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Photocatalytic Degradation of Dye Disperse Blue 94 by Strontium Chromate

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Abstract –

In the present study the photocatalytic degradation of dye was studied in presence of semiconductor $SrCrO_4$. The progress of reaction was observed spectrophotometrically at 630nm. The effect of various parameters such as catalyst loading, pH, initial concentration of Dye on discoloration and degradation have been determined. A tentative mechanism has also been proposed for the photocatalytic degradation of dye.

Key words- Disperse Blue94, Strontium chromate, photocatalytic Degradation.

Introduction-

Water pollution is a major problem for world. Industrial effluents are the main cause of water pollution. Waste water from the textile industry have a major threat to the surrounding ecosystem. It may cause of cancer. Dye effluents even at low concentration can change the color of water. Disperse blue 94 dye is one of the most colorants applicable in the textile industry and can be used in different processes such as nylon, polyester and acrylic fiber.

Advanced oxidation process have been successfully applied for treatment of polluted water received from textile industries. (1)

Dyes are basically classified according to process of dyeing. Generally dyes are divided into Acid dyes, reactive dyes and disperse dyes. Reactive and acid dyes are water soluble but disperse dyes are partially soluble in water and used for polyester fiber. In disperse dyes azo group (N=N) attached to two substituents. (2) Azo dyes are inactive towards aerobic degradation; however, under anaerobic condition, the azo linkage is breakdown into aromatic amines that are colorless but can also toxic. (3)

The Photocatalytic degradation of dye Disperse blue 1 has been investigated under UV light irradiation in the presence of TiO_2 and H_2O_2 under a variety of condition and the photocatalyst Degussa P25 was found to be more efficient for the degradation of dye. (4)

The coupling process of electrocoagulation process with ultrasound has been found useful for water and wastewater treatment in recent years. Under the optimum condition, the color and COD removal efficiencies for an aqueous solution of 100mg L-1 reached 100% for Disperse blue 60. (5)

Biodegradation and Discoloration of Disperse blue -284 by Klebsiella pneumoniae GM-04 and results of this Bio-remedial method was 95% discoloration of DB284(200ppm) within 24hrs.(6)

Photocatalytic degradation of Textile Disperse dye Coralene Dark Red 2B was done by H_2O_2 /TiO_2 in solar light various parameters were used to observe the rate of degradation and HPTLC method developed to check the complete degradation and end products obtained after degradation. (7) Photocatalytic degradation of Textile Disperse dye Coralene Dark Red 2B was also done by $CeFeO_3$ in visible light and observed spectrophotometrically. (8)

Photodegradation by composite Sr_2TiO_4/Sr_2TiO_3 (La, Cr) heterojunction based photocatalyst for H_2O_2 under visible light irradiation investigated. (9) Nano sized photocalatyst $BaO_3TiO.SrO_3Tio$ for degradation of Azure-B and ecofriendly process .(10)

MATERIALS AND METODS

For the present photocatalytic degradation studies Disperse blue 94 was used. It was Procured from Sanwariya processors private limited Bhliwara (Raj). The photocatalyst Strontium chromate was obtained from CDH. All laboratory reagents were of analytical grade.

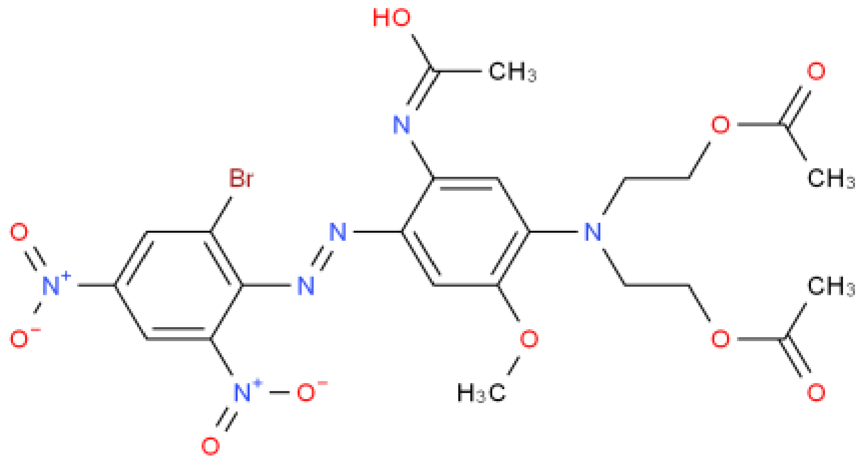

Fig: 1 Structure of Disperse blue 94(Molecular formula of DB94 is $C_{20}H_{20}BrN_7O_7$)

Experimental Procedure: -

The photocatalytic activity of photocatalyst SrCrO4 was studied for degradation of Disperse blue 94 at different pH level, catalyst loading and dye concentration. 1×10^{-3} M dye solution was prepared by dissolving 550.32g of dye in 1000 ml of distilled water. The initial absorbance of dye solution was observed with the help of Spectrophotometer (Systronics spectrophotometer 106). The maximum absorbance value was recorded at 630nm (λmax). The reaction mixture was prepared by taking 3 ml of dye solution ($1x10^{-3}$ M), 0.20g of Strontium Chromate in a round bottom flask. The total volume of the reaction mixture was 100 ml by adding double distilled water. The concentration of dye in the reaction mixture was $3x10^{-5}$M. To carry out the photooxidation, the reaction mixture was irradiated under light source (2 x 200 W Tungsten lamps). Water filters were used to prevent thermal radiation. The concentration of hydrogen ion of the solution was measured by pH meter (Systronics 106). The desired pH of the solution was adjusted by the addition of standard 0.1N Sulphuric Acid and 0.1N Sodium hydroxide solutions. The progress of the reaction was observed at definite time (15min) intervals by measuring absorbance at 630nm (λmax).

Result and Discussion: -

The photo-catalytic degradation of Disperse blue 94 was observed at 630 nm. The optimum conditions for the photooxidation of dye were [Dye] = 3×10^{-5} M, pH= 7.0, amount of catalyst = 0.25g /100ml dye solution. The result of photodegradation of Disperse blue 94 is graphically presented in Fig.2

Time	Abs	1+ log abs
0	0.626	0.796
15	0.558	0.746
30	0.479	0.680
45	0.402	0.604
60	0.343	0.535
75	0.299	0.475
90	0.262	0.418
105	0.225	0.352
120	0.207	0.316
135	0.198	0.296
150	0.189	0.276

Table 1: A typical run of photocataytic degradation of Disperse blue 94

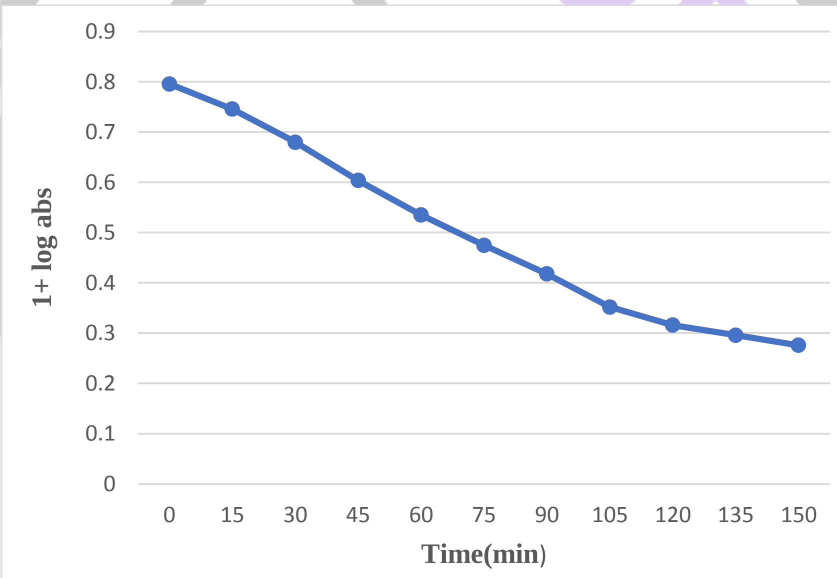

Fig 2: Plot of 1 + log abs verses time for a typical run

A plot of 1+logA versus time was linear following first order kinetics. The rate constant was calculated by using the expression-

k = 2.303 X Slop.

k = 7.65 X 10-5 sec- 1

Effect of parameter's: -

Effect of pH variation: -

The effect of pH range 4.0-9.0 Strontium Chromate, respectively. All other parameters were being constant. The results are given in Fig 3. At pH 7.0 rate of Degradation was maximum.

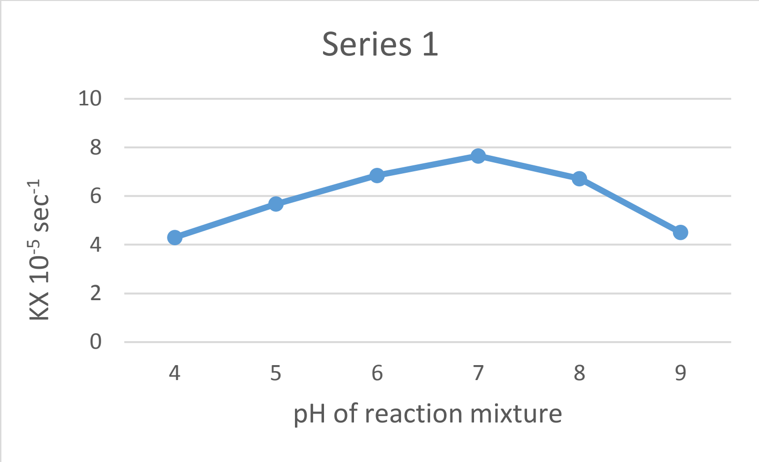

Fig 3: - A plot showing effect of variation in hydrogen ion concentration on the rate of decolorization of the dye.

Effect of variation in dye concentration: - The effect of variation of concentration of dye on its photodegradation has been observed in the range from 1.0 X 10^{-5} to 5 X 10^{-5} M for $SrCrO_4$ keeping all other parameter's to be the same. The results are given in Fig.4. It has been observed that the of degradation increases with increasing concentration of dye up to 3 X 10^{-5} M for Strontuim Chromate. Then further increasing the concentration of dye catalyst surface gets saturated. That is why intense colour of dye does not permit light to reach photocatalyst. As a result, rate of degradation decrease. Dye molecules adsorb on catalyst surface and degradation occurs.

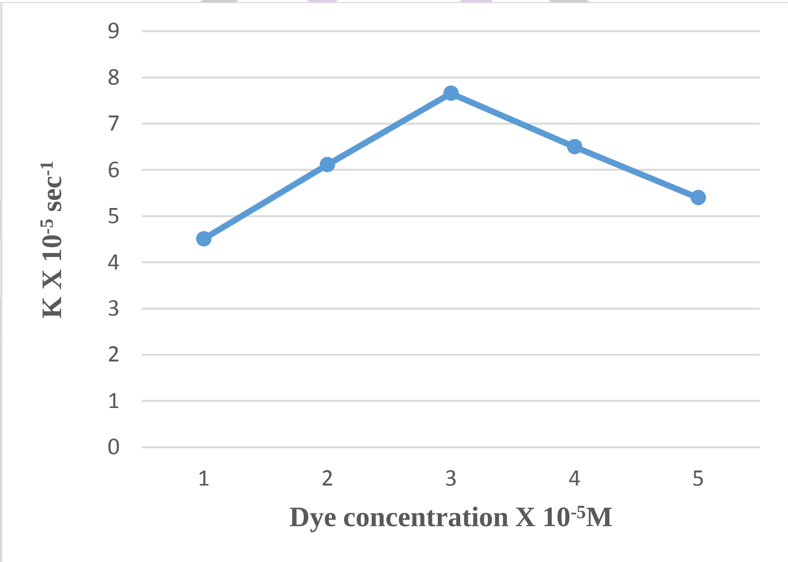

Fig 4: - A plot showing effect of variation in dye concentration on the rate of decolorization of the dye.

Effect of variation in Catalyst concentration: - The effect of amount of photocatalyst on the photo bleaching of Disperse blue 94 was monitored by varying amount of Strontium Chromate from 0.05g to 0.40g / 100mL keeping all other factors identical, it has been observed that with an increase in the amount of catalyst, the rate of degradation increases to 0.25g / 100mL for $SrCrO_4$. The results are given in Fig.5. Then after increase in the amount of catalyst the rate of reaction becomes almost constant or decreases. This behaviour may be explained by the fact that with an increase the amount of catalyst the active sites on surface area of catalyst will increases. After a certain level of catalyst (0.25g / 100mL) rate of reaction decrease because substrate dye molecules are not available for adsorption on active sites of semiconductor.

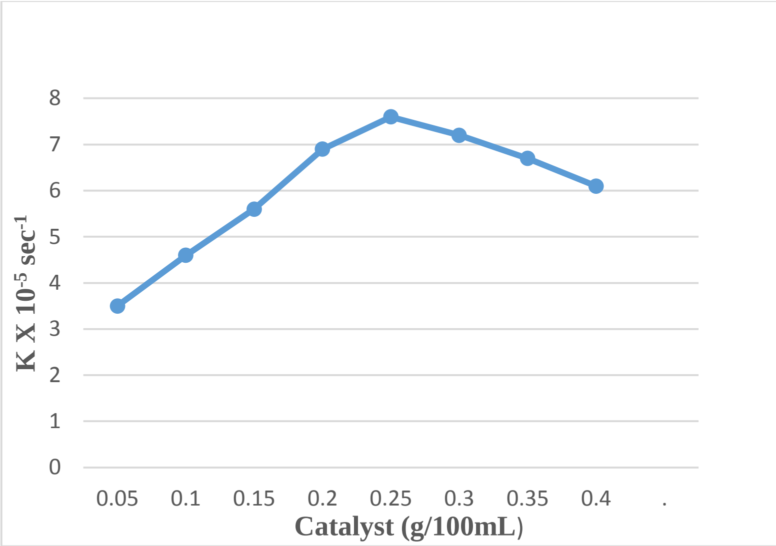

Fig 5: - A plot showing effect of variation in amount catalyst on the rate of decolourization of the dye.

Mechanism: - Based on the experimental observation a tentative mechanism has been proposed for degradation of Disperse blue 94 in the presence of SrCrO4.
Dye absorbs visible light radiation of suitable wavelength and convert singlet to triplet excited state through Inter System Crossing.

$_{1}Dye^{0} \longrightarrow {}_{1}Dye^{1}$

$_{1}Dye^{1} \longrightarrow {}_{3}Dye^{1}$

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 generated in valance band. Electron from conduction band will be abstracted by dissolved oxygen to generate $O_2^{\cdot -}$ radical. Holes react with OH- and form OH. Radical.

$SrCrO_4 \longrightarrow SrCrO_4{}^{*}$
$h^{+} (VB) + e^{-} (CB)$

$O_2 + e^{-} (CB) \longrightarrow O_2^{\cdot -}$
(Dissolved oxygen)

$h^{+} + OH^{-} \longrightarrow OH^{\cdot}$
$h^{+} + H_2O \longrightarrow OH^{\cdot} + H^{+}$

$OH^{\cdot}$, $O_2^{\cdot -}$ are strong oxidizing species and react with dye molecule to oxidize them.

$_{3}Dye^{1}$ + radical $\longrightarrow$ colourless product

Conclusion: Strontium Chromate used as a photocatalyst for degradation of dye Disperse blue94. The experimental results indicated that photodegradation of DB94 was affected by pH, concentration of Dye, amount of catalyst. It was observed optimum condition for photodegradation is at pH 7.0, 0.25g $SrCrO_4$/100mL, 3 X 10^{-5}M dye concentration. It may be explored for water treatment of industrial effluents in future.

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