



Photocatalytic Removal of Malachite Green Using Vanadium Pentaoxide

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ABSTRACT

This study examines the photocatalytic degradation of Malachite green using Vanadium pentaoxide anatas, which is accomplished by irradiating a suspended solution with 0.11 gm/100 ml of mixed metal oxide semiconductor vanadium pentaoxide anatas using a mercury lamp 160 Watts from an external source inside a pyrex photoreaction cell of 100 ml at room temperature 298 K. Several tests were conducted under various circumstances to get the best Photocatalytic degradation of Malachite green in order to evaluate the influence of metal oxide Vanadium pentaoxide anatas. Utilizing a UV-Vis spectrophotometer, the items were investigated.

Key words: Degradation; semiconductor; V₂O₅; Malachite green.

INTRODUCTION

Some businesses and local textile manufacturers have recently significantly increased the improper discharge of leftover dyes and dye wastewater into water bodies [1]. Due to their poor biodegradability and risk for cancer, these are exceedingly hazardous for people, animals, and aquatic ecosystem [2]. Organic dyes have drawn particular attention as significant environmental pollutants due to their non-biodegradability and adverse effects on humans as a result of their high potential to be carcinogenic. green. The effects of temperature and hydrogen per oxide are also included in these studies. Utilizing a UV-Vis spectrophotometer, the items were investigated.

By developing industrial sectors like textile, paper, leather, food, plastic, and pharmaceutical companies, dye-filled effluent is dumped into the environment. Untreated wastewater seriously threatens environmental pollution because most dyes are harmful and carcinogenic [3]. Therefore, it is essential to cleanse effluents before discharging them into water bodies. Since it is one of the xanthene dyes most frequently used in industries, Rhodamine B (RhB) was selected as the study's model pollutant.

High dye permeability for catalytic degradation is made possible by nanophotocatalysts' large specific surface areas, homogenous sizes, and porous architectural designs. One of the potential photocatalysts is ZnONPs, which has a wide band gap energy, a high exciton binding energy, increased electronmobility, and high catalytic, non-toxic, antibacterial, and biocompatible qualities [4]. Furthermore, it is asserted that the cost of manufacturing ZnONPs is substantially cheaper than that of ZnO and Al₂O₃ nanoparticles [5]. ZnONPs are currently required in a number of industries, including wastewater treatment, solar cells, textiles, and cosmetics, as a result of their intrinsic properties.

Advanced oxidation techniques are currently very interested in the efficient oxidation of a wide variety of organics and pigments. The most attention is placed on the photocatalytic degradation helped by semiconductors. Most photocatalytic experiments use commercial or synthesized ZnO as their photocatalyst. However, recent studies have evaluated the significance of additional metal oxides. Among the other semiconductors, the photocatalyst ZnO looks to be the most promising [6].

The usage of ZnO or ZnO nanocomposites to increase the optical responsiveness of these materials into the visible light spectrum has garnered a lot of attention in the photocatalysis sector. Wide-bandgap semiconductors can now perceive light at greater wavelengths thanks to a variety of modification methods and procedures. These techniques include metal doping of semiconductors and sensitizing semiconductor surfaces with organic dyes and polymers [7].

MATERIALS & METHODS

The chemicals used in this work are listed below and all chemicals are standard without further purification.

1-Vanadium pentaoxide anatas (V₂O₅) : purity (99%) , particle size (100) mesh, supplied by Fluka AG.

2 – Malachite green supplied by sigma – Aldrich .

Experiments were carried out in glass photochemical reactor. 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 cm³) was put in the reaction chamber.



Fig. 1- Main parts of the photocatalytic cell used in Photocatalytic degradation of Malachite green dye.

RESULTS AND DISCUSSION

1. The Effect of vanadium pentaoxide mass on photo catalytic degradation of Malachite green

Malachite green at a concentration of 10 ppm, air moving at a rate of 10 ml/min, and a temperature of 298 K were used to study the impact of vanadium pentoxide mass on the photocatalytic degradation of the dye. Malachite green photocatalytic degradation processes are depicted in Figure 2 at various V₂O₅ loaded masses.

Malachite green deterioration by photocatalysis, progressively increases as vanadium pentaoxide concentrations rise until they reach a mass of 0.11 g/100 ml, at which point they start to decline. The semiconductor vanadium pentaoxide can offer the maximum light absorption when its mass is equivalent to 0.11 gm per 100 ml.

Only the first layers of Malachite green will see a reduction in photodegradation efficiency for vanadium pentoxide masses greater than 0.11 g/100 ml, as the other layers of solution do not receive light photons. In addition, light scattering from high vanadium pentoxide loading results in a reduction in photon intensity, which causes severe absorption of light through the reaction vessel's first consecutive layers of solution and obstruction of light passage through all additional layers..Many workers studied this effect [9-11]. At the loading mass of vanadium pentaoxide below the optimum value 0.11 gm /100 ml the rate of photodegradation of Malachite green also decrease due to the quantity of mass of vanadium pentaoxide decrease that mean the surface area decrease which lead to decrease of light absorption of light by vanadium pentaoxide which cause lower photodegradation rate of Malachite green.

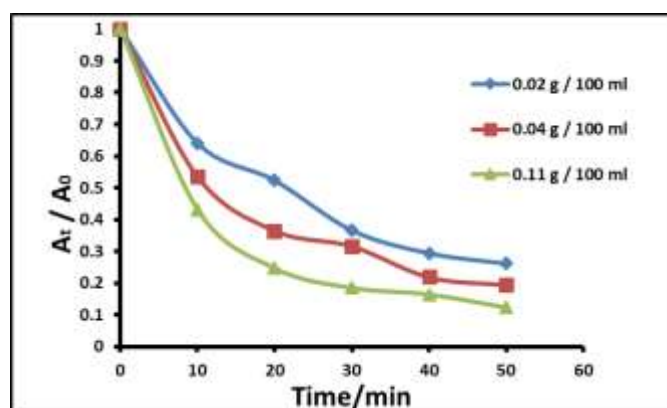


Fig. 2: The effect masses of vanadium pentaoxide on Photocatalytic degradation of Malachite green

The mass of V_2O_5 0.11 gm/100 ml gives the optimum photodegradation efficiency which is equal to 87.65%. The results of the change in photodegradation efficiency (P.D.E) with catalyst concentration plotted in figure 3.

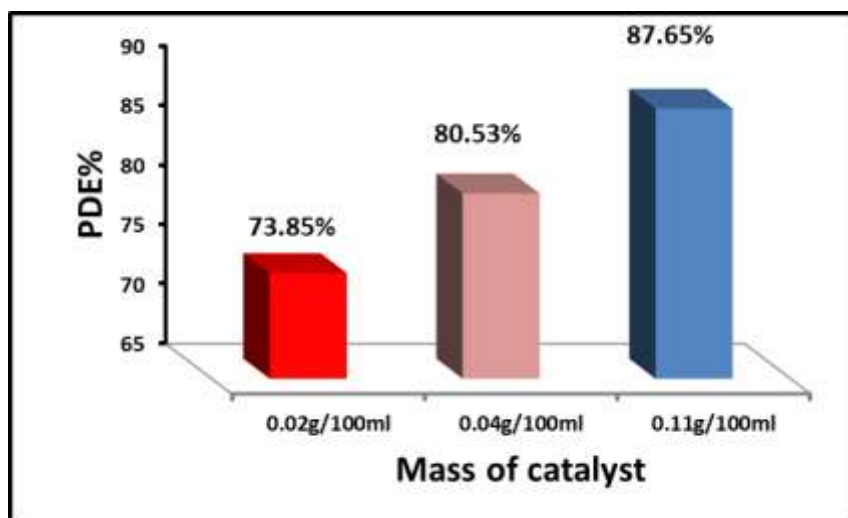


Fig.3 : The change of Photocatalytic Degradation Efficiency with irradiation time of different mass of catalyst

2. The Effect of initial Malachite green concentration on photo catalytic degradation processes

Malachite green photocatalytic degradation was tested using 0.11 gm/100 ml, 8.22 mW/cm² of light intensity, and 298 K of temperature. A number of tests were conducted to determine the impact of early changes (10 - 50 ppm) on the process. Figure 4 shows a visualization of the results. It has been found that as the initial concentration of malachite green increases, the rate of photocatalytic degradation steadily decreases. This behavior could be explained by the fact that 10 ppm was the ideal concentration for covering the vanadium pentoxide particles' greatest surface area., therefore absorbed maximum exciting photons to generate higher concentration of the activated vanadium pentaoxide semiconductor . Another explanation for this behavior is the sample's high quantity of malachite green, which is present in the sample at a concentration of 10 ppm on 0.11 gm/100 ml of vanadium pentoxide. It is difficult to create the necessary excited state of the malachite green adsorbed on vanadium pentaoxide due to the oversupply of malachite green, which blocks light from passing through successive layers of malachite green on the surface [12-14] .

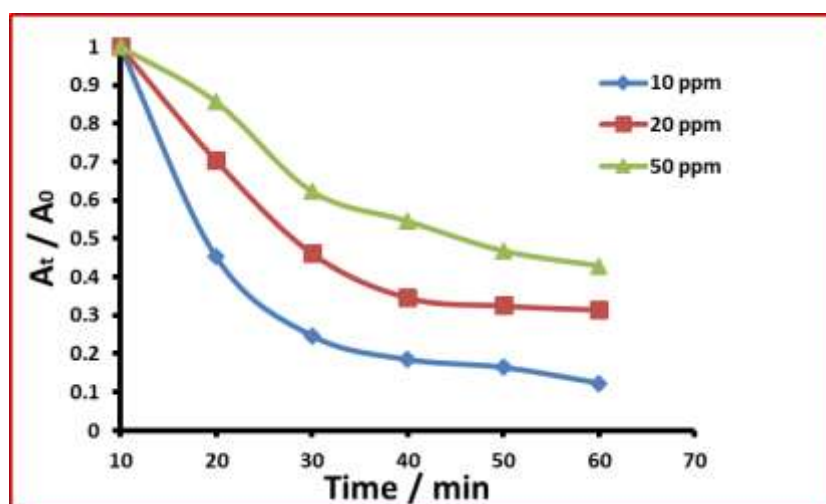


Fig.4: The change of (A / A₀) with irradiation time at concentration of Malachite green.

3. Effect of light intensity on photocatalytic degradation process of Malachite green

A series of experiments were conducted to determine the effects of light intensity ranging from 2.24 to 8.22 mW/cm² from a high mercury lamp 160 watts. All of the experiments were conducted under ideal conditions, which included loading vanadium pentoxide at a rate of 0.11 grams per 100 milliliters and starting with a concentration of Malachite green of 10 parts per million. figure 5, illustrate the effect of light intensity on the photocatalytic degradation of Malachite green. The results indicate that the photocatalytic degradation of Malachite green increases with the increase of light intensity, the maximum value of light intensity 8.22 mW/cm². Generally speaking, utilised lamp output photons promote electron transport from the valance band to the conduction band in vanadium pentoxide, which increases Malachite green's photocatalytic process. [15-17] .

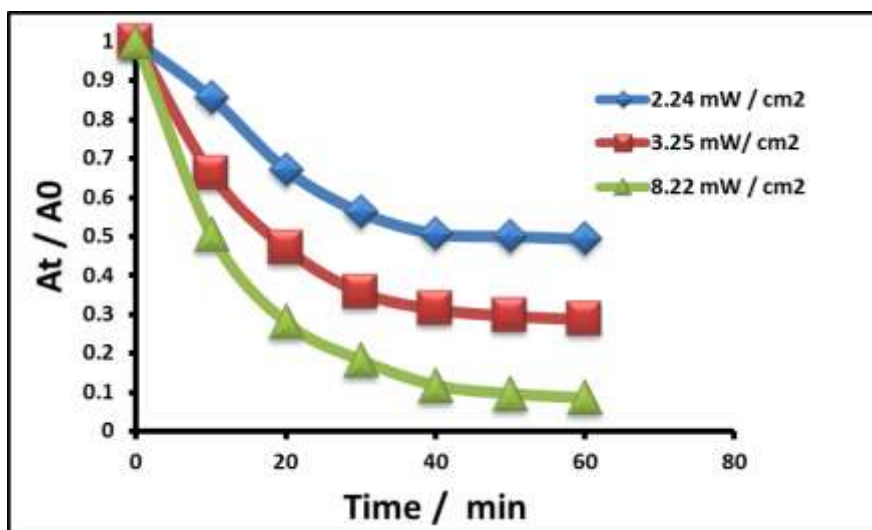


Fig.5: The change of (A / A₀) with irradiation time at different light intensity.

Conclusion

- 1- The photo degradation of Malachite green not degraded in absent of catalyst.
- 2 – The degradation of dye successfully degraded when used the catalyst with the light.
- 3 – The optimum condition for the Photocatalytic degradation of Malachite green (0.13 gm / 100ml mass of TiO₂ and 1ppm concentration of Malachite green.
- 4- Photocatalytic Degradation Efficiency (P.D.E %) was 91.82 %.

ACKNOWLEDGMENTS

Insincerely thank for the University of Babylon ,College of Science for women, for providing the necessary infrastructural facilities during my research.

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