A study on reaction kinetic of textile wastewaters degradation by $O_3/H_2O_2$

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**Abstract**

In this paper, a kinetic parameters of process $O_3/H_2O_2$ process for chemical oxygen demand, and color removal of textile wastewater were conducted. Parameter such as concentration of $H_2O_2$ was examined in the ozonation process. It was demonstrated that the chemical oxygen demand removal by $O_3/H_2O_2$ was about 44%, and color removal was 71%, respectively. On the other hand, the kinetic study shows that decomposition of chemical oxygen demand follows a first-order for processes. The rate of degradation is highly dependent on the initial concentration of initial concentration of $H_2O_2$. Maximum degradation rate was achieved for $O_3/H_2O_2$ at optimum concentrations of $H_2O_2$.

**Introduction**

Textile industry is one of the largest industries in various parts of the world. Water pollution by the cotton textile mills is the resulting combination of wastewater from various stages of production like desizing, scouring, bleaching, mercerizing, dyeing, and printing [1]. The colored wastewater discharged from a textile industry exhibits low biochemical oxygen demand (BOD), high values of chemical oxygen demand (COD), changeable pH, suspended solids, and organic chlorine compounds [2]. An important characterize of the textile mills is the use of different types of dye[3]. Thus, removal of color is the most difficult constituent of the textile wastewater [4]. Advanced oxidation processes (AOP) such as ozonation, UV and ozone/UV combined oxidation, Fenton reactive, and ultrasonic oxidation are based on the production of hydroxyl radicals as oxidizing agents to mineralize organic chemicals[5]. Using of ozone as pretreatment of textile wastewater in a pilot-scale plant was investigated by Somensi et al. ozonation was enhanced the biodegradability of textile wastewater (BOD5/COD ratios) by a factor of up to 6.8-fold[6]. Neamtu et al. examined the degradation kinetics of reactive azo dyes by the UV/H2O2. The pseudo-first order has been applied from the experimental data [7]. To date, various techniques, including biological processes, ozonation, ultraviolet UV/H2O2 oxidation, the Fenton processes, adsorption and have been reported to treatment of textile wastewaters [8-12]. Neamtu et al. was studied the kinetics of degradation of reactive azo dyes in aqueous solution by the UV/H2O2 process. The results showed that the maximum reaction rate constants was 0.1 min$^{-1}$ at a H2O2 dose of 24.5 mmol/l[7]. Also photochemical degradation of reactive azo dye with UV–H2O2 process studied by Muruganandham et al [13].

The aim of this study is to examine ozonation for reduction of color and COD textile wastewaster. The primary focus is to study the effect of, H2O2 concentration, and initial concentration of COD in ozonation system. In the literature, only a limited number of studies have so far been focused on the kinetic analysis of degradation textile wastewater so the experimental data were also analyzed using the first-order kinetic model.

**Materials and Methods**

**Material:**

The wastewater used for the laboratory-scale was obtained from the textile plant. The characteristics of the untreated wastewater are given in Table 1. The absorbance at specific wavelengths of the supernatants was concluded using ultra violet visible spectrophotometer, type UV-2100 UV/Vis Spectrophotometer.
Table 1: Characteristics of textile wastewater

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>Chemical oxygen demand (mgO₂ L⁻¹)</td>
<td>1650</td>
</tr>
<tr>
<td>Biochemical oxygen demand (mgO₂ L⁻¹)</td>
<td>390</td>
</tr>
<tr>
<td>BOD/COD</td>
<td>0.23</td>
</tr>
<tr>
<td>pH</td>
<td>11</td>
</tr>
<tr>
<td>Color (A₃₃₅)</td>
<td>0.81</td>
</tr>
</tbody>
</table>

Ozone reactor:

Fig. 1 schematically illustrates the ozone reactor system. In this system, the radiance intensity of 300 watt UV lamp can break the O₂ bond to produce O atoms, and meanwhile, by join up a free atom to another O₂ molecule, O₃ is produced.

In the O₃/H₂O₂ process, Hydrogen peroxide (H₂O₂, 33 %w/v, Fischer Scientific) was added to the reactor at the beginning of the reaction. The temperature was controlled and maintained at 30°C by running water through the reactor jacket. All the experiments were carried out with hydrogen peroxide concentrations 23.2 and 116.3 mM. The effect of initial concentration of H₂O₂ in the O₃/H₂O₂ process was investigated by studying the degradation at different solution initial concentration of H₂O₂ (0–116.3 mM) with an initial COD concentration of 1650 mg/l. The samples were collected at different time intervals and were analyzed for chemical oxygen demand (COD). Analytical procedures followed in this study for COD determinations were those outlined in standard methods for the examination of water and wastewater [8].

RESULTS AND DISCUSSION

Various procedures have been used to increase ozone decay and present high hydroxyl radicals concentrations. One of the most ordinary these processes complicates adding hydrogen peroxide to ozonated water, a process commonly indicated as peroxone. Using Process ozone-hydrogen peroxide, as well as an effective system for textile wastewater treatment is considered. COD removal efficiency in H₂O₂/O₃ oxidation experiments under different conditions are presented in Fig 2. The effect of H₂O₂ concentration on COD removal was examined by changing the H₂O₂ concentration between 23.2 and 116.3 mM. The increase on H₂O₂ concentration from 23.2 to 69.8 mM improved the removal of organic matter. However, the extended H₂O₂ concentration above 69.8 mM could not extended COD removal efficiency. The COD degradation decreased from 45 to 43% as the H₂O₂ dose increased from 69.8 to 116.3 mM. This is probably due to both the auto-decomposition of H₂O₂ into oxygen and water, and the scavenging of hydroxyl radicals by H₂O₂[15]. For the 69.8 mM of peroxide, 44% of COD and 71% of color was removed. It is reasonable, since as the concentration of H₂O₂ is increased, more hydroxyl radicals are available to attack the pollutant compounds and decolorization efficiency increases. Figure 3 and Table 2 show results curves of rate constant and results of color removal, respectively. K and R² calculated values are given in Table 3. As can be seen, the removal rate increased with increasing H₂O₂ concentration.

Fig. 2: Effect of concentration of H₂O₂(mM)
**Fig. 3:** Effect of initial H2O2 concentration on decomposition rate constant

**Table 2:** Color removal percent after (O3/H2O2) process (H2O2=69.7mM)

<table>
<thead>
<tr>
<th>Color removal (%)</th>
<th>Raw wastewater</th>
<th>After (O3/H2O2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>71</td>
<td>0.81</td>
<td>0.19</td>
</tr>
</tbody>
</table>

**Table 3:** K and R², after 60 min of starting the reaction (O3/H2O2)

<table>
<thead>
<tr>
<th>R²</th>
<th>K(1/min)</th>
<th>H2O2(mM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.991</td>
<td>0.0047</td>
<td>0</td>
</tr>
<tr>
<td>0.994</td>
<td>0.0065</td>
<td>23.2</td>
</tr>
<tr>
<td>0.991</td>
<td>0.0093</td>
<td>69.8</td>
</tr>
<tr>
<td>0.994</td>
<td>0.0082</td>
<td>116.3</td>
</tr>
</tbody>
</table>

**Conclusion:**

In this study, ozonation processes for the removal of dyes and organic load of textile effluent were examined. After 1 h of ozone/peroxide treatment wastewater, the average efficiencies for color and COD removal were 71% and 45%, respectively. The kinetic study shows that COD removal by advanced oxidation follows first-order models adequate to describe the kinetic of biodegradation process. It is clear that mineralization of the total organic content of the textile wastewater is not economical during ozonation in a pilot-scale, but partial oxidation altering the original product can have beneficial effects by reducing toxicity effects of wastewater, and enhancing the biodegradability of organic wastewater contents in a sequential microbiological treatment of textile wastewaters.

**REFERENCES**


