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Photocatalytic Activity of Aluminum Oxide as A Catalyst for the Degradation of a Synthetic Azo Dye

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Abstract

The photocatalytic degradation of the azo dye [3-((4-hydroxyphenyl) diazenyl)-4,5-dimethyl-1-phenyl-1,5-dihydro-2Hpyrrol-2-one][N1] was studied using aluminum oxide as a catalyst. The degradation process was performed at Rt, with a 125-watt mercury lamp as the external source. In this process, the impact of different amounts of aluminum oxide was tested, and the best degradation of the azo dye was achieved by using 0.12g of Al_2O_3. The effect of dye concentration was also studied in the presence of the optimal amount of Al_2O_3, with an optimal dye concentration of 20 ppm. For the entire process, the photodegradation efficiency was 82.78%.

Introduction

Water pollution is considered a life-threatening issue because it affects human life, animals, and aquatic ecosystems [1-3]. Various factors contribute to this issue. For example, domestic waste and factory waste [4,5]. The main materials discharged from factories are azo dyes, a widespread class of chemicals that enter water and lead to water pollution [6]. These dyes have been used in painting, cosmetics, and printing [7-9]. These dyes are characterized by their bright color, high solubility, and chemical stability [10,11]. Therefore, it is difficult to be degraded [12,13].

However, researchers have developed many techniques to solve this problem [14,15]. For example, chemical, physical, and biological techniques have been used [16]. One of the most effective chemical techniques is photocatalytic degradation using metal oxides as catalysts [17-19]. In this type of degradation, the metal oxide generates active free radicals during oxidation, which are responsible for dye degradation [20]. One of these interesting oxides is Al_2O_3, which has been widely used due to its significant properties [21, 22].

In this work, Al_2O_3 was used to photocatalytically degrade a synthetic azo dye, and several parameters were investigated to assess the catalyst's photocatalytic activity.

2. Materials and Methods

The used azo dye and the photocatalytic degradation process were previously described in the literature [23, 24]. Al_2O_3 was supplied by Fluka (Buchs, Switzerland).

Result and Discussion

1- Effect of catalyst weight on the degradation process

Figure 1 shows the photocatalytic degradation of the azo dye using various quantities of Al_2O_3. In this figure, the gradual increase in the catalyst weight leads to an increase in the photocatalytic degradation of this dye. However, the optimal catalyst weight was 0.12g/100ml. Beyond this amount, the photocatalytic degradation was decreased. Due to light scattering, which reduces the light reaching the lower solution layers, photocatalytic degradation is reduced [25-27].

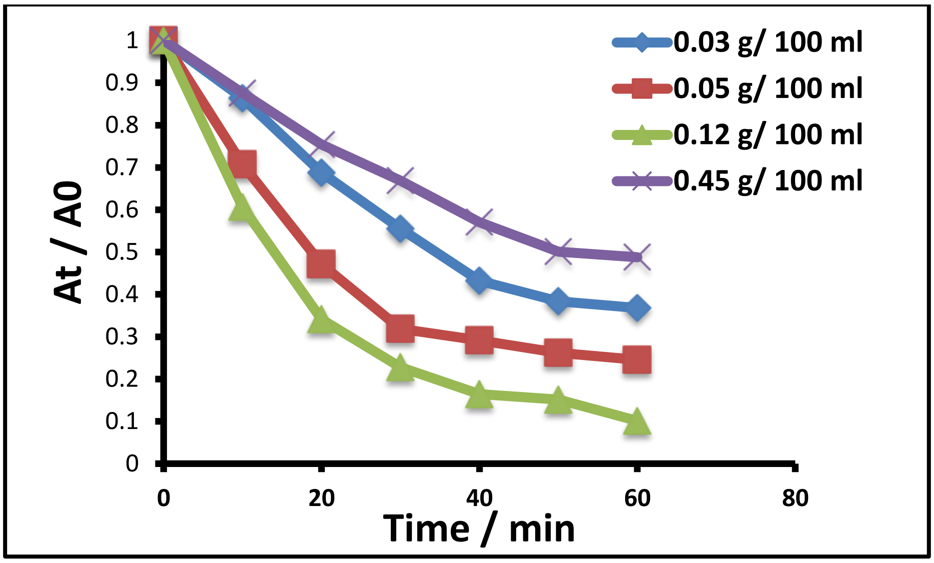

Fig. 1: Effect of Al_2O_3 weight on the azo dye photocatalytic degradation.

The kinetic analysis is shown in Figure 2. $\ln(A0/A_t)$ was plotted against time, and the plot is linear through the origin. As a result, a first-order photocatalytic degradation was obtained.

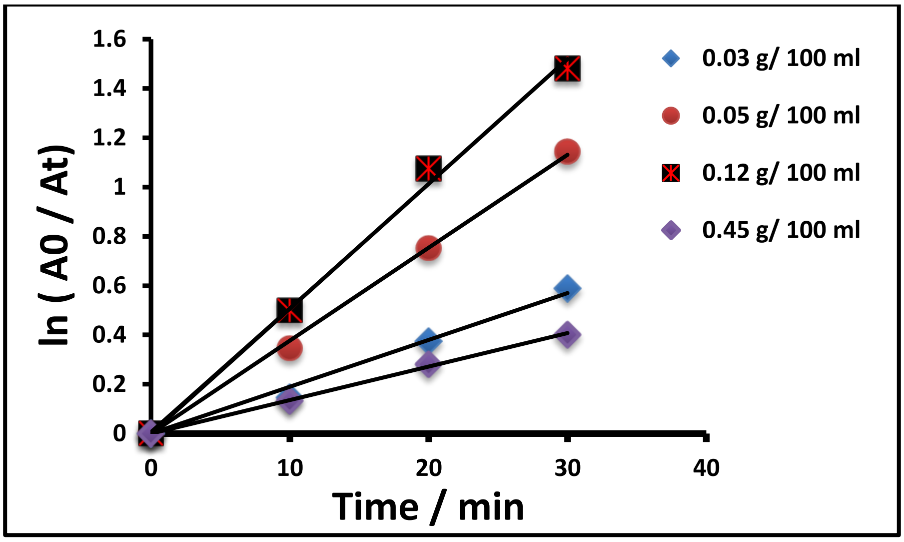

Fig. 2: Relationship between $\ln(A_o/A_t)$ and irradiation time.

2 - Effect of azo dye concentration

As mentioned before, various concentrations of the azo dye (20-50 ppm) were treated with a constant weight of Al2O3 (0.12 g). In Figure 3, the degradation rate decreased as the dye concentration increased. Where the best dye concentration was (20) ppm. When a high concentration of the azo dye is used, less photocatalytic degradation will be observed because less light penetrates the deeper layers of the dye solution [28-31].

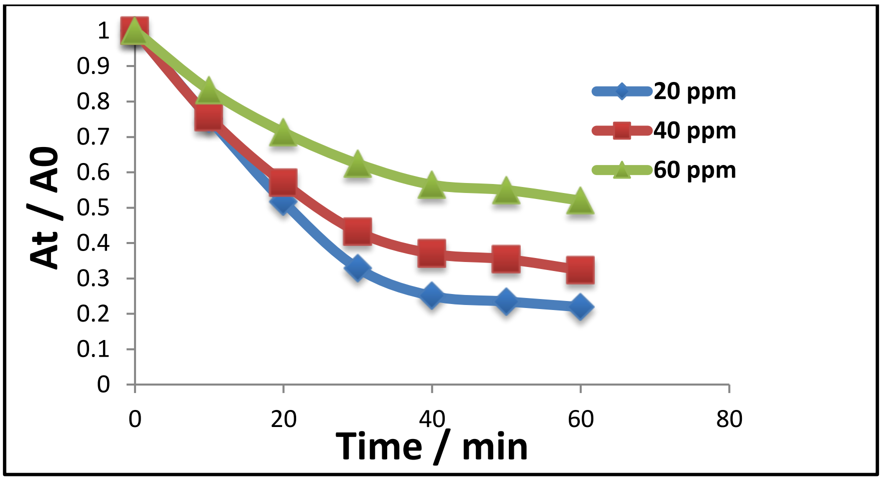

Fig. 3: Effect of dye concentration on the photocatalytic degradation at a constant weight of Al_2O_3

While the relation between ln(A0/At) and time is linear, it agrees with the Langmuir-Hinshelwood model, as shown in Figure 4.

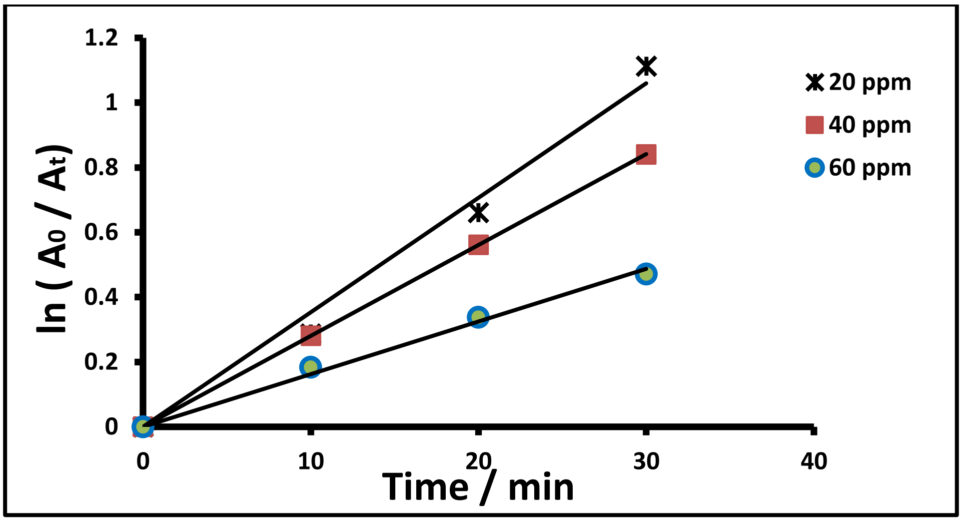

Fig.4: Relation between ln (A / A0) with irradiation time at various concentrations of the dye

The highest photodegradation efficiency (PED), at the optimal dye concentration (82.78%), is shown in Figure 5.

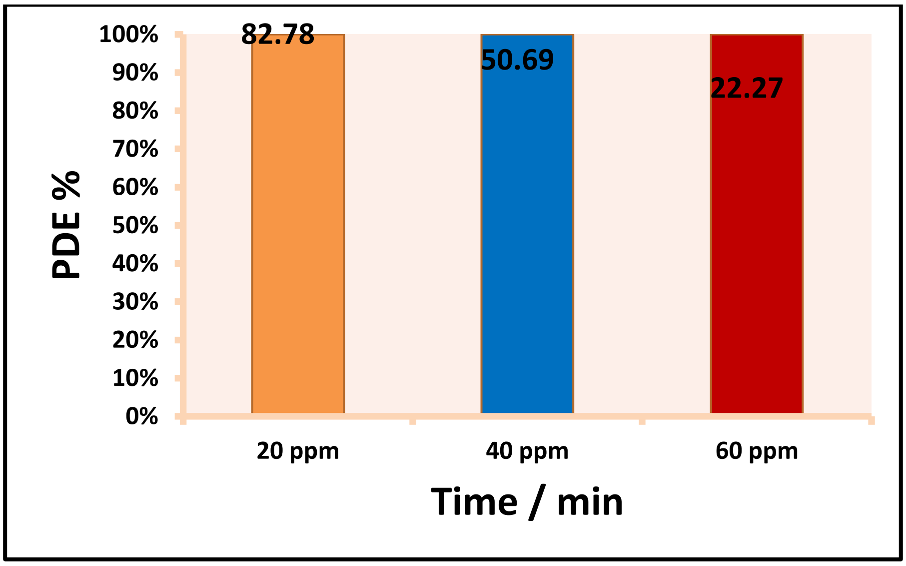

Fig.5: Photodegradation efficiency (PED) at various concentrations of the dye

Conclusion

The photocatalytic degradation activity of aluminum oxide was tested using the azo dye [3-((4-hydroxyphenyl) diazenyl)-4,5-dimethyl-1-phenyl-1,5-dihydro-2Hpyrrol-2-one][N1]. Various experiments have been conducted to determine the optimal conditions for the photodegradation process. It was found that the catalyst exhibits a high photodegradation efficiency (82.78%) at the optimal dye concentration (20 ppm) and catalyst weight (0.12g/100 mL).

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