Photodegradation of Methylene Blue (MB) in presence of Strontium Chromate

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ABSTRACT

The textile industries produce wastewater containing toxic synthetic organic compounds like dyes. There were photocatalyst SrCrO₄ used for photodegradation of dye Methylene Blue in aqueous media under visible light. The effect of different parameter’s such as Hydrogen ion concentration, concentration of Dye solution, catalyst loading also studied. Degradation has been determined by spectrophotometer at 695 nm. A tentative mechanism also has been proposed for the photo catalytic degradation of Dye.

Key words: Methylene Blue, Strontium Chromate, Photo catalysis and Photo degradation.

Introduction

Water is an important compound of oxygen and hydrogen for life. The air, water and soil are the main elements of our environment (Obafemi, 2012). A wide variety of organic compounds like dyes harmful compounds introduced into the water resourced from industries and water gets polluted. The textile industry usually produce a large amount of wastewater which contains many type of pathogens, oxygen-demanding substances and inorganic and synthetic organic chemicals (Kumar, 2017). Dyes in water give out a bad odour and can cause diseases like haemorrhage, ulceration of skin, nausea, severe irritation of skin and dermatitis (Nese, 2007). Industrial wastewater used to irrigation can reduce the quality of the crop and make fruits toxic (Aulakh, 2009). Textile dyestuff are found to contain a large amount of organic substances which are difficult to degrade. They are also found to be reduced into carcinogenic agent (Jain, 2003). So, the treatment of dye- polluted effluents is considered to be one of the most challenging task among the environment community.

Many techniques have been investigated for dye degradation such as filtration process (Abid, 2012), absorption (Ashraf, 2013), coagulation and biodegradation methods (Birmole, 2014). Some of dyes cannot degraded into minerals by normal methods, so to decompose toxic compound into harmless minerals need an alternative treatment methods. Advance Oxidation Process have proved innovative, cost effective, catalysed

Textile Disperse dye Coralene Dark Red 2B was treated by photocatalyst CeFeO₃ in visible light to decompose into harmless product. The whole experiment was observed spectrophotometrically (Pamecha, 2016).

In the presence visible light, Composite Sr₂TiO₄ / Sr₂TiO₃ (La, Cr) heterojunction based photocatalyst has been used for hydrogen production (Jia, 2013). Azure- B was degraded by Nano sized photo calyst BaO₂TiO₃SrO₂Tio through ecofriendly process (Bhardwaj, 2013).

Under visible light photo degradation of Methylene Blue dye in presence of Ca In₂O₄ photocatalyst.
The resultant \( \text{SO}_4^{2-} \) concentration was shown as a product of MB degradation (Tang, 2003). Degradation of Methylene Blue by \( \text{TiO}_2/ \) UV in aqueous heterogeneous suspension was investigated and through this process almost complete mineralization occurs (Houas, 2001).

**Materials and Method**

In this work Methylene Blue (Molecular Formula is \( \text{C}_{16}\text{H}_{18}\text{ClN}_3\text{S} \), Molecular Weight is 319.85) was used. It was procured from textile industry Bhliwara (Raj). The photocatalyst Strontium Chromate was obtained from CDH. All laboratory reagents were of analytical grade.

The chemical structure of MB is presented below:

![Chemical structure of MB](image)

**Experimental Procedure**

For the preparation of stock solution, 0.320g dye Methylene Blue was dissolved in one litre of double distilled water. Therefore, the concentration of stock solution was \( 1 \times 10^{-3} \) M. This solution was further diluted according to requirement. The maximum absorbance of dye solution was recorded at 695nm by spectrophotometer. Control experiments confirm the necessity of light and presence of photocatalyst strontium chromate for degradation of dye Methylene Blue.

Strontium chromate (0.25g) and dye solution (3.5ml) were combined in a round bottom flask to make the reaction mixture. Adding double distilled water to the reaction mixture resulted in a volume of 100 mL. Reaction mixture was treated by visible light radiation with light source (2× 200 W tungsten lamp). Water filter is used for reduce the thermal radiation. Reaction was controlled by pH, dye concentration and amount of catalyst. The pH of mixture was measures by pH meter and control by the addition of sulphuric acid & sodium hydroxide solution. The progress of degradation was observed by spectrophotometrically (695nm) at definite time interval.

**Results and Discussion**

The photo-catalytic degradation of Methylene Blue was observed at 695nm. The most favourable conditions for the photooxidation of dye were concentration of dye = \( 3.5 \times 10^{-5} \) M, hydrogen ion concentration= 11.0, amount of catalyst = 0.25g / 100 ml dye solution. The result of photodegradation of Methylene Blue is graphically presented in Fig. 2.

<table>
<thead>
<tr>
<th>Time</th>
<th>Abs</th>
<th>1+ log abs</th>
</tr>
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<tbody>
<tr>
<td>0</td>
<td>0.527</td>
<td>0.7218</td>
</tr>
<tr>
<td>10</td>
<td>0.471</td>
<td>0.673</td>
</tr>
<tr>
<td>20</td>
<td>0.401</td>
<td>0.603</td>
</tr>
<tr>
<td>30</td>
<td>0.356</td>
<td>0.551</td>
</tr>
<tr>
<td>40</td>
<td>0.295</td>
<td>0.469</td>
</tr>
<tr>
<td>50</td>
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<tr>
<td>60</td>
<td>0.202</td>
<td>0.305</td>
</tr>
<tr>
<td>70</td>
<td>0.181</td>
<td>0.257</td>
</tr>
<tr>
<td>80</td>
<td>0.163</td>
<td>0.212</td>
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<tr>
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<td>0.133</td>
<td>0.123</td>
</tr>
<tr>
<td>100</td>
<td>0.117</td>
<td>0.068</td>
</tr>
</tbody>
</table>

A plot of 1+logA versus time was linear, showing kinetics of first order.

\[
 k = 2.303 \times \text{Slop.} \\
 k = 1.51 \times 10^{-4} \text{ sec}^{-1}
\]

**Effect of parameter’s**

**Effect of changes in pH of reaction mixture**

We looked at the impact of pH on the bleaching rate of dye solution in a pH range (5-13). Figure 4.5.3 illustrates the findings. pH 11.0 was demonstrated to be the ideal pH for photocatalytic corruption of
Methylene Blue. The pace of reaction decreases as pH rises and falls.

**Effect of changes in dye concentration**

As long as all other parameters are constant, the influence of dye concentration on photodegradation has been reported in the range of $1.5 \times 10^{-5}$ to $7.5 \times 10^{-5}$ M for SrCrO$_4$. Figure 4.5.4 shows the findings. For Strontium Chromate, the degradation of dye has been reported to rise with increasing dye concentrations up to $3.5 \times 10^{-5}$ M. The catalyst surface becomes saturated when the dye concentration was increased. As a result, dyes with a high degree of saturation block the passage of light to the photocatalyst. Consequently, the rate of decomposition drops. Dye molecules cling to the catalyst’s surface, causing it to degrade.

**Effect of changes in amount of Catalyst**

Methylene Blue photo bleaching is studied by altering the quantity of Strontium Chromate from 0.05 g/100ml to 0.40 g/100 ml, and it has been shown that the degradation rate rises to 0.25 g/100 ml for the SrCrO$_4$ photocatalyst while all other parameters remain constant. In Fig.4.5.5, you can see the findings. The pace of reaction then stabilizes or declines as the quantity of catalyst increases. Increasing the quantity of catalyst on the catalyst’s surface area will lead to an expansion in its number of dynamic destinations. After a certain amount of catalyst (0.25g /100mL) dye particles are unavailable for adsorption so, rate of degradation decrease.

**Photooxidation Product of Methylene Blue**

Under a visible light source, the reaction mixture comprising $3.5 \times 10^{-5}$M Methylene Blue and 0.25g/100ml catalyst SrCrO$_4$ was irradiated. 11.0 was the pH of the reaction mixture. The absorption band at 478 nm ($\lambda_{\text{max}}$) in UV-Vis region also absent. Two-propanol, a powerful radical scavenger, verified the presence of OH$^-$. Adding 2-propanol to the mix significantly decreased the pace of reaction. OH$^-$ radical oxidized dye. The photodegradation yield further oxidized by OH$^-$ radical and form carbon dioxide, water, nitrate ion and nitrite ions. As a result, the colour has been completely mineralized. The final result is a harmless molecule or ion that does not affect the environment. The existence of harmless end product was done by some chemical experiments.

**Mechanism:** A tentative mechanism has been proposed for degradation of Methylene Blue on the ba-
sis of the experimental observation in the presence of SrCrO$_4$.

Dye absorbs visible light radiation of suitable wavelength and convert singlet to triplet excited state through Inter System Crossing.

\[
\begin{align*}
\text{Dye}^0 & \rightarrow \text{Dye}^1 \\
\text{Dye}^1 & \rightarrow \text{Dye}^1
\end{align*}
\]

The catalyst also absorbs the radiation with energy equal to band gape or more than of catalyst. Electron moved from valance band to conduction band of catalyst. Thus a hole (h$^+$) is generated in valance band. Dissolved oxygen grabbed the electron from conduction band to creat O$_2^-$ radical and Hole react with OH and form OH radical.

\[
\begin{align*}
\text{SrCrO}_4 & \rightarrow \text{SrCrO}_4^* \\
h^+ (\text{VB}) & + e^- (\text{CB}) \\
\text{O}_2 & + e^- (\text{CB}) \\
\text{O}_2^- & + \text{H}_2\text{O} \\
\text{h}^+ & + \text{OH}^- \\
\text{h}^+ & + \text{H}_2\text{O} \\
\text{OH} & , \text{O}_2^- \text{are strong oxidant and these species are oxidized dye molecules.}
\end{align*}
\]

**Conclusion**

Strontium Chromate used as a photocatalyst for degradation of dye Methylene Blue. Hydrogen ion concentration, concentration of Dye and amount of catalyst effects the photodegradation of MB. It was concluded favourable condition for photodegradation is at pH 11.0, 0.25g SrCrO$_4$/100mL, 3.5 X 10$^{-5}$M dye concentration. It may be explored for water treatment of industrial effluents in future.

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**References**


