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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 $SrCrO_4$ used for photodegradation of dye Methylene Bluein 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 catalaytic 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 $CeFeO_3$ in visible light to decompose into harmless product. The whole experiment was observed spectrophoto metrically (Pamecha, 2016).

In the presence visible light, Composite Sr_2TiO_4 / Sr_2TiO_3 (La, Cr) heterojunction based photocatalyst has been used for hydrogen production (Jia, 2013). Azure- B was degraded by Nano sized photo calatyst $BaO_3TiO.SrO_3Tio$ through ecofriendly process (Bhardwaj, 2013).

Under visible light photo degradation of Methylene Blue dye in presence of Ca In_2O_4 photocatalyst.

The resultant SO_4^{-2} concentration was shown as a product of MB degradation (Tang, 2003). Degradation of Methylene Blue by 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 $C_{16}H_{18}ClN_3S$, 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-

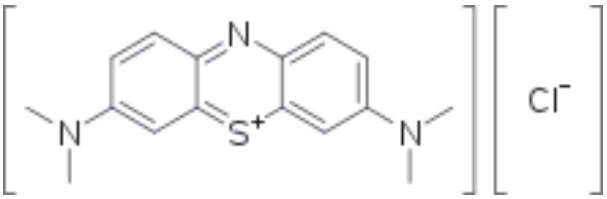

Fig. 1. Chemical structure of MB

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 1×10^{-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 = 3.5×10^{-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 1. A typical run of photocatalytic degradation of Methylene Blue

Time	Abs	1+ log abs
0	0.527	0.7218
10	0.471	0.673
20	0.401	0.603
30	0.356	0.551
40	0.295	0.469
50	0.241	0.382
60	0.202	0.305
70	0.181	0.257
80	0.163	0.212
90	0.133	0.123
100	0.117	0.068

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

k = 2.303 X Slop.

k = 1.51 X 10^{-4} 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

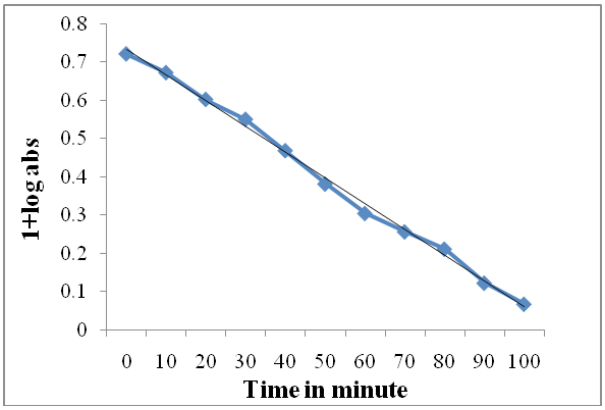

Fig. 2. A sketch between time and log abs +1 of Methylene Blue photocatalytic degradation.

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 1.5×10^{-5} to 7.5×10^{-5} M for $SrCrO_4$. Figure 4.5.4 shows the findings. For Strontuim Chromate, the degradation of dye has been reported to rise with increasing dye concentrations up to 3.5×10^{-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.

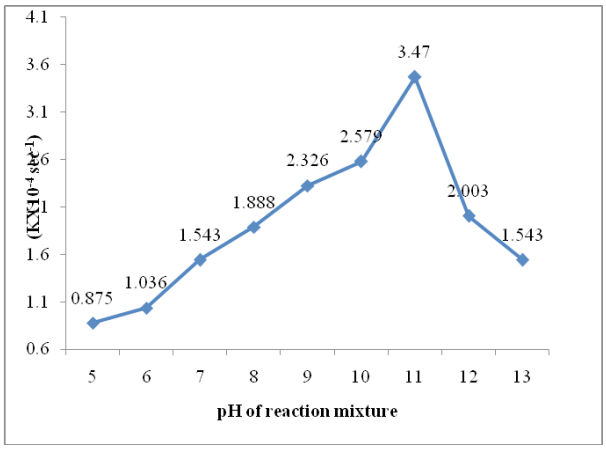

Fig. 3. A graph showing impact of the hydrogen ion concentration on degradation of Methylene Blue.

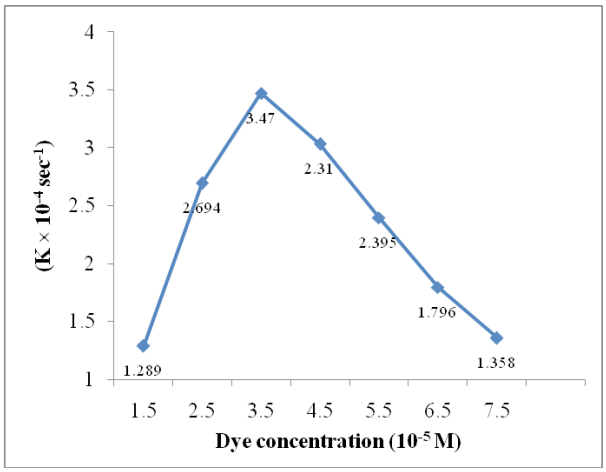

Fig. 4. A graph illustrating the impact of dye concentration change on dye decolorization rate.

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 3.5×10^{-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 (λmax) 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 Blueon the ba-

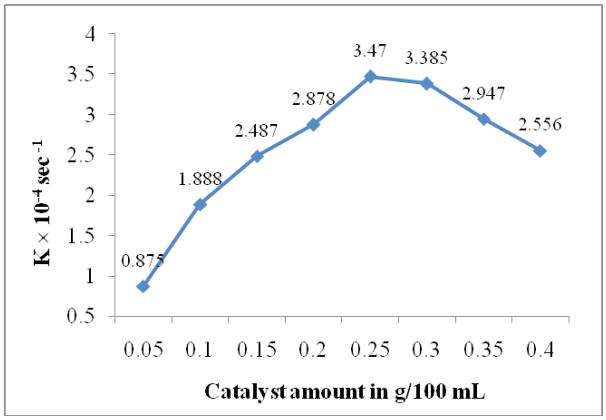

Fig. 5. A graph illustrating the impact of catalyst quantity variation on dye decolourization rate.

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.

$$_1Dye^0 \longrightarrow {}_1Dye^1$$
$$_1Dye^1 \longrightarrow {}_3Dye^1$$

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 generatedin valance band. Dissolved oxygen grabbed the electron from conduction band to creat O_2^{-} radical and Hole react with OH^- and form $OH^{\cdot}$Radical.

$$SrCrO_4 SrCrO_4^* \longrightarrow h^+ (VB) + e^- (CB)$$
$$O_2 + e^-(CB) \longrightarrow O_2^{\cdot -}$$
(Dissolved oxygen)
$$h^+ + OH^- \longrightarrow OH^{\cdot}$$
$$h^+ + H_2O \longrightarrow OH^{\cdot} + H^+$$
$$_3Dye^1 + \text{radical} \longrightarrow \textbf{colourless end product}$$

$OH^{\cdot}$, O^{2-} are strong oxidant and these species are oxidized dye molecules.

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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