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Photodegradation of Commercial Dye 920 DB_2 Using TiO_2

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Abstract

Photo decomposition of 920 (DB_2) dye have been performed at (nm) in deionized water at 25C°.Under irradiation Uv Lamp. The absorbance spectrum for this dye have been recorded with the time of irradiation in order to examine the kinetics of photo decay. The specific rate constant the (Kd) for the first order reaction have been calculated and found to be (Kd = 0.0248 min^{-1}). Study the effect of various parameters such as catalyst loading, pH of the medium and initial dye concentration. On photodecomposition of 920 (DB_2).

Keywords: UV radiation, TiO_2 catalyst, 920 DB_2 dye.

Introduction

For the textile industry. The dyeing and the finishing process is the main pollution source of waste water. It is estimated that 2% of the dyes production are discharged in effluent from manufacturing operations while 10% are discharged in effluent from textile associated industries [1]. Azo dyes which contain one or more of nitrogen to nitrogen double bonds, Which reduced to aromatic amines under anaerobic conditions that are colourless and can be toxic and potentially carcinogenic[2-4].

Photocatalysis systems that used TiO_2 was acting much interest for degradation of dye pollutants [5,6] Photo reactions on the surface of semiconductors at first evoked by relevant light to create electrons. The electrons are scavenged by molecularly O_2 to yield superoxide radical anion $O^{\cdot}$ and H_2O_2. These intermediates can interac to produce OH, The $OH^{\cdot}$ is powerful oxidizing agent capable of degradation most pollutants (eq.1) [7,8].

$OH^{\cdot}$+ dye→peroxylated intermediates → degraded or mineralized products .... (1)

The basics of the focus of this research is to use anatase TiO_2 in the photocatlytic degradation of DBH (Direct Black BH) under illumination of UV. lamp (100w medium pressure mercury lamp). The rate determining parameters like initial dye concentration catalyst loadings pH of medium and using another catalysts for comparison.

Experimental

Materials: The dye direct blue 2/ Apollo direct black BH (direct black DBH) Fig.(1) was collected from the factory textile industry in Baghdad, TiO_2 99% (Fluka (A.G)), zinc oxide, All chemicals were employed without further purification. All experiments were carried out using deionized water.

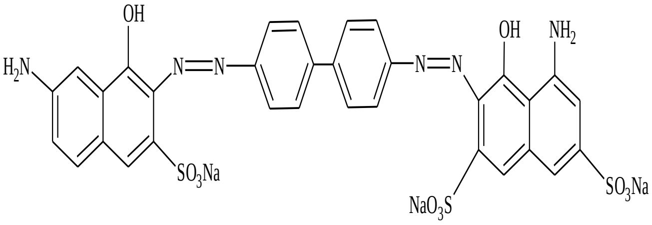

Fig.(1): The structure of DBH.

Photocatlytic degradation

100ml of dye solution (different concentrations) and catalyst TiO_2 were taken in double jacket photo cell with quartz window and exposed to medium pressure mercury lamp.

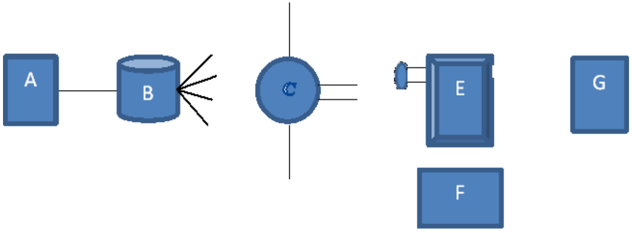

Fig.(2):Shematic diagram of the experimental apparatus for photolysis of complex.

A) Power supply unite.
B) Medium pressure mercury lamp MPML.
C) Lenses; (D) filter (365 nm); (E) quartz cell.
F) Magnetic stirrer (G) circulating water thermostat.

Result and Discussion

1-Effects of pH medium

The pH value was an important variable. This value influenced the surface electric charge of TiO_2, it was adjusted using different concentration of HCl and NaOH. Photocatalytic degradation was studied in the pH range 2-11 for constant dye concentration (60ppm) and catalyst loading (1g/L). Fig.(2) shows that rate of BDH degradation follow the following order:

pH4> pH7>pH11>pH9 and the decolization efficiency at PH9 was 40% after 75 min. While it was just 23% for pH=4. So the rate increased with increasing pH, but further increasing in pH decreased the rate of reaction. It is known that the metal oxide particles suspended in water behave similar to diprotic acids. The interaction of TiO_2 with electron donor and electron accepter would be favoured for photocatalytic activity at high pH greater than the zero point charge (ZPC), The ZPC for TiO_2 found to be 6.25 [9], The hydroxyl group undergoes two acid base equilibrium [10,11], [Eqs.(2) and (3)].

$$>TiOH_2^+ \rightarrow >TiOH + H^+ \quad PH<6.25. \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$>TiO^- + H^+ \rightarrow >TiOH \quad PH>6.25 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

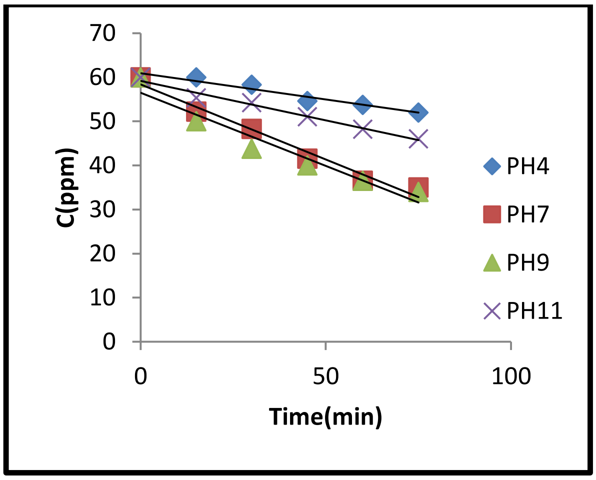

Fig.(3): Photodecomposion rate of BDH by different pH (λ=750 at $25C^{\circ}$).

Significant increase in degradation efficiency in range of pH [7 to 9] due to presence of ^-OH in the medium and near the surface of catalyst that leads to generation of hydroxyl radical but when the pH greater than 9 more of ^-OH are introduced in the reaction mixture which make the surface of the semiconductor negatively charged repulsive forces start interacting between negatively charged semiconductor surface and dye anions similar behaviour has also reported for the photo catalytic efficiency of TiO_2 for degradation of dyes [12,13].

2- Effect of catalyst loading

In order to determine the effect of catalyst loading the experiments performed by using three concentrations of TiO_2 (0.5g/L, 1g/L, 1.5g/L) for dye solution (60ppm) at neutral pH(7). It was observed that degradation rate of DB2 increases with an increase the amount of TiO_2 see Fig.(4) we can explain that optimum catalyst loading is found to be (1.5g/L) because with the increase of catalyst dosage, total active surface area increase and more active sites on catalyst will be available [14]. So the catalyst load 1.5g/L was fixed for DB2 with decolourization efficiency 70% after 75min. Fig.(4)

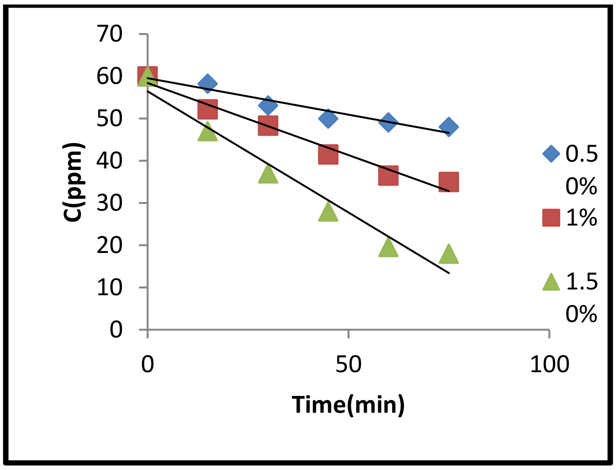

Fig.(4): Effect of catalyst loading (λ=750 at $25C^{\circ}$) on the photodegredation rate of BDH.

3- Effect of Initial concentration of dye

Initial dye concentration Of DB2 form an aqueous solution on TiO_2 surface was the studied at room temperature (298K) and at natural pH (7). The results of this study shown in Fig.(4) the quantities Of DB2 dye are plotted as a function of the irradiation time. We show that rate of degradation decreased with increased of dye concentration. The decolourization efficiency of dye(20 ppm) was

99% within 75min. and 23% for (80ppm) of dye solution. The number of photons entering the solution decreases in higher concentration but in the lower concentration the number of photons increasing [15,16]. Similar behaviour was observed in refs, [1718]. During the photocatalic degradation of commercially dyes using TiO_2.

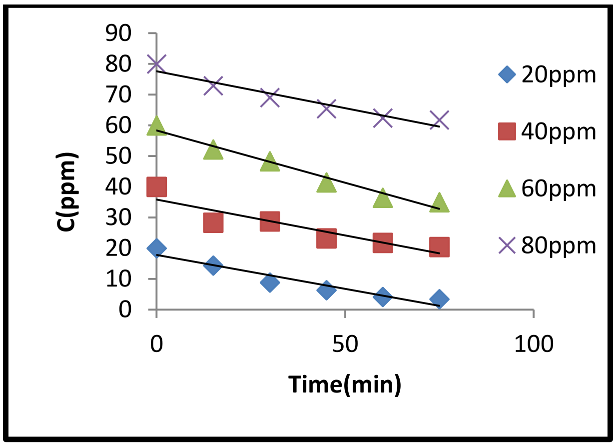

Fig.(5): The relationship between the concentration of DB_2 dye and the irradiation time with λ=750 at 25C°.

The specific decomposition rate constant of dye (Kd) was determined after examining the order of reaction of this dye. The spectra of the DB_2 dye treated kinetically by plotting the curve between (ln C/C_0) versus irradiation time Table (1). The plot of (ln C/C_0) with irradiation time gives straight line Fig.(5) which indicates that reactions first –order the value of Kd for this dye is (0.0248 min^{-1}).

In $C_o/C = Kt$ .... (4)

Where C_o is the initial concentration and C is the conc. at any time t. The value of correlation coefficient R^2 is equal to 0.9809 and the rate constant equal to 0.0248.

Table (1)
Concentration of DB2 dye at different time.

time	Conc.	lnC/Co
15	14.4	0.328
30	8.8	0.821
45	6.3	1.156
60	4.18	1.565
75	3.45	1.76

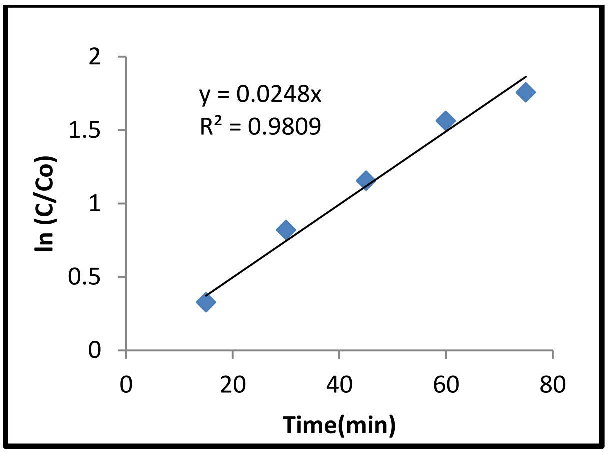

Fig.(6): Variation of neutral logarithm of concentration with irradiation time of (20ppm) of dye and (1 g/L) of catalyst at 298K ,λ=750.

4- Effect of different catalysts

The influence of Tio_2, ZnO and Al_2O_3 were studies as semiconductors we found that the TiO_2 is best catalyst for degradation of dye from Zno and Al_2O_3 (1 g/L from catalyst with 60 ppm from dye solution at pH=7).due to TiO_2 it has wide band gap and more sensitive to UV. Fig.(7).

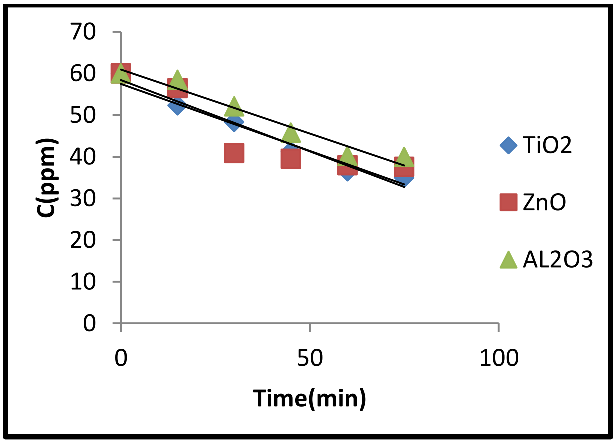

Fig.(7): Effect of different catalysts on the photodegredation process of BDH at (λ=750 at 25C°).

Conclusion

In this study the photodegradation of 920 DB_2 dye using TiO_2 .The uv-vis.–spectrum shows maximum absorbance around the visible region at 750 nm, and the optimum condition pH =7 at 25 °C; catalyst loading (0.006gm); initial concentrate of dye (60ppm) was selected.

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الخلاصة

تم في هذا البحث دراسة التجزئة الضوئية للصبغة (290) (direct blue2 DB_2) باستخدام TiO_2, ZnO , Al_2O_3 كمحفزات ضوئية وتمت مقارنة بين المحفزات الثلاث ووجد بان TiO_2 افضل محفز ضوئي مقارنة بـ Zno و Al_2O_3. درست حركية تفكك هذه الصبغة ضوئيا في درجة حرارة ٢٥م باستخدام الماء المقطر الخالي من الايونات كمذيب. ووجد ان التفاعل التجزئة الضوئية هو من المرتبة الاولى, وتم قياس ثابت السرعة النوعي للتجزئة الضوئية (Kd) وبدرجة حرارة ٢٥م من خلال متابعة التغير في امتصاصية مطيافية الاشعة فوق البنفسجية–المرئية وبطول موجي (٧٥٠nm) فكانت تساوي ($Kd= 0.0248\ min^{-1}$). تم دراسة العوامل المختلفة للتفاعل مثل تاثير الدالة الحامضية وتاثير تغير التراكيز المختلفة للصبغة وتاثير تغير كمية المحفز الضوئي.