Photo-Bleaching of Amcot Red 3 Blf Using in Situ Chemical Oxidation by Fenton’s Reagent

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ABSTRACT

The oxidative decolourization of AMCOT Red 3BLF in aqueous medium has been studied using photo Fenton process. Fenton’s reagent (H₂O₂/Fe²⁺) was used to generated hydroxyl radical (OH). A visible light source was used to provide radiation for photo Fenton process. The experimental parameter such as pH, light, air, time and catalyst strongly influenced the dye removal rate in photo Fenton process. The result shows that the AMCOT Red 3BLF bleaches upto 70% within 4 hrs and degrades into CO₂ and H₂O. The proposed mechanism for the reaction of OH with AMCOT Red 3BLF dye molecules is summarized.

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Materials and methods

AMCOT RED 3BLF dye (Amrit Lal Chemoux Ltd.) Photocatalyst FeSO₄ (Merck) and H₂O₂ (6%) were used in the present investigation. For the photo bleaching process 5x10⁻³ M stock solution of AMCOT RED 3BLF dye was prepared in double distilled water and diluted as required. Stock solution of FeSO₄ (0.05M) was prepared and H₂O₂ (6%) in round bottom flask. Total volume of reaction mixture was made up to 100ml by adding double distilled water. AMCOT RED 3BLF dye solution containing catalyst was exposed to visible light from tungsten filament lamp (2x200W, Philips). Water cell of 15cm thickness was used to cutoff thermal radiations. The pH of solution was measured and maintained within a range of 3.0 to 6.5 by addition of previously prepared NaOH solution to pH 7. Air was continuously purged through the dye solution with help of aerator (Aqua air). The controlled experiments were performed in absence of (i) Light (ii) Air and (iii) Catalyst. Progress of Photobleaching reaction was observed at different time intervals by measuring absorbance using spectrophotometer (systronics model-112).

Result and Discussion

The photochemical degradation of AMCOT RED 3BLF dye was observed in the presence of air.

Figure 1. Variation of absorbance with time when air, light and catalyst are present.
catalyst and light at $\lambda_{\text{max}} = 500\text{nm}$. The results are depicted in table-1. The optical density decreases with increase in the time of exposure of radiation. The plot of optical density against time suggested that initially the rate of photobleaching is high and then reduced with time.

Table 1.

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>Absorbance in the presence of catalyst, air and light (nm)</th>
<th>Absorbance in absence of catalyst (nm)</th>
<th>Absorbance in absence of air (nm)</th>
<th>Absorbance in absence of light (nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>0.12</td>
<td>0.12</td>
<td>0.12</td>
<td>0.12</td>
</tr>
<tr>
<td>30</td>
<td>0.10</td>
<td>0.11</td>
<td>0.12</td>
<td>0.11</td>
</tr>
<tr>
<td>60</td>
<td>0.09</td>
<td>0.11</td>
<td>0.12</td>
<td>0.10</td>
</tr>
<tr>
<td>90</td>
<td>0.07</td>
<td>0.11</td>
<td>0.12</td>
<td>0.10</td>
</tr>
<tr>
<td>120</td>
<td>0.06</td>
<td>0.11</td>
<td>0.11</td>
<td>0.09</td>
</tr>
<tr>
<td>150</td>
<td>0.05</td>
<td>0.11</td>
<td>0.11</td>
<td>0.09</td>
</tr>
<tr>
<td>180</td>
<td>0.04</td>
<td>0.11</td>
<td>0.11</td>
<td>0.09</td>
</tr>
<tr>
<td>210</td>
<td>0.04</td>
<td>0.11</td>
<td>0.10</td>
<td>0.09</td>
</tr>
<tr>
<td>240</td>
<td>0.04</td>
<td>0.11</td>
<td>0.10</td>
<td>0.09</td>
</tr>
</tbody>
</table>

Figure 2. Variation of absorbance with time in absence of catalyst.

The absorbance of solution is almost same for all time intervals. This was confirmed that photobleaching is negligible in absence of Fenton’s reagent. Hence presence of Fenton’s reagent is necessary for photobleaching of dye solution.

Photobleaching in absence of air: - The process of photobleaching of dye has been studied in absence of air and results were depicted in table-1 and figure-3.

Figure 3. Variation of absorbance with time in absence of air.

The plot shows that the absorbance at all time intervals are almost equal and suggested that air is one of the necessary conditions for photobleaching.

Photobleaching in absence of light: - A very minute and irregular decreases in absorbance with time in absence of light (table-1 and figure-4) are suggested that the light is one of the necessary condition for photobleaching of dye solution.

Figure 4. Variation of absorbance with time in absence of light.

Mechanism

The “Photo Fenton” reagent has been found to act as an antioxidant. Ferrous ions ($\text{Fe}^{2+}$) of Photo Fenton reagent are react with hydrogen peroxide to form $\text{Fe}^{3+}$ ions, a hydroxyl radical and a hydroxide anion. The hydroxyl radical react with substrate to give the product. This can be shown in figure 5.

Figure 5. Schematic representation of Fenton’s reaction.

\[
\begin{align*}
\text{Fe}^{3+} + \text{H}_2\text{O}_2 + h\nu & \rightarrow \text{Fe}^{2+} + \text{OH}^+ + \text{H}^+ \\
\text{Fe}^{3+} + \text{H}_2\text{O}_2 + h\nu & \rightarrow \text{Fe}^{2+} + \text{O}_2\text{H} + \text{H}^+ \\
\text{Fe}^{2+} + \text{H}_2\text{O}_2 & \rightarrow \text{Fe}^{3+} + \text{OH}^+ + \text{OH}^- \\
\text{OH} + \text{H}_2\text{O}_2 & \rightarrow \text{H}_2\text{O} + \text{O}_2\text{H} \\
\text{Fe}^{2+} + \text{OH} & \rightarrow \text{Fe}^{3+} + \text{HO}^- \\
\text{Fe}^{3+} + \text{O}_2\text{H} & \rightarrow \text{Fe}^{2+} + \text{O}_2 + \text{H}^+ \\
2\text{OH} & \rightarrow \text{H}_2\text{O}_2 \\
\text{Amcot Red 3BLF} + \text{OH} & \rightarrow \text{Products}
\end{align*}
\]

Conclusion

Photo Fenton’s can decolorize the effluent water from industries. Photo bleaching of Amcot Red 3 BLF dye occurred gradually with time and it was bleach upto 70% within 4 hrs. Thus Photo Fenton’s reagent can be used as a cost effective and eco-friendly potential chemical oxidant for the treatment of waste water of dyeing, printing and textile industries.
References