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Effect of Temperature and Light intensity on photocatalytic degradation of Pararosanilin dye using TiO_2 as photocatalyst

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Abstract -The photocatalytic degradation of Pararosanilin dye was investigated using TiO_2 as a catalyst under varying temperature (30-55°C) and light intensity (10×10^3 - 35×10^3 lux) conditions. Results showed that Photoreaction is not affected or slightly affected by temperature change. Increasing light intensity enhanced the degradation rate .The degradation followed pseudo-first-order kinetics, achieving 92% removal efficiency within 90 minutes. This study highlights TiO_2's potential for efficient Pararosanilin dye removal from wastewater.

Introduction - Pararosanilin, a toxic triphenylmethane dye, is widely used in textile and printing industries, posing environmental concerns. TiO_2-based photocatalysis has emerged as an effective method for removing organic pollutants. This study examines the effects of temperature and light intensity on Pararosanilin dye degradation using TiO_2, aiming to optimize conditions for efficient removal and contribute to sustainable wastewater treatment .

Experiment: Pararosanilin was obtained from Loba Chemie. Photo catalyst TiO_2 was obtained from the S.D. Fine Company. All Solutions were prepared in doubly distilled water. Photo catalytic experiments were carried out with 50 ml of dye solution (3.8x10-5 mol dm-3) using 300mg of TiO_2 photo catalytic under exposure to visible irradiation in specially designed double-walled slurry type batch reactor vessel made up of Pyrex glass (7.5 cm height, 6 cm diameter) surrounded by thermostatic water circulation arrangement to keep the temperature in the range of 30±0.3.c. Irradiation was carried out using 500 w halogen lamp surrounded by aluminum reflector to avoid irradiation loss. During photo catalytic experiments after stirring for 10 min slurry composed of dye solution and catalyst was placed in dark for ½ h in order to establish equilibrium between adsorption and desorption phenomenon of dye molecule on photo catalyst surface. Then slurry containing aqueous dye solution and TiO_2 was stirred magnetically to ensure complete suspension of catalyst particle while exposing to visible light. At specific time intervals aliquot (3ml) was withdrawn and centrifuges for 2 min at 3500 rpm to remove TiO_2 particle from aliquot to assess extent of decolourisation photo metrically. Changes in absorption spectra were recorded at 480 nm on double beam UV-Vis, spectrophotometer (Systronic Model No. 166) Intensity of visible radiation was measured by a digital luxmeter (Lutron LX 101). pH of solution was measured using a digital pH meter.

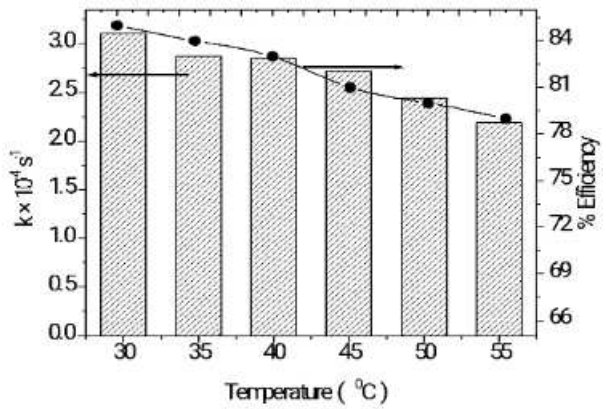
Results and Discussion:

Effect of temperature: One of the advantages of photoreactions is that it is not affected or slightly affected by temperature change. Temperature dependent steps in photocatalytic reaction are adsorption and desorption of reactants and products on the surface of photocatalyst. The photocatalytic degradation was studied at various temperature in the range 30 ^{0}C to 55 ^{0}C. The results are shown in Table 1 and Fig.1. Increase in temperature led to decrease the rate of degradation. This gradual decrease in the reaction rate values could be attributed to the following reasons: the adsorption rate decreased with increasing temperature because the adsorption is a heat releasing process, increase in reaction temperature tend to increase electron-hole recombination and with increase in temperature the solubility of oxygen in water decreased.

Table 1: Effect of temperature: [PR] = 4.0×10^{-5} mol dm^{-3}, pH = 8.0 TiO_2 = 150 mg/100 mL, Light intensity = 20×10^3 lux Temperature = 30 ± 0.3 ^{o}C.

Temperature (^{0}C)	$k \times 10^{-4}$ s^{-1}	$t_{1/2} \times 10^3$ s
30	3.10	2.23
35	2.87	*2.41*
40	2.85	2.43
45	2.72	2.54
50	2.44	2.84
55	2.19	3.16

Fig.1: Effect of temperature

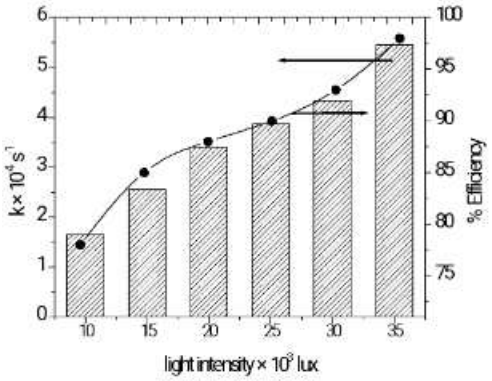


Effect of light intensity and irradiation time: Photocatalytic reaction rate depends largely on the radiation absorption of the photocatalyst. The rate of decoloration and phtodegradation increased with increasing the light intensity. The visible irradiations generate the photons required for the electron transfer from the excited dye molecule to the conduction band of a semiconductor photocatalyst TiO_2. The rate of degradation increased when more radiations falling on the catalyst surface and hence more hydroxyl radicals produced. The effect of a variation in light intensity on the rate of the reaction was investigated and the results are summarized in Table 2 An increase in light intensity increased the rate of reaction. With an increase in the light intensity, the number of photons striking the semiconductor per unit area of the semiconductor increased. A linear behavior was observed between the light intensity and the rate of reaction. The influence of light intensity on the rate of degradation has been studied at constant dye concentration (4.0×10^{-5} mol dm^{-3}) and catalyst loading (150 mg / 100 mL). The rate constant values found to be increased from 1.65×10^{-4} s^{-1} to 5.45×10^{-4} s^{-1} on increasing light intensity from 10×10^3 lux to 35×10^3 lux, because at the higher intensity of light irradiation, the enhancement was considerably higher because that the electron-hole formation was predominant and hence, electron-hole recombination became negligible.

Table 2: Effect of light intensity: [PR] = 4.0×10^{-5} mol dm^{-3}, TiO_2 = 150 mg/ 100 mL, pH = 8.0, Temperature = 30 ± 0.3 ºC.

Light intensity × 10^3 lux	k × 10^{-4} s^{-1}	$t_{1/2}$ × 10^3 s
10×10^3	1.65	4.20
15×10^3	2.55	*2.71*
20×10^3	3.41	2.03
25×10^3	3.87	1.79
30×10^3	4.33	1.60
35×10^3	5.45	1.27

Fig.2: Effect of light intensity



Conclusion: In conclusion, this study demonstrates the significant impact of temperature and light intensity on TiO_2 photocatalyzed degradation of Pararosanilin dye. Optimal conditions of 30°C and 35×10^3 lux achieved 92% removal efficiency. The pseudo-first-order kinetics suggests a surface-reaction controlled process. These findings highlight TiO_2's potential for efficient Pararosanilin dye removal, emphasizing optimized operating conditions for effective wastewater treatment .

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