

UV/H₂O₂ coupled with adsorption for decolorization of dye mixtures in water and phytotoxic effects

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Abstract

The present study reported the decolorization by UV/H₂O₂ of three dyes and their binary and ternary mixtures in water, simulating colored effluents of the textile industry. The effect of the initial concentration of H₂O₂, the initial concentration of dyes and the reaction kinetics in the decolorization of textile dyes in water was studied. The efficiency of decolorization of three treatment processes was compared (UV, H₂O₂ and UV/H₂O₂). Moreover, after decolorization of the simulated waters by UV/H₂O₂ the effluents were then treated by adsorption using a commercial aluminosilicate and a silica gel (waste from industry). The phytotoxicity of the effluents was determined before and after adsorption treatment using the *Raphanus sativus* bioassay.

Keywords: phytotoxicity, dye mixtures, decolorization, mineralization, AOPS.

1. Introduction

The public demand of color-free industrial effluents and the increasing regulatory requirements of color in wastewater makes challenging and costly the decolorization of the effluents (Hao *et al.*). Moreover, usually textile industries usually have high variability in water composition and several dyes are used and combined in the final effluent which make it difficult to treat (Khamparia *et al.*). UV/H₂O₂ is effective for the decolorization of dyes in water (Aristizábal *et al.*); however, if complete mineralization is not achieved, the toxicity of the wastewater usually increases due to the generation of intermediate compounds (Hachem *et al.*). Complete mineralization requires higher operating costs; thus, a subsequent process to reduce toxicity of the decolorized effluent is desirable to reduce costs and to minimize environmental impacts when the treated effluent is discharged in water corps or to allow water reuse (Waghmode *et al.*). Few reports focused in the UV/H₂O₂ decolorization of mixtures of dyes in water (Khamparia *et al.*) and some others considered couple processes with other process in order to increase removal efficiency and to decrease phytotoxicity

(Waghmode *et al.*). The aim of this work is to study the decolorization of different dyes and dye mixtures in water by UV/H₂O₂ process and to analyze the phytotoxicity of decolorized effluents. Also, the phytotoxicity of decolorized effluents by UV/H₂O₂ couple to and adsorption process was evaluated.

2. Materials and Methods

Textile dyes (Methylene Blue (MB), Oliva Novazul Luz J (ON) and Turquesa EFDCE (TE)) were used to prepare solutions of dyes and dye mixtures to be used as synthetic waters. The UV-Vis spectra and phytotoxicity of these solutions (0 – 2000 mg/L) were analyzed. UV/H₂O₂ experiments were performed to study the effect of the initial total concentration of dyes in the solutions (0 – 45 mg/L), the initial concentration of H₂O₂ solution (0 – 2% v/v) and reaction time (0 – 240 min) in the decolorization of dyes and dye mixtures in water. Also, the solutions were treated by UV alone and H₂O₂ alone to study the effect of each type of treatment. The phytotoxicity of decolorized solutions of dyes and dye mixtures by UV/H₂O₂ (at the minimum reaction time) was determined, and then these effluents were coupled to an adsorption process to evaluate phytotoxicity removal. Adsorption experiments were carried out by contacting 0.5 g of adsorbent (Silice Gel (SG) and Aluminosilicate (AS)) with 30 mL of decolorized effluent during 18 h. Then, the adsorbent was separated from the treated water by centrifugation. After the adsorption process, the phytotoxicity of the supernatant were measured. The decolorization experiments were performed in batch reactors irradiated with five LP-Hg lamps were 14 mL solution were treated and then decolorization of solution was determined by UV-vis. Phytotoxicity of solutions and effluents was determined using *Raphanus sativus* bioassay. Germination was assessed at 24h and root elongation was measured at 48h. Control treatment was performed with deionized water (DW) instead of solution or effluent.

3. Results and Discussion

The effect of the H₂O₂ initial concentration in the decolorization of dyes and dye mixtures by UV/H₂O₂ during 30 min was studied (Table 1). Decolorization efficiency differs for the different solutions and differences are related to the absorbance spectrum of each solution. Thus, the amount of H₂O₂ required to optimize the UV/H₂O₂ differs.

Table 1. Decolorization of dyes and dye mixtures in water by UV/H₂O₂ process at different initial H₂O₂ concentrations.

Dyes	Total Decolorization (%)			
	0%	1%	1.5%	2%
MB	2.2	21.1	23.4	26.1
ON	2.3	31.5	40.4	55.9
TE	5.3	13.4	22.6	30.2
MB-ON	5.0	37.8	47.1	57.9
MB-TE	7.1	37.5	39.7	45.0
ON-TE	9.8	47.9	54.3	65.6
MB-ON-TE	11.1	37.0	47.6	55.0

Also, the effect of the initial concentration of dyes in the decolorization kinetics of dyes and dye mixtures in water by UV/H₂O₂ was studied. The UV/H₂O₂ showed significantly higher decolorization at the same time than H₂O₂ alone or UV alone.

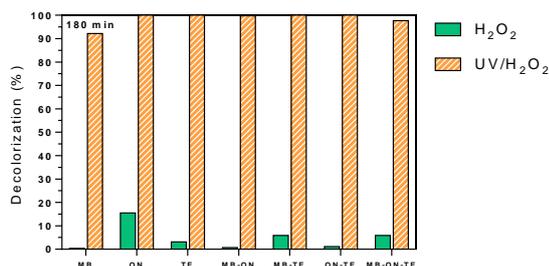


Figure 1. Effect of the H₂O₂ addition and UV irradiation in the decolorization of dyes and dye mixtures in water.

From the phytotoxicity bioassays carried out on dye solutions between 0 - 2000 mg/L, it was observed that germination of seeds was not significantly affected under 1000 mg/L. Germination decreased for MB, ON and TE compared to the control treatment at 1500 and 2000 mg/L. High concentrations of these textile dyes are required to observe significant phytotoxic effects. The germination % of dye solutions decolorized by UV/H₂O₂ and after subsequent treatment by adsorption are shown in Table 2. The results showed that the seed germination percentages (Table 2) were reduce after used material AS in the treatments TE, MB-TE, ON-TE and MB-ON-TE.

Table 2. Germination percentage of solutions decolorized by UV/H₂O₂ and solutions decolorized by UV/H₂O₂ and then treated by adsorption.

Dyes	Germination <i>R. sativus</i> at 24h (%)		
	After UVH ₂ O ₂	Adsorption with AS	Adsorption with SG
Control DW	100.0	90.0	93.3
MB	28.3	35.0	21.7
ON	40.0	46.7	15.0
TE	30.0	41.7	30.0
MB-ON	35.0	35.0	30.0
MB-TE	28.3	43.3	10.0
ON-TE	26.7	50.0	33.3
MB-ON-TE	21.7	56.7	23.3

4. Conclusions

Operating parameters differed according to water composition and the change in the absorption spectrum of the resulting wastewater. The phytotoxicity of the solution increased after UV/H₂O₂ treatment; however, adsorption can be an alternative to reduce phytotoxicity, but it should be optimized.

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