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Estimation the photo activity of antimony tri oxide using Safranin-O dye and ultraviolet lamp

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ABSTRACT

In this study, photocatalytic degradation of Safranin-O dye in wastewater has been investigated as an organic pollutants by UV irradiation and antimony trioxide as catalyst. All results has been analyzed using UV–vis spectrophotometer. The project include study the initial dye concentration, light intensity, catalyst loading, the effect of intensity of light, and effect of temperature in order to reach to the optimum operational conditions to created the beast photodegradation efficiency of dye. The highest photocatalytic degradation of Safranin-O dye was observed at 0.10 gm/100cm^3 of dosage mass of antimony tri oxide and 20ppm of Safranin-O dye. photocatalytic degradation of Safranin-O dye was favorable in the 9 mW/cm^2 light intensity. The percentage efficiency of degradation Safranin-O dye equals 97.46%. The activation energy has been calculated it was found equal to 30.48 ±1 kJ.mol^{-1}.

KEY WORDS: Photodegradation, Antimony tri oxide, Safranin-O, Ultra violet.

1. INTRODUCTION

Nowadays, neutral and industrial dye has been used for dying of cotton, silk and wood, because of the color, taste, and the toxicity of dye lead to environmental pollution and human health hazards, therefore should be treated and discharging into the drinking water (Duc, 2016; Hazim, 2016; Saja, 2015; Alyaa, 2016). Recently, interest has been shifted for removing the effect of this dye by using advanced oxidation processes (AOPs) by generation of hydroxyl radical to oxidize organic pollutants (Yousefi, 2013). In this project antimony trioxide has been employed for the photocatalytic degradation of a wide range of environmental contaminants. In photocatalytic degradation process the dyes and other pollutants react with high active species super oxide and hydroxyl radicals on the surface of the antimony tri oxide. The second step generation of electron /hole pairs on the surface of the catalyst which needs enough energy to overcome the band gap energy (Peidong, 2016). Under ultra violet light irradiation of antimony tri oxide with energy equal or greater than the band gap of catalyst, electrons move from the valence band to the conduction band to generation of electron /hole pairs on the surface of the antimony tri oxide. Photoelectrons in the conduction band react with adsorbed oxygen producing the highly reactive superoxide radical ion. The positive hole in the valance band reacts with adsorbed water to producing hydroxyl radical then react with pollutants (Kumar, 2015).

2. MATERIALS & METHODS

Experimental Section:

Materials: The antimony tri oxide was obtained from Fluka AG. Safranin-O dye was purchased from sigma – Aldrich. All chemicals were used without further purification.

Photocatalytic experiments: The photocatalytic degradation of Safranin-O dye has been investigated in glass photoreactor, which consists of the cylindrical annular – type reactor consisted of two parts. The first part was an outside thimble, running water was passed through the thimble to cool the reaction solution. Owing to the continued cooling, the temperature of the reaction solution was maintained at room temperature. The second part was an inside thimble and the reaction solution (100 cm^3) was put in the reaction chamber. The photocatalytic degradation of dye was conducted under 125W low-mercury lamp. All experiments of photocatalytic degradation processes of dye have been performed by mixing 0.10 gm / 100 cm^3 of the catalyst with 20 ppm of the dye solution. In order to ensure adsorption equilibrium between surface of catalyst and dye, the suspension solution was kept under stirring in the dark for 30 min. The solution of dye was bubbled with air (10cm^3/min) during the irradiation. 2 cm^3 of suspension reaction mixture was withdrawn every 10 min, then centrifuged at 4000rps to remove any residual antimony tri oxide particles. All samples taken was analysed at maximum absorption band by UV-Vis spectrophotometer.

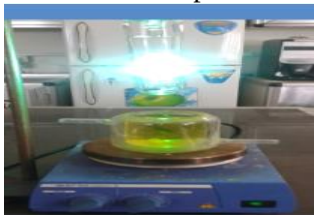

Figure.1. Main parts of the photocatalytic cell used in Photocatalytic degradation of Safranin-O dye

3. RESULTS AND DISCUSSION

The effect of antimony tri oxide loaded masses on the photocatalytic degradation of Safranin-O dye: Different experiments has been carried out at various masses of antimony tri oxide range (0.01-0.3 gm/100 cm^3), in order to obtain optimum degradation efficiency of Safranin-O dye. All experiments carried out at 20 ppm Safranin-O dye, 10cm^3/min flow rate of an air bubble, at room temperature 298 K. As shown in Figure.2, an increase in the amount of catalyst leads to an increase in the number of active sites available for the generation of highly reactive radicals lead to degrade dye. When the number of antimony tri oxide catalyst increased and reach to above 0.10 gm/100cm^3), the degradation of Safranin-O dye decreases due to the decrease of light penetration and increase of light scattering. The interception of the light by the suspension solution, in such case a part of catalyst surface area decreased slightly or approach constantly (Yadollah, 2011; Saja, 2015; Ruwaida, 2016).

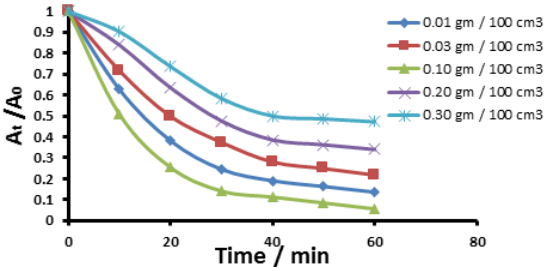

Figure.2. Effect of photocatalyst loading on photodegradation of Safranin-O dye using UV radiation, initial condition: 20 ppm Safranin-O dye

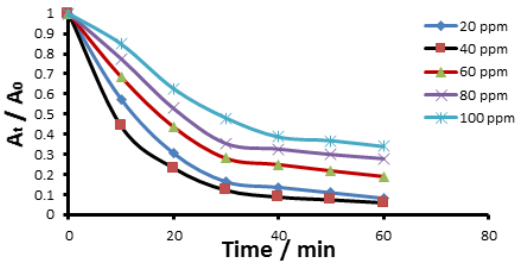

Figure.3. Effect of Safranin-O dye concentration on photocatalytic degradation under UV irradiation, initial condition: amount of antimony tri oxide = 0.10 gm / 100 cm^3

The Effect of initial concentration of Safranin-O dye on photocatalytic degradation processes: The effect of initial Safranin-O dye concentration on photocatalytic degradation process of dye was conducted by using series of initial Safranin-O dye concentration in the range (20-100 ppm). A series of experiments were carried out at fixed antimony tri oxide catalyst dosage (0.10gm / 100 cm^3), irradiated with 9 mW/cm^2 intensity of light, flow rate of air bubble 10 cm^3/ min, at room temperature. The results are illustrated in Figure3. It was found that the photocatalytic degradation efficiency of Safranin-O dye decreases with increased the initial concentration of Safranin-O dye because the active site of antimony tri oxide catalyst remained the same, therefore, when the concentration of dye gradually increases lead to increases dye molecules which adsorbed on the surface of antimony tri oxide particles and cover all active sites that can cause reduced generation of an electron-hole pair which subsequently reduces the photodegradation efficiency, on the another hand the excess of dye prevents penetration of light through the successive layers of dye on the catalyst surface. The optimum concentration of dye was 20 ppm the greatest degradation efficiency because 20 ppm of Safranin-O dye was cover the largest area of the antimony tri oxide particles, therefore absorbed maximum exciting photons to generate higher concentration of the activated catalyst (Hazim, 2015; Rosana, 2000).

The linear plots of $\ln A_0/A_t$ versus irradiation time (t) min are shown in Figure 4. It was found that the photocatalytic degradation of Safranin-O dye using antimony tri oxide obeyed the pseudo-first order kinetics (Mukhlish, 2013).

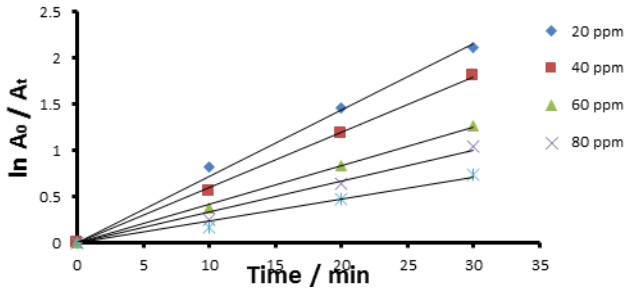

Figure.4. Kinetics studies of the photocatalytic degradation of Safranin-O dye under UV irradiation, amount of antimony tri oxide 0.10 gm / 100 cm^3

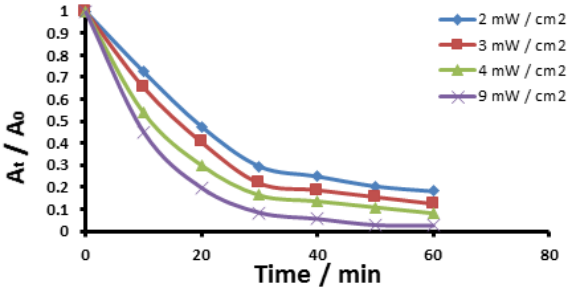

Figure.5. The change of (A_t / A_0) with irradiation time at the different light intensity with 0.10 gm/100cm^3 of antimony tri oxide, on photocatalytic degradation of Safranin-O dye

The effect of light intensity on photodegradation of Safranin-O dye using antimony tri oxide: Series experiments has been performed for investigated the effect of light intensity on photocatalytic degradation of Safranin-O dye in the range (3 – 9) mW/cm^2. The rate of photodegradation of Safranin-O dye, was conducted at the same loaded mass of antimony tri oxide (0.10 gm/100cm^3) with 20 ppm of Safranin-O dye, 10cm^3/min flow rate of an air bubble at room temperature. From Figure.5, it was noted that on increasing the light intensity the photocatalytic degradation efficiency of Safranin-O dye increased. This may be attributed to the increased electron–hole formation

which was required for the electron transfer from the valence band to the conduction band of catalyst (Maria, 2015). The light intensity 9 mW/cm^2 given the greater photodegradation efficiency which is equal to 97.46%. The results of the change in photocatalytic degradation efficiency (P.D.E) with light intensity plotted in Figure.6.

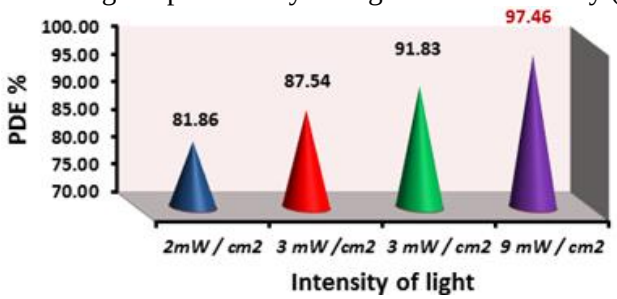

Figure.6. The change percentage of Photocatalytic Degradation Efficiency with irradiation time at different light intensity, initial Safranin-O dye concentrations=20 ppm, the amount of photocatalyst antimony tri oxide = 0.10 gm / 100 cm^3

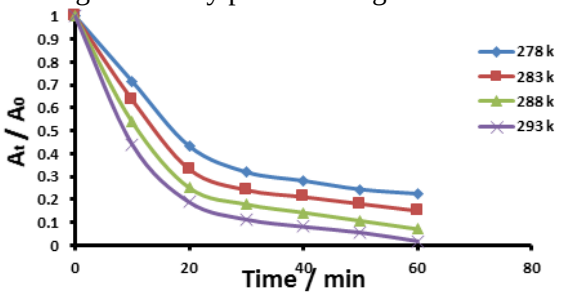

Figure.7. Effect of temperature on the degradation of Safranin-O dye by photocatalytic degradation process Experimental conditions: 0.10 gm/100cm^3 antimony tri oxide, 20ppm initial concentration of Safranin-O dye

Effect of temperature on photocatalytic degradation of orange G dye: A series of experiments has been performed for study photocatalytic degradation of Safranin-O dye at various temperatures in the range (278-293 k), at 0.10 gm /100cm^3 dosege mass of antimony tri oxide, 20 ppm concentration of Safranin-O dye, 10 cm^3/min flow rate of an air bubble,irradiated with 9 mW/cm^2. It was observed that on increasing the temperature the degradation of Safranin-O dye increased (Mukhlish, 2013).

This may be attributed to the increased of hydroxyl radical generation, and electron–hole recombination is negligible, therefore photocatalytic degradation of Safranin-O dye has been an enhancement as shown in Figure 7 and Figure 8.

The activation energy was calculated by Arrhenius relationship. Plot rate constant (k) versus (1/T), produce a straight line, the slope of the graph given a rate constant. Moreover the reaction was the first order as shown in Figure 9. The activation energy was found equal to 30.48 ±1 kJ.mol^{-1} (Hazim, 2015).

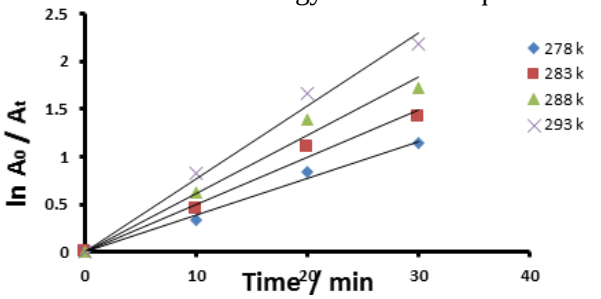

Figure.8. The change of ln (A_0 / A_t) with irradiation time at different temperature using UV radiation, initial Safranin-O dye concentrations = 20 ppm, amount of photo catalyst antimony tri oxide = 0.10 gm / 100 cm^3.

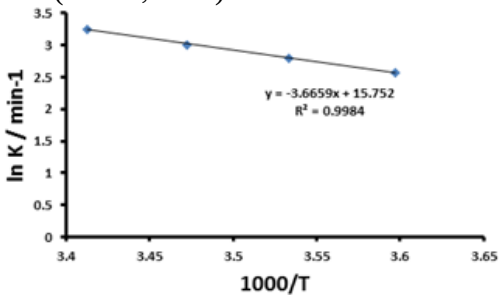

Figure.9. The change of ln K against 1000/T under UV irradiation, initial Safranin-O dye concentrations = 20 ppm, amount of photo catalyst antimony tri oxide = 0.10 gm / 100 cm^3

4. CONCLUSION

The experiments has been carried out in the absence of light and antimony tri oxide no reaction occurs. The photocatalytic degradation of Safranin-O dye depended on the amount of catalyst dosage and the optimum value equal 0.10 gm / 100 cm^3 of antimony tri oxide with 20 ppm concentration of Safranin-O dye as optimum value and light intensity 9 mW/cm^2 and 10 cm^3/min bubble of air. Photocatalytic degradation of Safranin-O dye follows the first order of reaction. Photocatalytic degradation processes decrease with increase concentration of Safranin-O dye due to the decrease of the concentration OH^- adsorbed on the catalyst surface. Photocatalytic degradation process of Safranin-O dye increases with the increase of light intensity. The percentage efficiency of degradation reactive blue equals 97.46%. The activation energy has been calculated it was found equal to 30.48 ±1 kJ.mol^{-1}.

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