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Reuse of Textile Effluent Treated with Advanced Oxidation Process by UV/H_2O_2

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The objective of this work was to study the possibility of reuse of effluent in continuous dyeing of 100% cotton. Were made five dyeing, four with reactive dyes and one with fluorescent brightener, using the same bath after treatment by advanced oxidation process (AOP) by UV/H_2O_2. The efficiency results were higher than 85 % in all cases allowing total reuse of the effluent. The dyeing made with treated effluent were compared against dyeing made with water, with values of deviations smaller than 1.10. Based on these results and working with 1:10 liquor ratio, the consumption of water for a monthly production of 100 tons would be about 8,000 m^3. The same dyeing made with treated effluent, adding approximately 10 % loss by evaporation, would spend only 88 m^3, which represents a monthly saving of water around 7,912 m^3.

1. Introduction

Nowadays, wastewater treatment and reuse of water are two of the most researched topics and many studies involving AOP have been developed, some of them searching on textile effluent (Gomez M. et al, 2010). In the textile industry, the dyeing end finishing of knitted cotton increased from 246,588 t in 2003 to 371,191 t in 2007, representing a growth of 50.53 % (Prado & Prado, 2009). Besides this, the textile sector is currently responsible for grate part of the economy in developed countries and the main economic activity in some emerging countries (Ignachewski et al., 2010).
All those products is dyed, washed or printed and, therefore, uses an average of 75 liters for each treated kilogram (Ruschioni, 2007). When those data are crossed, it shows an evident and alarming increase in the average water consumption by approximately 9.3 million cubic meters in four years. The fact is even more concern when all those data are concatenated with the study of 166 Wastewater Treatment Plants in operation in Brazil, all with performance considered unsatisfying (Oliveira e von Sperling, 2005; Rosa et al., 2010).
Water is a natural resource essential to the biochemical processes of living beings and is an important factor in industrial activities of various consumer goods. The rational use of it, avoiding waste and pollution should not be of concern only to environmentalists but also to government institutions and for most productive process, mainly because 1/6 of the world population has no access to potable water (Fávere, Riella e Rosa, 2010).
The main aim of this work was to study the behavior of reactive dyes during dyeing made with treated effluent. Those kinds of dyes are relatively easy to apply, have a good wet treatments fastness and

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according to the Brazilian Association of Chemical Industry, their use and trade represents 57 % of all dyes used in Brazil (Abiquim, 2011). A considerable amount of research on wastewater treatment has focused on the elimination of reactive dyes, essentially for three reasons. Firstly, fractions of reactive dyes (10 to 50 %) are wasted during the dyeing process (up to 0.6 $g \cdot L^{-1}$ can be detected in dyestuff effluent), because these dyes react not only with the substrate as well as water. Secondly, conventional wastewater treatment methods, which rely on adsorption and aerobic biodegradation, were found to be inefficient for complete elimination of many reactive dyes (Al-Degs et al., 2008) and thirdly, they also require large amounts of water during the washing process to remove the hydrolyzed dye from the surface of fiber (Rosa et al., 2009; Oliveira et al., 2009).

2. Experimental

2.1 Material

Equipment: Gehaka Analytical Balance AG 200, Batch Type Reactor with two UV-C 6W lamps Philips and a magnetic stirrer, UV-VIS Spectrophotometer Datacolor SF-600 Plus, HT-1 Alt Mathis and Quimis pHmeter.

Reagents: Buffer acetic acid/sodium acetate, CI Reactive Yellow 145 (RY145), CI Reactive Red 239 (RR239), CI Reactive Blue 222 (RB222), CI Reactive Violet 5 (RV5), CI Reactive Black 5 (RB5) Black Base RB5, fluorescent brightener, sodium chloride, sodium carbonate, nonionic surfactant, organic polymer anionic levelling, hydrogen peroxide 35 %, sulfuric acid, enzyme catalase, sodium hydroxide 50 ºBé, sodium metasilicate. According to the manufacturer, with the exception of CI Reactive Black 5, a reactive bi-homofunctional sulfate-ethyl-sulphone type, the reactive dyes are bis-heterofunctional, mono-chloro-triazine/ sulfate-ethyl-sulphone type.

2.2 Methods

The samples were bleached and dyed in accordance with instructions shown at procedure described below. Five dyeings were made being: A, B, C and D with reactive dyes and E, with fluorescent brightener. In the Table 1, the amount of chemicals used in the bleaching recipes and in the Table 2, the amount of dyes and auxiliaries used in the dyeing recipes.

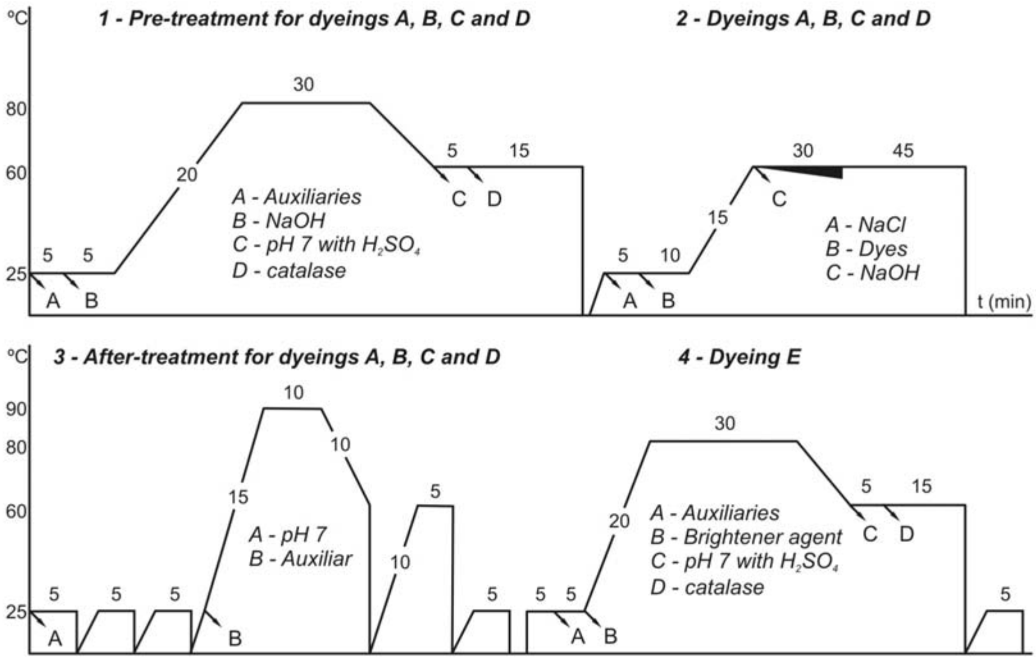

Figure 1: Processes graphics

Table 1: Bleaching recipes

BLEACHING (Except Dyeing E)	
Surfactant ($g \cdot L^{-1}$)	1.00
Levelling ($g \cdot L^{-1}$)	1.00
Sodium Metassilicate ($g \cdot L^{-1}$)	1.50
Hydrogen Peroxide 35 % ($mL \cdot L^{-1}$)	4.00
Sodium Hydroxide 50 ºBé ($mL \cdot L^{-1}$)	2.00
Catalase (%)	0.40
Sulfuric Acid ($mL \cdot L^{-1}$)	0.30

Table 2: Dyeing recipes and order of dyeing processes

Dyeing	A	B	C	D	E
Pantone	TP 194025	TP 183828	TP 181230	TP 190303	White
C.I. RY145 (%)	-	-	1.365	-	-
C.I. RR239 (%)	-	-	0.662	-	-
C.I. RB222 (%)	-	-	0.243	-	-
C.I. RV5 (%)	-	2.0	-	-	-
C.I. RB5 (%)	2.5	-	-	-	-
Black Base RB5 (%)	-	-	-	5	-
Fluorescent Brightener (%)	-	-	-	-	0.8
Sodium Chloride ($g \cdot L^{-1}$)	60.0	60.0	60.0	70.0	-
Sodium Carbonate ($g \cdot L^{-1}$)	6.0	6.0	6.0	6.0	1.0
Sodium Hydroxide 50ºBé ($g \cdot L^{-1}$)	1.4	1.4	1.4	2.4	0.5
Surfactant ($g \cdot L^{-1}$)	-	-	-	-	1.0
Sodium Metasilicate ($g \cdot L^{-1}$)	-	-	-	-	2.0
Hydrogen Peroxide 35 % ($mL \cdot L^{-1}$)	-	-	-	-	6.0
Catalase (%)	-	-	-	-	0.5
Sulfuric Acid ($mL \cdot L^{-1}$)	-	-	-	-	0.2
Levelling ($g \cdot L^{-1}$)	1.0	1.0	1.0	1.0	1.0

The effluent of whole dyeing process was collected since the bleaching stage. After that it was diluted five times and had pH changed to 7. The first dyeing (A) was diluted with water and the other one's (B, C and D) were diluted with treated effluent from the previous dyeing.

The treatment, a AOP UV/H_2O_2 homogeneous photocatalysis, was accomplished by adding a 1.0 $mL \cdot L^{-1}$ Hydrogen Peroxide 35 % and subsequent exposure to ultraviolet waves (237 nm) in the batch reactor at 296 K until maximum allowed conversion. Were collected samples with an interval of fifteen minutes each for further evaluation of the absorbance (Abs) by spectrophotometry UV/Vis, in acrylic buckets with 1.0 cm of optical path. The photochemical treatment efficiency was calculated using the Equation 1:

$$\% \, \text{Efficiency} = \frac{(\text{Abs}_o - \text{Abs}_f)}{\text{Abs}_o} \qquad (1)$$

The liquor ratio used in the dyeing processes, in order to obtain values for the calculation of water consumption and also for the projection of monthly water consumption was 1:10.

3. Results

The color decomposition behavior in the photochemical treatment is shown in Figure 2.

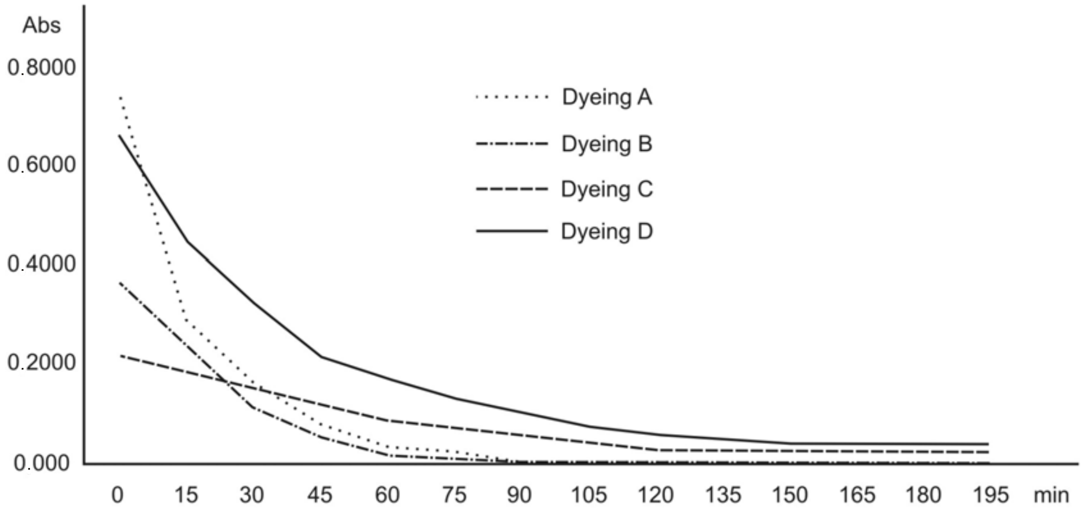

Figure 2: Photochemical decomposition of effluent A, B, C and D.

The values about the percentage of efficiency obtained in the photochemical processes are described in Table 3.

Table 3: Percentage of efficiency

Dyeing	Abs_o	Abs_f	% Efficiency
A	0,7495	0.0072	99.04
B	0.3659	0.0095	97.40
C	0.2186	0.0325	85.13
D	0.6656	0.0372	94.41

The dyeings made with the treated effluent were compared by spectrophotometry UV/Vis, CIELab system, against dyeing made with water. The partial and total deviations are shown in Table 4 and shown graphically in Figure 3. In that one's, the solid line represents the dyeings made with water and the dash line, the dyeings made with treated effluent.

Table 4: Partial and total deviations about dyeings

Deviation	Dyeing				
	A	B	C	D	E
DL*	- 1.05	+ 0.13	- 0.01	- 0.07	- 0.24
Da*	+ 0.15	- 0.10	- 0.68	+ 0.03	- 0.06
Db*	+ 0.30	+ 0.16	+ 0.26	+ 0.01	- 0.34
DE*	+ 1.10	+ 0.23	+ 0.73	+ 0.08	+ 0.26

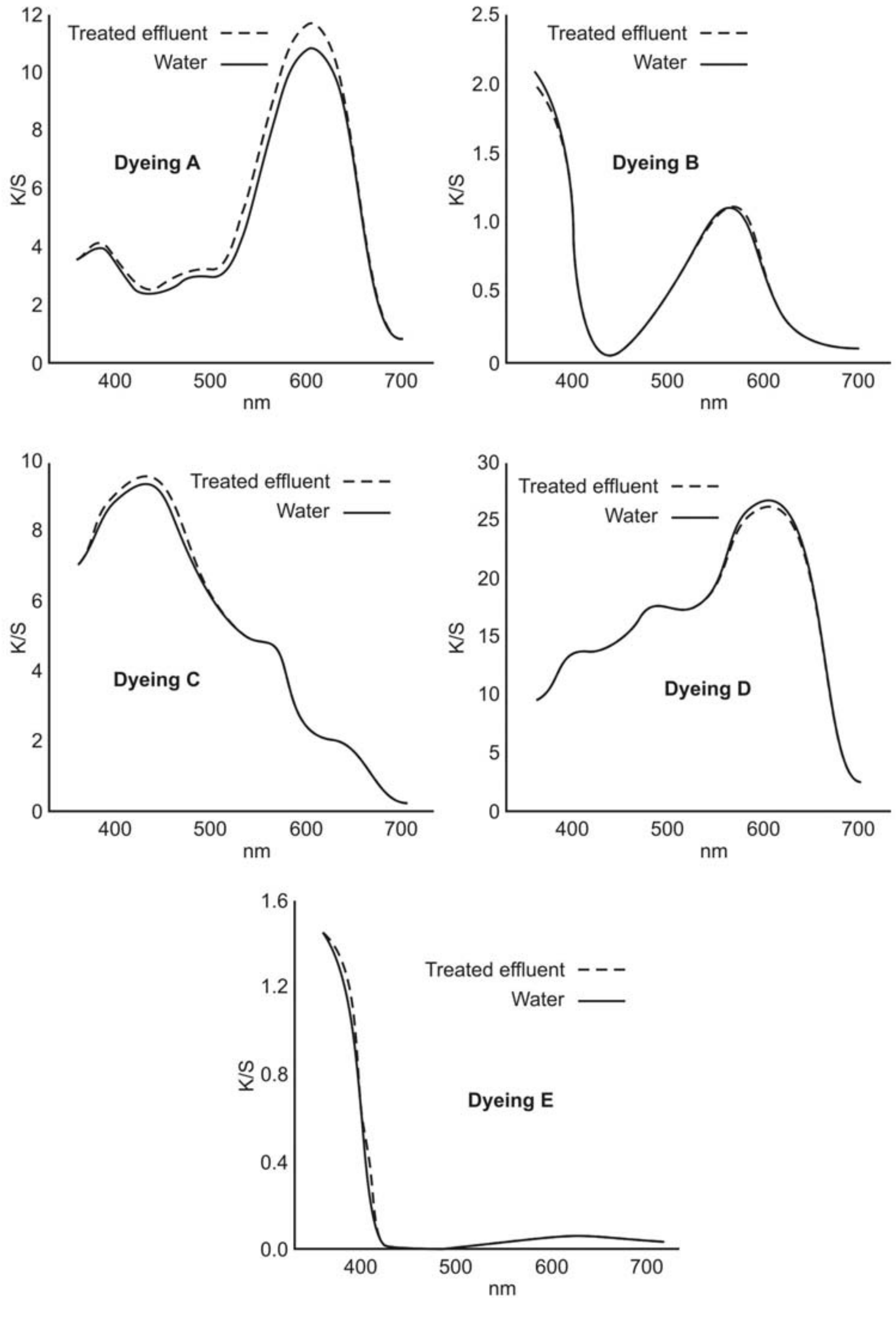

Figure 3. Comparisons of dyeings made with water and treated effluents

4. Conclusions

The use of hydrogen peroxide in AOP has been applied successfully mainly because the its oxidizing capacity is so strong that is considered a highly reactive oxigens species (Biasi et al, 2011). That kind of treatment has allowed results like the obtained in this paper, where it can be concluded that the reuse of treated effluent is possible to be applied. All dyeings total deviations were equal or less than 1.05, perfectly acceptable values for the garment industry.

The liquor ratio used in all steps was 1:10. Working with that liquor ratio, the consumption of water for a monthly production of 100 t would be about 8,000 m^3. The same dyeing made with treated effluent, adding approximately 10 % loss by evaporation, would spend only 88 m^3, which represents a monthly saving of water around 7,912 m^3.

However, there are too many topics to be researched. The photochemical treatment decomposes only organic matter and just five dyeing were done. Based on those data, were estimated a consumption for 100 t. In the five dyeing made with treated effluent was not observed a negative interference in the excess of electrolyte, for example, which could cause problems after a certain amount of dyeing.

It is also important to note that there are several steps to be developed, because it was only the study of a type of dye, working with cotton knitted and under certain conditions.

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