.0040	400	2
0.0041-0.0072	400	6
0.0074-0.0101	400	7

The results indicated that the amount of activated carbon depended on colour strength. At the high colour strength the greater activated carbon could be used. These results corresponded to contact time also.

3.3 Effect of pH in residual dye

Firstly, pH value and colour strength of dye solutions at maximum wavelength of the dye must be measured before pretreatment. For this study the values of pH and colour strength were measured for three different concentrations, being at 0.5%shade, 1.0%shade, and 2.0% shade. The results are presented in Table 3.

Table 3 Comparison of pH values

Dyestuff	**Conc. (% shade)**	**pH**
Direct dye	0.5	7.65
	1.0	7.82
	2.0	7.56
Reactive dye	0.5	11.59
	1.0	11.59
	2.0	11.63
Disperse dye	0.5	7.65
	1.0	6.92
	2.0	6.64
Acid dye	0.5	4.17
	1.0	4.23
	2.0	4.59
Basic dye	0.5	3.75
	1.0	4.81
	2.0	4.75

The pH value is the essential factor for adsorption of activated carbon according Zogerski's theory " If pH value of contaminate solution is higher than power of dissociation constant (PKa), the adsoption ability will decrease because the interaction between the anions and the surface area of activated carbon or between the anions themselves". The results showed, the acidic condition was the best state for dye adsorbtion. And, the neutral condition was greater than basic condition in order to absorb the dye effluent.

Conclusion

Physical pretreatment is suitable for all types of effluent. At low colour strength good results are obtained. However, to be effective in the removal of colour strength from highly coloured effluent, large amount of activated carbon is needed. The cost of activated carbon would be high. Although treatment of high colour strength effluent by physical method is expensive but the treated effluent obtained had a better clarity method.

Finally, the process chosen to remove the colour strength must match the dye waste of a factory. It must be recognized that the smaller the discharge, the higher the unit cost. Most industries in Thailand are small or medium-size enterprises.

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