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Original Research Article

Photodegradation Methyl Red Dye Using Optimal Conditions and Zinc Oxide

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Abstract: This study is intended to determine the photodegradation pathway of methyl red dye that is used in industrial applications under zinc oxide catalytic action. The light source was UV radiation emitted from a mercury lamp with a power rating of 125 Watts. The process of the current rate of degradation of methyl red dye was studied by measuring its absorbance over a wavelength range of 380–700 nm, and the point that had the maximum absorption (640 nm) was shown. The study used different weight catalysts to compare the effect on the photodegradation of the dye, where the best weight at which the dye was broken down was 0.06 g of zinc oxide at a particular level of concentration. It was studied to determine the level of photodegradation of the dye, and it was shown that at a concentration of 1 x 10-4 M, the catalyst was most effective at the dye degradation, and the temperature also had an important effect on the methyl red dye.

Keywords: Methyl Red Dye, Zinc Oxide, Catalytic Degradation.

INTRODUCTION

The catastrophic development in population and the wasteful activities of urban and industrial lives over the last decade has led to the problem of environmental issues on a large scale. One of the most worrying environmental problems in our world today is water pollution (admired) by the scientific community to the greatest ever-height [1]. It is estimated that about a fifth of the total amount of the synthetic dyes that are being used is discharged as wastewater during the fabric dyeing processes with the annual discharge of dyes being over 70,000 tonnes [2, 3]. The input of organic dye into aquatic environments is bulky and might be harmful to both the health and environment. So, it is vital to get rid of these wastewaters by treatment and prevent their discharge into freshwater streams [4, 5]. However, methyl red are of the most common dyes in sectors and goods such as textiles, food products, pharmaceuticals and as adsorbate [6]. Methyl red (MR) is classified as a mono-azo dye that contains (—N=N—) functionality as one of the constituent functional groups and it is widely used in batches of textiles and commercial merchandise [7].

The use catalysts and the photocatalysis considered method of purifying water by splitting up contaminants, organic dyes to be exact, in the presence of light to produce ecologically favorable outcomes is one option of getting rid of this particular issue [8]. Along with that, the cost of eliminating the lethal organic materials by this means is the lowest possible when compared to other methods [9, 10].

Finally, semiconductor metal oxides can be deployed to sense chemicals and gases as well as for photocatalytic breakdown of dyes that are not biodegradable otherwise [11-13]. Zinc oxide (ZnO) is a semiconductor of the n-type possessing a band gap of about 3.4 eV [14, 15]. Photocatalytic properties of the material are also widely focused on. It is cheap, easy to synthesized and ecologically friendly. In addition, it also have a powerful oxidation ability which can generate the photo excited holes [16-17].

MATERIALS AND METHODS

This design involves the research of the ideal conditions supporting the maximal degradation of the most important dyestuff by the commercial photo-chemical reactors. The methyl red dye with (III) at a pre-dosed temperature of 25 °C for 60 minutes with continuous stirring and passing the added O2 gas at a speed of 10 ml/min.

In sequence of arrangements experiments were carried out in order to select the ideal factors that create the maximum breakdown of the greatest volume of methyl red dye by the inside immersive glass photochemical reactors was discovered by the spectral method. Conducting a methyl red dye (1ml) irradiating by exposing it to 25 °C temperature level and a power of 10 ml/min of oxygen gas in 60 minutes under stirring conditions continuously.

1. **The effect of the weight of zinc oxide on light reactions:** A number of experiments were performed to reveal the dependence of the degradation of methyl red dye by zinc oxide ingredient with a constant shaking at a temperature 25°C, passing a stream of air at the speed of 10 ml/min for a 1 hour of a period.
2. **The effect of dye concentration on the degradation of methyl red:** Several experiments were studying found that the breaking down process of methyl red at a constant shaking after a period of 60 minutes was affected by dye concentration with temperature 25°C and air stream of 10 ml/min were fixed.
3. **The effect of temperature on the optimal concentration of methyl red:** A series of experiments were conducted that included irradiating 100 ml of methyl red dye in the presence of 0.06 g/100 ml of catalyst and passing O2 gas at a speed of 10 ml/min with continuous stirring within the temperature range of (5-20)˚C, and the cracking result was estimated spectrophotometrically.

RESULT AND DISCUSSION

1- The Effect of the Weight of the Catalyst

A series of experiments were conducted that included irradiating 100 ml of methyl red dye solution at a temperature of (20)˚C and passing O_2 gas at a speed of 10 ml/min and using different weights of the catalyst (ZnO) in order to determine the ideal weight of the catalyst that leads to creating the highest reaction speed in the direction of breaking down the methyl red dye. By plotting the relationship between A/A0 versus the irradiation time, as shown in Figure (1), we note that the highest change in the reaction speed in order to degradation the methyl red dye was at the weight (0.06) of the catalyst (ZnO) upon irradiation for 60 minutes.

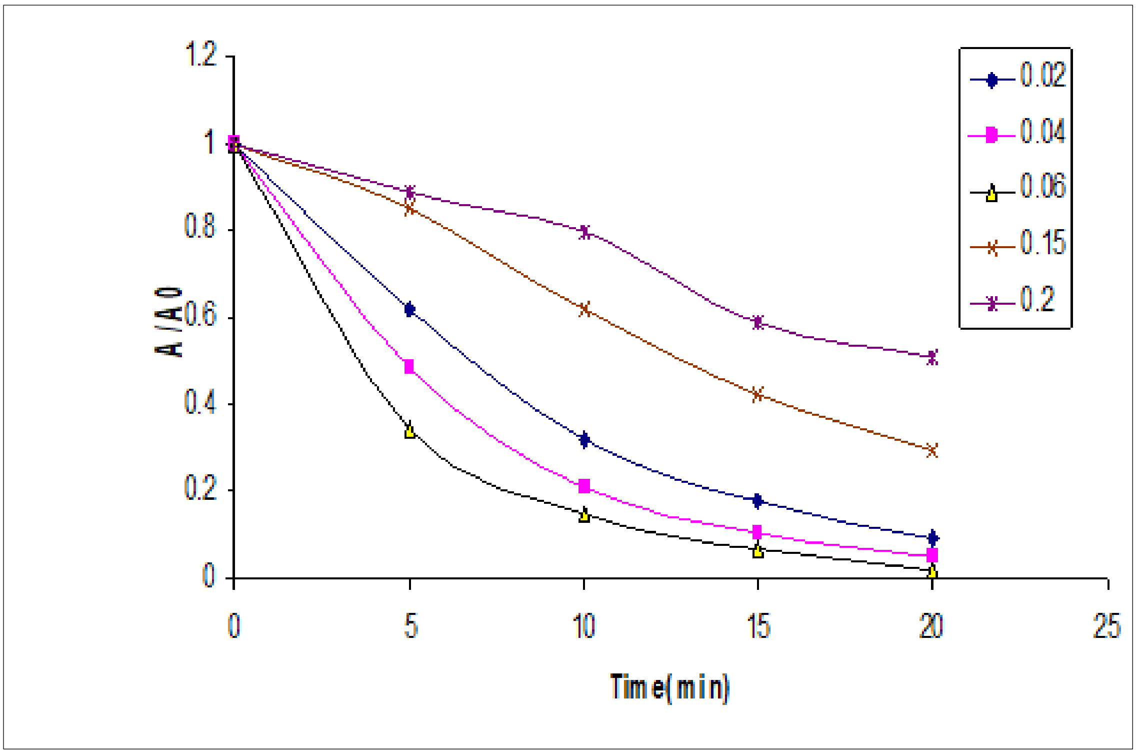

Figure 1: The effect of different weights of the catalyst ZnO on the process of breaking down the methyl red dye

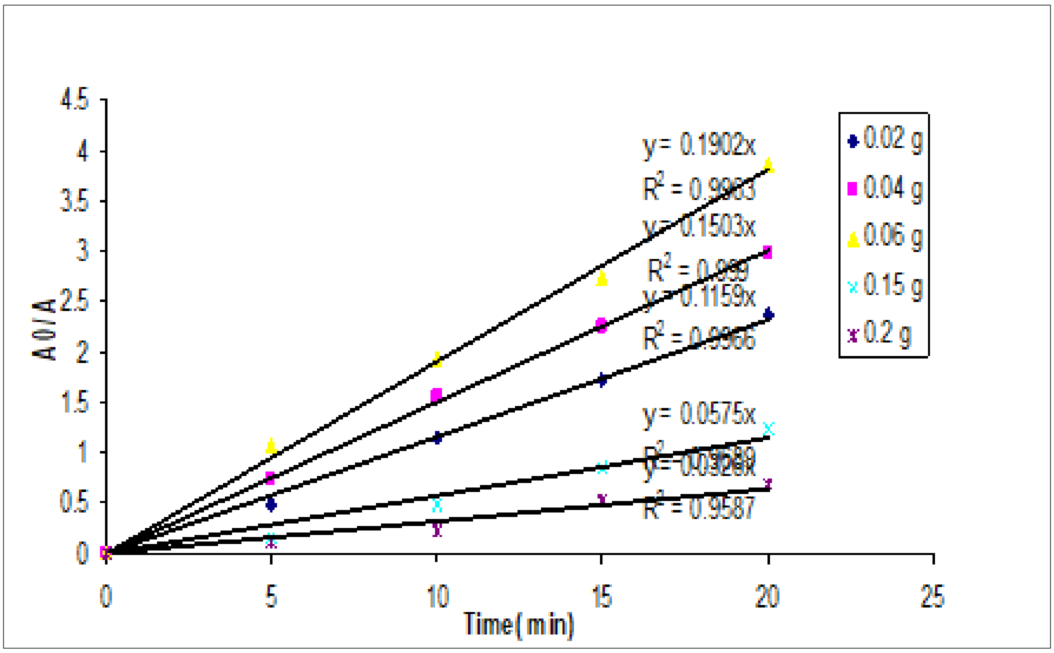

Figure 2: The relationship between (lnA0/A) and irradiation time using different weights of the catalyst (ZnO)

It was found that there is a variation in the process of photodegradation of methyl red dye with variations in different weights of zinc oxide. The reason for this variation in the speed of the reaction is attributed to the fact that the light-receiving ZnO molecules when using light weights of the catalyst are few with the large number of incident photons.

In the case of using large weights of the catalyst, the particles of the catalyst in the dense solutions facing the light act as an inner filter, absorbing most of the photons and scattering the others. Thus, the number of photons absorbed by the catalyst on which the dye molecules are adsorbed decreases [18].

2 - The effect of methyl red dye concentration on the photodegradation process

A series of experiments were conducted that included irradiation of different concentrations of methyl red dye ($1X10^{-5}$, $1X10^{-4}$, $3X10^{-4}$, $1X10^{-3}$) in the presence of (0.06 g/100 ml) of the catalyst and passing O_2 gas at a speed of 10 ml/min with continuous stirring for 60 minutes at a temperature of 25 ˚C, the degradation product was detected spectrophotometrically.

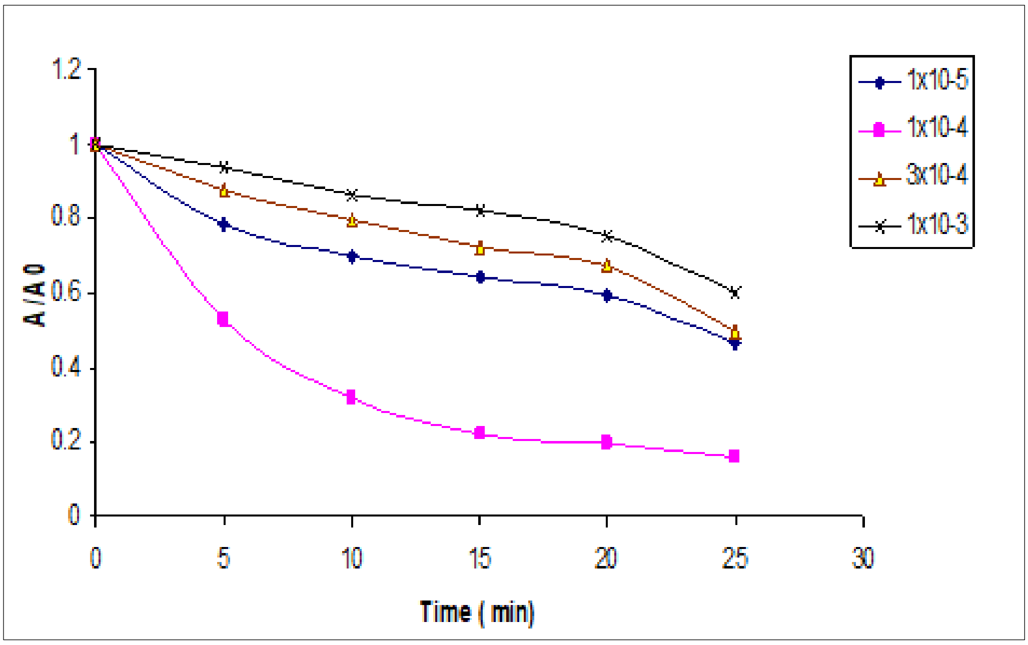

Figure 3: The effect of the concentration of methyl red dye on the process of breaking down the dye in the presence of the catalyst ZnO

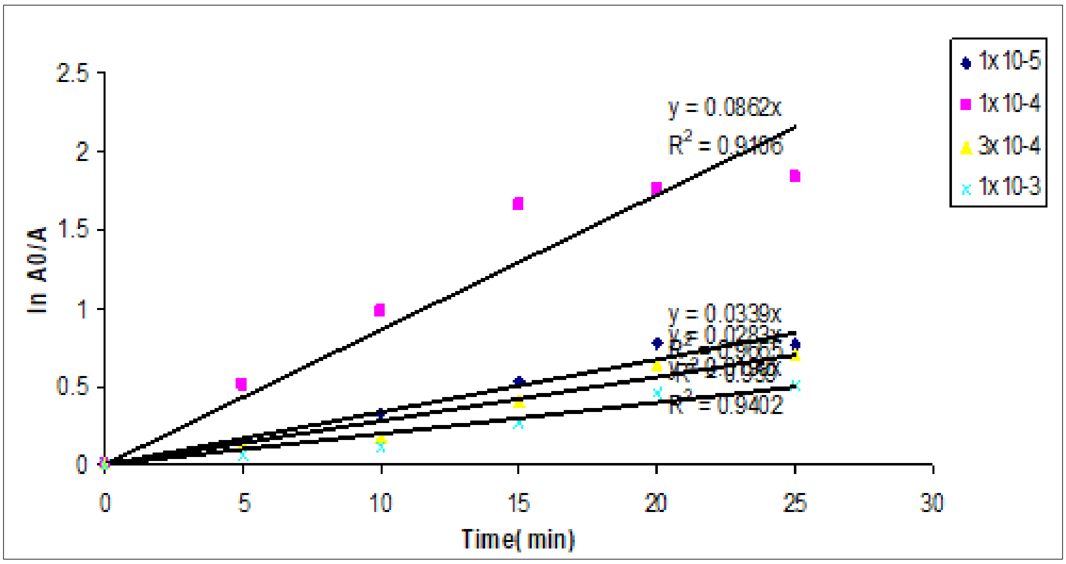

Figure 4: The relationship between (lnA0/A) and irradiation time using different concentrations of methyl red dye and in the presence of the catalyst (ZnO)

The practical results in Figure (3) show that the concentration ($1X10^{-4}$)the ideal concentration of the dye and in the concentration ($3X10^{-4}$) the degradation process decreases. The reason for this is attributed to the possibility of light not being absorbed by the molecules of the catalyst. The reason can also be attributed to an increase in the number of layers of dye deposited on the oxide surface, which leads to a reduction in the percentage of light entering the lowest layer deposited on the surface of the catalyst [19].

3- The Effect of Temperature

A number of experiments were conducted at different temperatures (5, 10, 15, 20)˚C, for a period of 60 minutes, with continuous stirring and passing O2 gas at a speed of 10 ml/min. (0.5 ml) of the reaction suspension was withdrawn, and after the suspension was separated by a centrifuge, a Detection using spectroscopic examination and the results were:

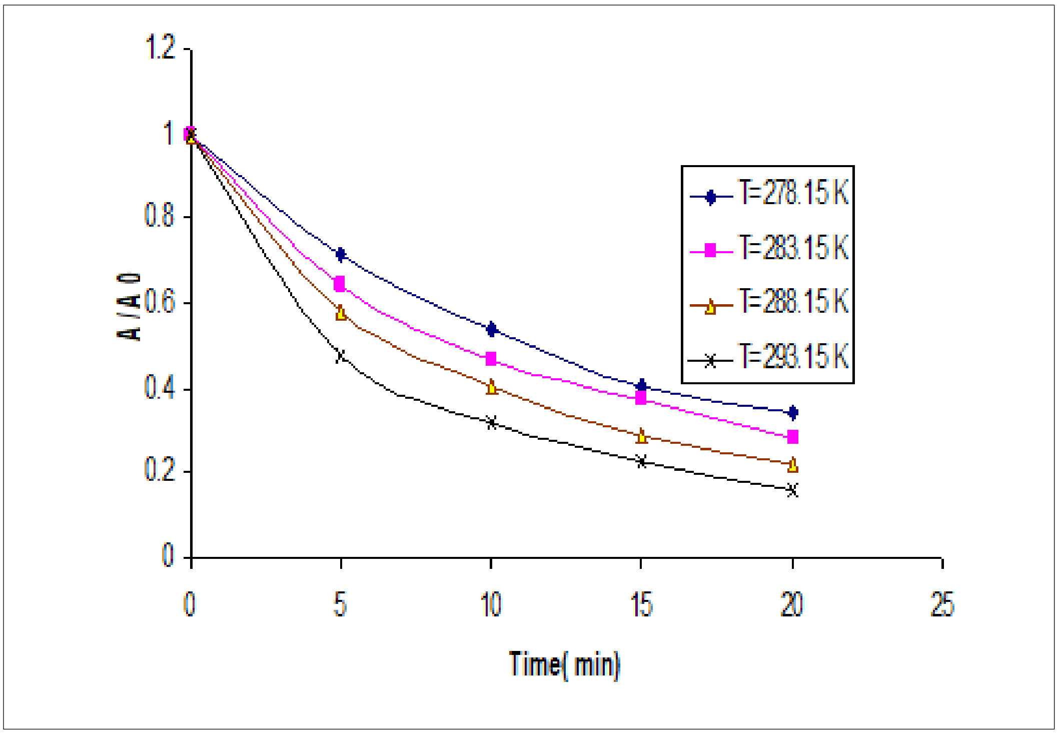

Figure 5: The effect of different temperatures on the process of degradation methyl red dye in the presence of pure zinc oxide

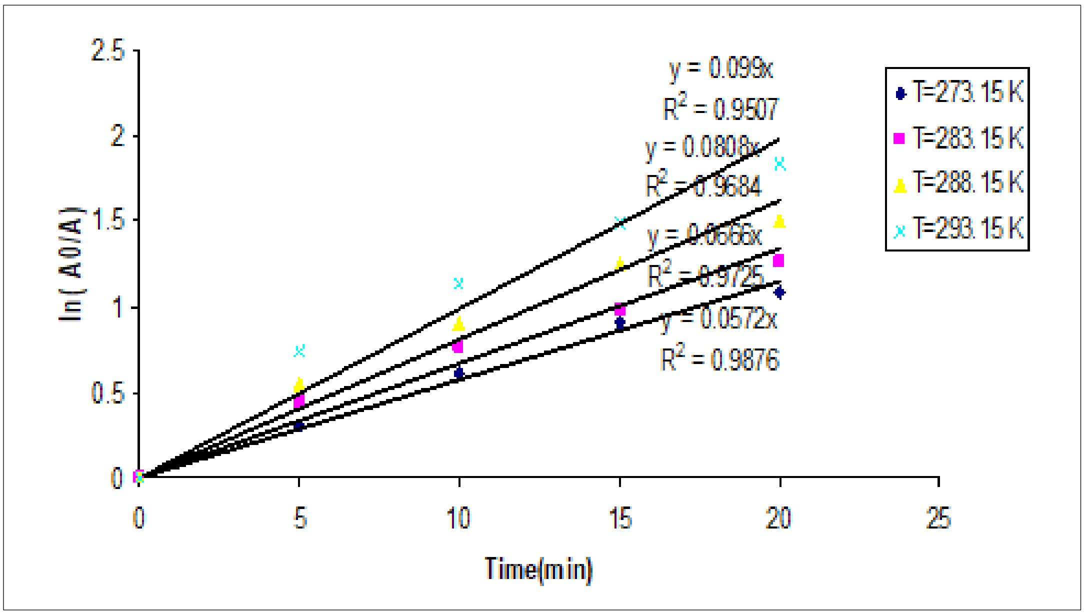

Figure 6: The relationship between (lnA0/A) and irradiation time using different temperatures and in the presence of the catalyst (ZnO)

The results in Figure (5) show that increasing the temperature has an effect in increasing the process of breaking down the methyl red dye. This is due to the increase in the number of photoelectrons excited to the conduction beam, which helps to increase the process of breaking down the methyl red dye [20].

CONCLUSION

Through the results of the study, the optimal conditions necessary to be used to break down methyl red dye, which is used in many industries to reduce pollution resulting from industrial dyes, were known. It was concluded that the importance of the presence of oxygen as a holder of electrons on the surface of the ZnO catalyst, which leads to reducing the reaction with positive holes, Using the optimal concentration of the dye and the optimal weight of the ZnO catalyst increases the effectiveness of cracking the methyl red dye as well. It was found that using high concentrations of dye leads to reducing the photodegradation process.

Conflict of Interest: No conflict of interest is associated with this work.

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