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Research Article

Photocatalytic degradation of Disperse Blue 73 dye by photo-Fenton process

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Abstract

Photocatalytic bleaching using AOPs is a field of interest for the researchers as it offers an interesting approach for colour removal and reduction to simple inorganic compounds. It was found that treatment with Fenton Reagent was also effective for the colour removal and convert into smaller pollutants. Photocatalytic degradation of Disperse Blue 73 was studied in detail using H_2O_2/Fe^{3+}. The experimental results showed that photocatalytic degradation depends on the dye concentration, catalyst concentration, H_2O_2 concentration, pH and light intensity. Photodegradation optimized for these parameters. This photodegradation follows pseudo first order kinetics. Experimental results show effectiveness of photo catalytical degradation of DB 73 using Fenton system.

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KEYWORDS: Disperse Blue 73, photo-Fenton, Photodegradation, Bleaching, Advance oxidation process.

INTRODUCTION

Water pollutants of industrial and domestic waste is big issue for both developed and developing nations. These nations are dealing with issues like organic water contamination, heavy metals, biological contamination, and intensive nutrients. Phenols, dioxins, pesticides, fertilizers, and detergents are usually non-biodegradable or persistent which effect the environment severely [1]. Among the various sections, the effluents from pulp bleaching are responsible for most of the colour, organic matter, and toxicity of the water discharges of this industry [2, 3]. Certain industrial wastewaters have been found to be effectively treated by solar photo-catalysis. Advanced oxidation process (AOP) employs strong oxidants of $H_2O_2$and ozone to degrade organic carbon, especially under the promotion of photo irradiation, catalyst addition (TiO_2, Fe (II), and Fe (III)), thermal input, and ultrasound penetration [4,5]

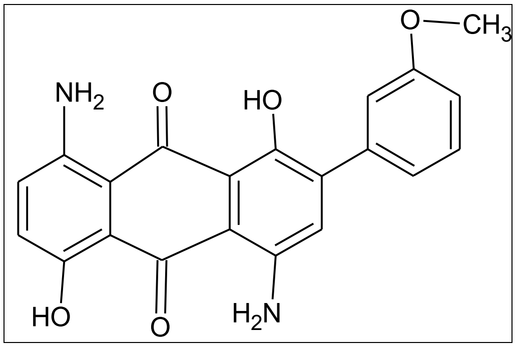

Fig 1: The structure of Disperse Blue 73

Molecular Formula $C_{21}H_{16}N_2O_5$ and Molecular Weight 376.36 g

It is an anthraquinone dyeand has C.I. number 63265. It is used for polyamide fibre and polyester dyeing and also used for the polyester/cotton blended fabric printing. The direct release of wastewater containingDisperse Blue 73causes serious environmental problems due to its dark color and toxicity.

Experimental

In this study Disperse Blue 73 (ATUL Limited,Valsad), anhydrous FeCl3(SDFCL) and H_2O_2 (30% v/v, SDFCL) was employed. Photochemical degradation of Disperse Blue 73was investigated using Fe3+ ion as a catalyst, $H_2O_2$and visible light. A stock solution of Disperse Blue 73 and ferric ion was prepared in demineralised water. For photobleaching of dye diluted solution of stock solution is used. Measurement of pH done using pH meter and absorbance was measured using spectrophotometer.

Results and Discussion

Control experiments (without photocatalyst and light) verified that photocatalyst with light alone are needed in order to follow the photocatalytic pathway for dye photobleaching. We observed that Blue 73 dispersed at its λmax = 564 nm and underwent photochemical degradation. Table 1 as well as Figure 2 do provide results for a typical run. Solution optical density (OD) diminishes as irradiation time increases. This suggests that Disperse Blue 73 is degraded with photolight, and the plot of absorbance versus time was linear.

Effect of pH

Photobleaching of dye depend on pH value; therefore, the photodegradation experiment was conducted with a range of pH values from 2.0 to 4.8 (Figure 3). The results showed that the rates of photobleaching of Dye Disperse Blue 73 increase as the pH increases up to 2.8, and decrease as the pH increases above 2.8. The optimum pH 2.8 was set for bleaching of dye.

Effect of Dye (Disperse Blue 73) Concentration

The rate of photochemical degradation increased with increasing concentrations of Disperse Blue 73 up to 6.0×10^{-5} M (Figure 4), and then decreased at higher concentrations, perhaps because more molecules of Disperse Blue 73 are present for degradation or because an excess of Disperse Blue 73 may serve as a filter that reduces the amount of light incident on the dye molecule in solution.

Effect of Ferric Ion Concentration

With all other variables being held constant, the effect of varying catalyst concentration was studied by changing the amount of catalyst present in the reaction mixture to observe how it affects the photochemical degradation rate. Figure 5 shows that the photobleaching dye rate increases as Fe^{+3} ions increase up to 3.71×10^{-4} M. This concentration of ferric ion was set as optimum value for bleaching of dye.

Effect of H_2O_2 Concentration

As shown in Figure 6, the rate of photobleaching of dye increases with increasing concentration of H_2O_2upto a maximum at about 2.5 mL, and then remains unchanged as more H_2O_2 is added . 2.5 mL was set as optimum value for bleaching of dye.

Effect of Light Intensity

Figure 7 illustrates how the rate constant changed linearly with light intensity, meaning that a decrease in light intensity results in a slower rate of reaction. This could be because every photon interacts with Fe3+ ions, and as the number of photons rises, the rate of reaction rises as well because there are more hydroxyl radicals.

[Disperse Blue 73] = 6.0×10^{-5} M H_2O_2 = 2.5 mL [Fe^{+3}] = 3.71×10^{-4} M

Light intensity = 80.0 mW cm^{-2} pH =2.8

Table 1: A Typical Run

Time (min.)	Optical Density (O. D.)	2 + log O. D.
0	0.828	1.918
5	0.673	1.828
10	0.547	1.738
15	0.444	1.648
20	0.361	1.558
25	0.294	1.468
30	0.238	1.378

k = 6.909×10^{-4} s^{-1}

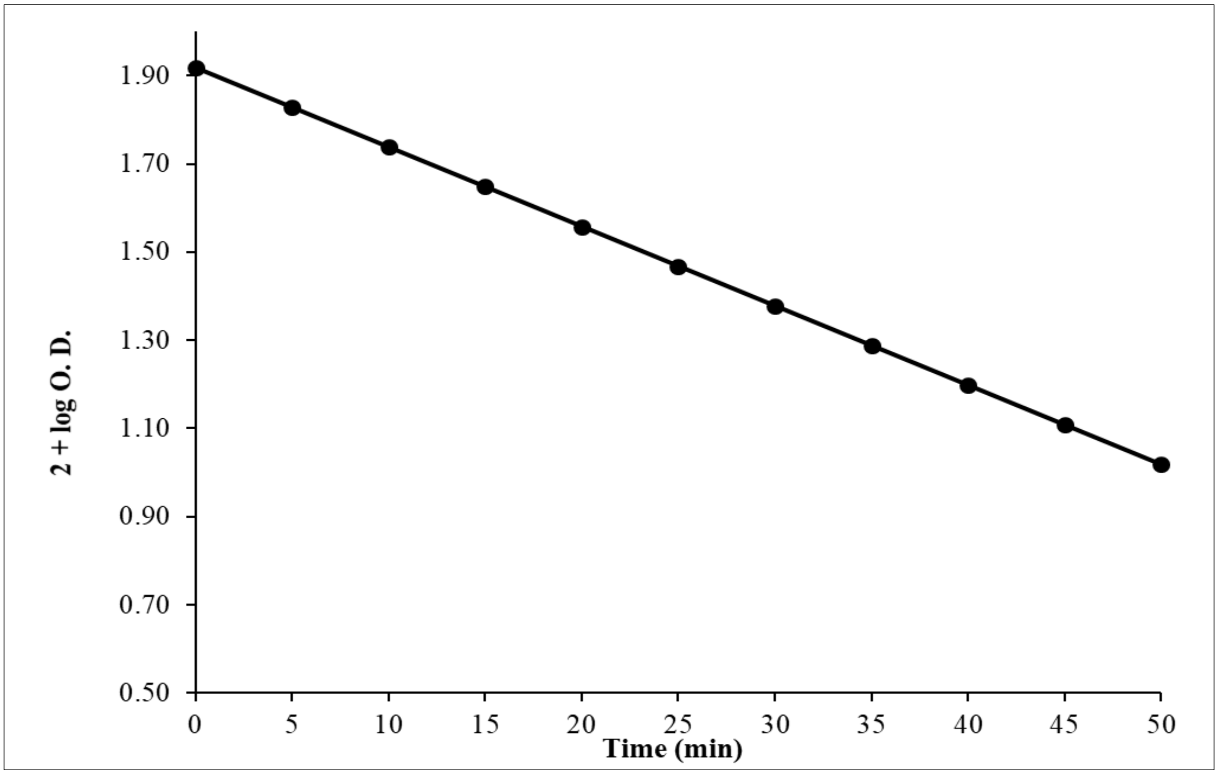

Fig 2: A typical photochemical degradation of Disperse Blue 73 at λmax= 564 nm under the optimized condition of [Disperse Blue 73] = 6.0 × 10^{-5} M, H_2O_2 = 2.5 mL, [Fe^{+3}] = 3.71 × 10^{-4} M, Light intensity = 80.0 mW cm^{-2} and pH =2.8

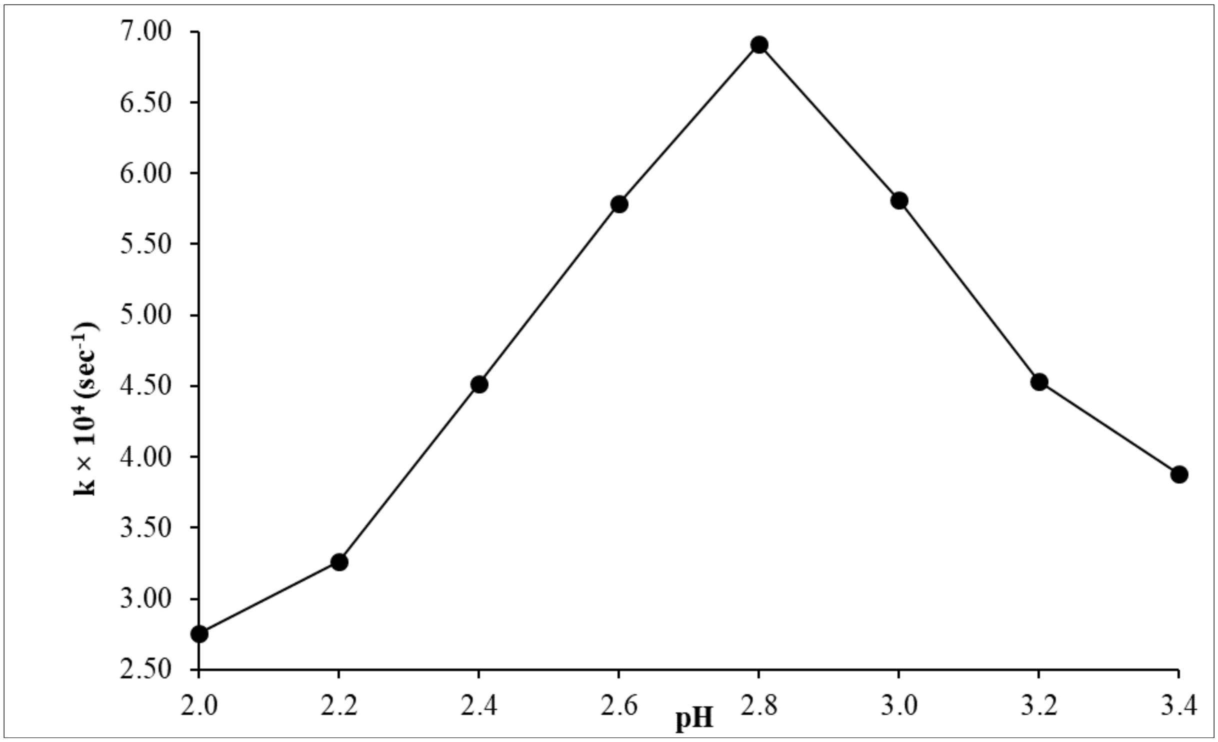

Fig 3: Effect of pH on photobleachimg of Disperse Blue 73 at λmax = 564 nm under the optimized condition.

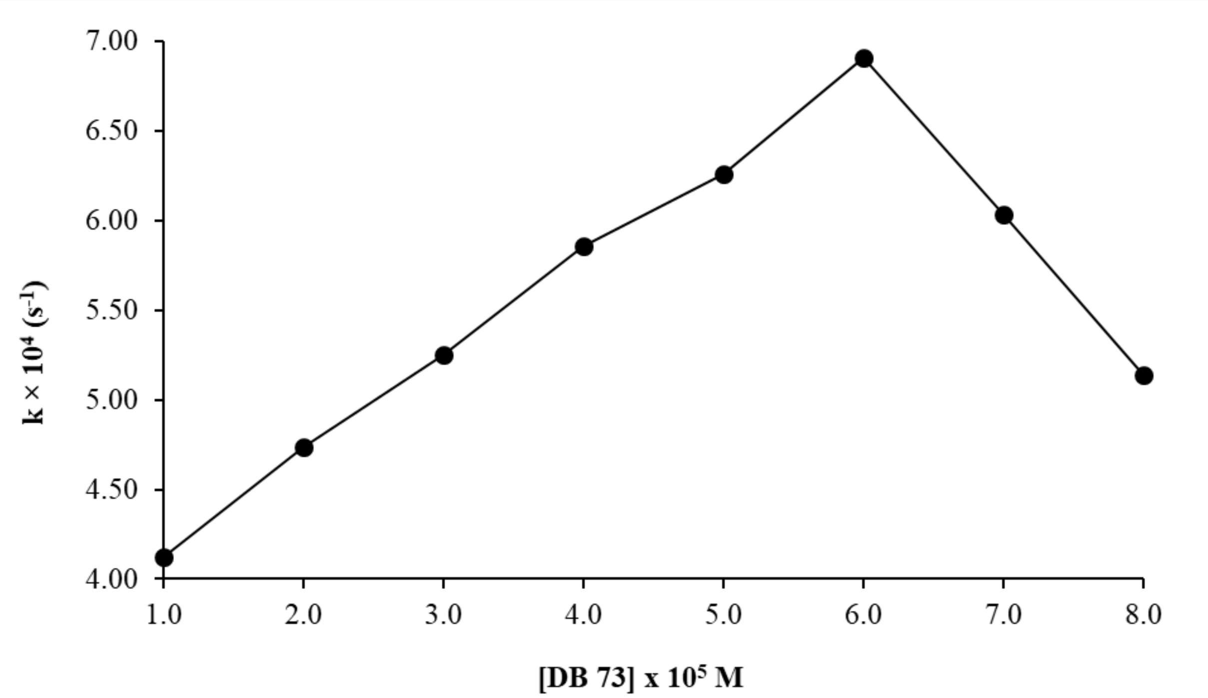

Fig 4: Effect of dye concentration on photobleaching of DB 73 at λmax = 564 nm under the optimized condition.

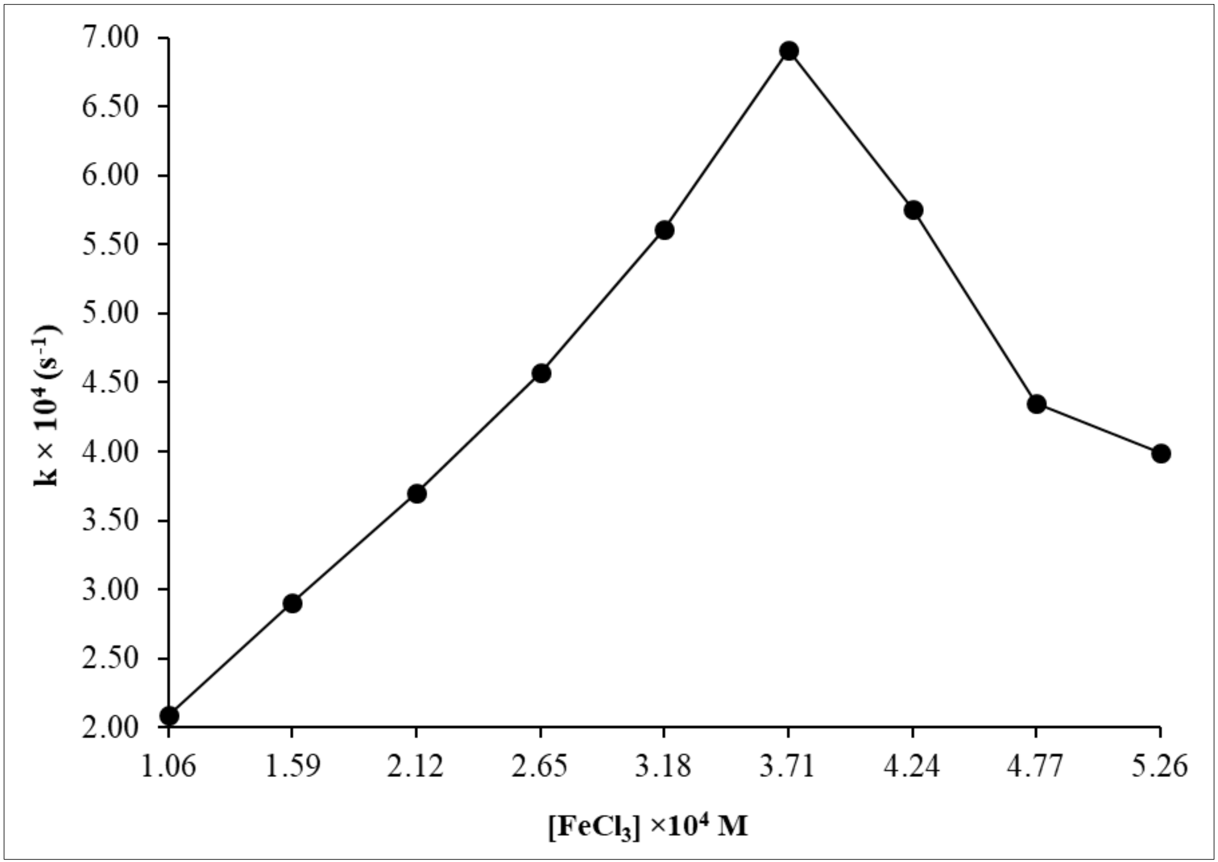

Fig 5: Effect of Fe^{+3} concentration on photobleaching of DB 73 at λmax = 564 nm under the optimized condition.

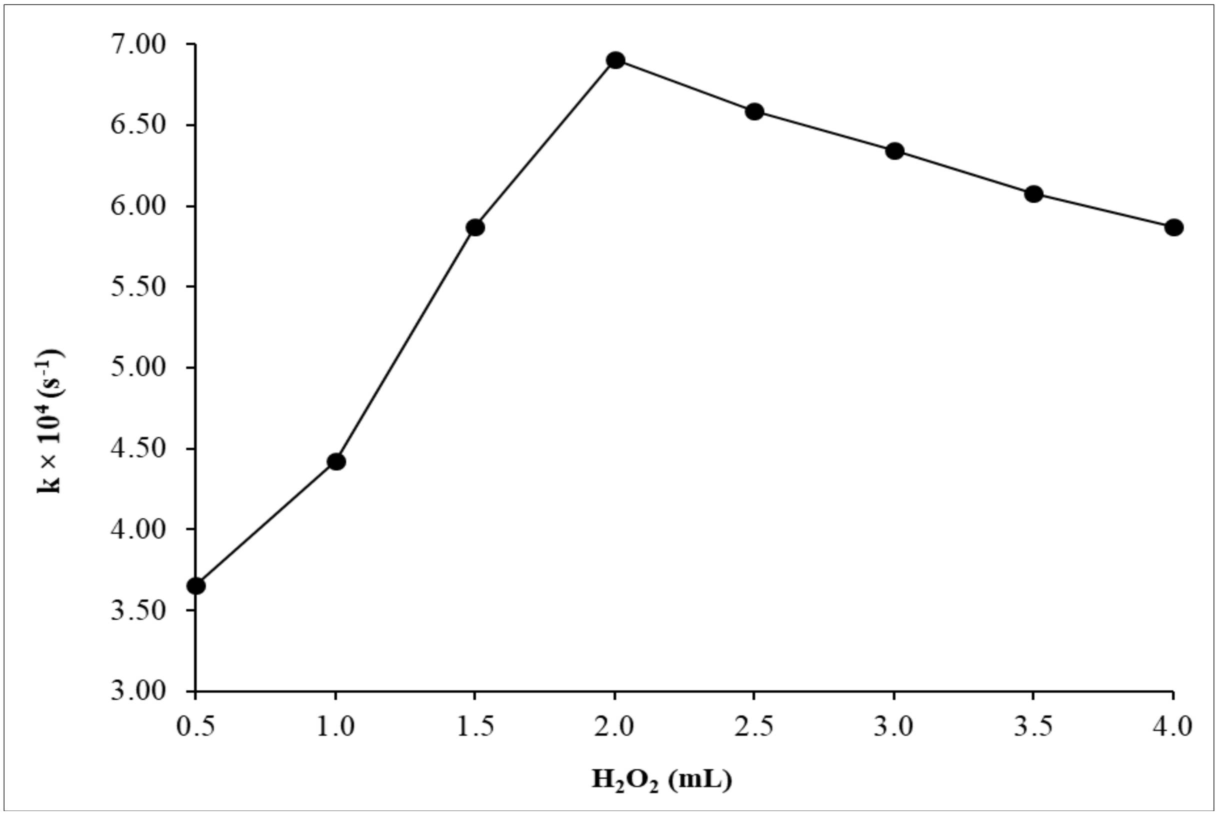

Fig 6: Effect of H_2O_2 concentration on photobleaching of DB 73 at λmax = 564 nm under the optimized condition.

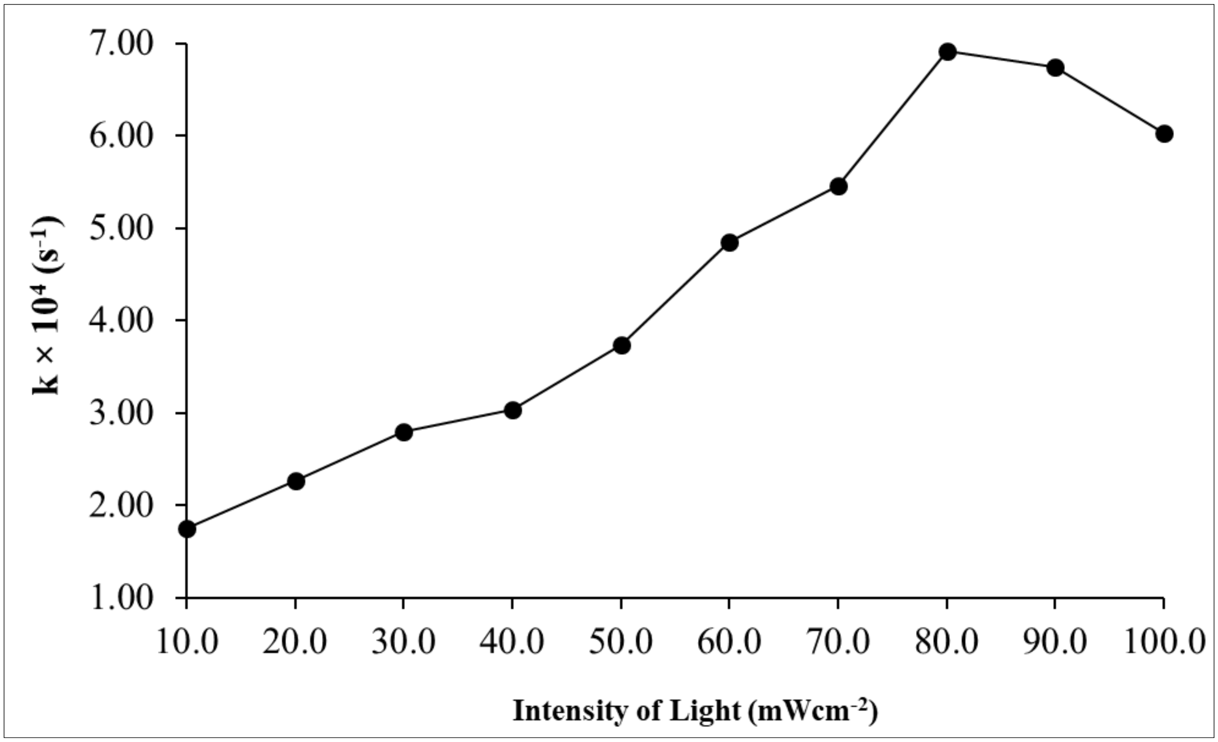

Fig 7: Effect of light intensity on photobleaching of DB 73 at λmax = 564 nm under the optimized condition.

CONCLUSION

Photobleaching of disperse blue 73 was investigated using photo Fenton (H_2O_2/Fe^{3+}) as a catalyst. Various parameters such as dye concentration, H_2O_2 concentration, ferric ion concentration, pH values, light intensity were tested. This work shows that photocatalysis is very effective technology for bleaching of disperse blue 73. Photo Fenton reagent produce hydroxyl radicals in suitable amount for bleaching of dye.

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Dileep Khandelwal works in the Laboratory Department at GNFC Limited, Bharuch, Gujarat, India, with research interests in chemical analysis and environmental remediation techniques.