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Photocatalytic degradation of rhodamine B using titanium dioxide

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Abstract
This research includes the study of Photocatalytic degradation of Rohdamine B using Titanium dioxide anatas, which is achieved by the irradiation of suspended solution consists of different concentration of Rohdamine b with 0.13 gm/100 ml of mixed metal oxide semiconductor titanium dioxide anatas by using mercury lamp 160 Watts from external source inside a pyrex photoreaction cell of 100 ml at room temperature 298 K. In order to study the effect of metal oxide Titanium dioxide anatas in Photocatalytic degradation of Rohdamine b, several experiments were carried out in various conditions to attain the best Photocatalytic degradation of Rohdamine B. These experiments include the effect of hydrogen per oxide, the effect of temperature. The products was studied by using UV-Vis spectrophotometer.

Keywords: Photo degradation, semiconductor, TiO_2, rohdamine B

Introduction
Recent times have seen a significant increase in the improper discharge of residual dyes and dye effluent into water bodies by some enterprises and local textile makers [1]. These are extremely dangerous for people, animals, and the aquatic ecology due to their poor biodegradability and potential for cancer [2]. Due to their non-biodegradability and negative impacts on humans as a result of their high potential to be carcinogenic, organic dyes have received special attention as important environmental pollutants.
Dye-filled wastewater is released into the environment by expanding industrial sectors like textile, paper, leather, food, plastic, and pharmaceutical businesses. Since the majority of dyes are dangerous and carcinogenic, untreated wastewater poses a serious risk of environmental pollution [3]. As a result, treating effluents before releasing them into water bodies is crucial. Rhodamine B (RhB) was chosen as the study's model pollutant since it is one of the most often utilized xanthene dyes in industries.
Large specific surface areas, homogeneous sizes, and porous architectures of nanophotocatalysts allow for high dye permeability for catalytic degradation. ZnONPs, which has a wide band gap energy, a high exciton binding energy, improved electron mobility, and high catalytic, non-toxic, antibacterial, and biocompatible properties, is one of the promising photocatalysts [4]. Additionally, it is claimed that ZnONPs are produced at a significantly lower cost than ZnO and Al_2O_3 nanoparticles [5]. Due to their inherent qualities, ZnONPs are now a necessary component in a number of industries, including wastewater treatment, solar cells, textiles, and cosmetics.
The efficient oxidation of a wide range of organics and dyes is currently of great interest in advanced oxidation techniques. The semiconductor assisted photocatalytic degradation is given top emphasis among them. The photocatalyst used in the majority of photocatalytic investigations is either synthesized or commercial ZnO. However, current research has been done to assess the importance of additional metal oxides. The photocatalyst ZnO appears to be the most promising among the other semiconductors [6].
Catalyst mass concentration is a crucial factor in the tuning of NP colloidal solution photocatalytic activity. In this study, we examined how photodegradation rates of Methylene Blue (MB) and Rhodamine B (RB) varied in response to different ZnO nanoparticle concentrations produced by laser synthesis. Much interest in photocatalysis field has focused on the use of ZnO or ZnO Nano composites to extend the optical response of these materials

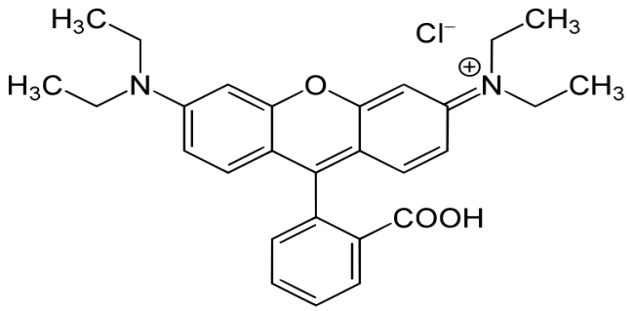
into the visible light range. Various modification methods and techniques have been obtained to make wide-bandgap semiconductors sense light at higher wavelengths as well. Such methods include sensitization of semiconductor surfaces with organic dyes and polymerd, coupling of semiconductors and metal doping of semiconductors [7].

Rhodamine B: Is a chemical compound and a dye. It is often used as a tracer dye within water to determine the rate and direction of flow and transport. Rhodamine dyes fluoresce and can thus be detected easily and inexpensively with instruments called fluorometers. Rhodamine dyes are used extensively in biotechnology applications such as fluorescence microscopy, flow cytometry, fluorescence correlation spectroscopy and ELISA.

Rhodamine B is used in biology as a staining fluorescent dye, sometimes in combination with auramine O, as the auramine-Rhodamine stain to demonstrate acid-fast organisms, notably Mycobacterium.

Rhodamine B is tunable around 610 nm when used as a laser dye. Its luminescence quantum yield is 0.65 in basic ethanol, 0.49 in ethanol, 1.0, and 0.68 in 94% ethanol. The fluorescence yield is temperature dependent [8].

The solubility of Rhodamine B in water is ~15g/L. However, the solubility in acetic acid solution (30 vol. %) is ~400 g/L. However, the solubility of Rhodamine B in water is reported as 0.8 g/100 mL and 1.5 g/100 mL in ethanol, which is more consistent with solubility in water and ethanol. Chlorinated tap water decomposes Rhodamine B. Rhodamine B solutions adsorb to plastics and should be kept in glass.



Structure of Rhodamine B

Materials and Methods

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

1. Titanium dioxide anatas (TiO_2): purity (99%), particle size (100) mesh, supplied by Fluka AG.
2. Rhodamine b supplied by sigma – Aldrich.

1. Titanium dioxide nanoparticle (TiO_2): Supplied by Fluka AG.

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 cm^3) was put in the reaction chamber.

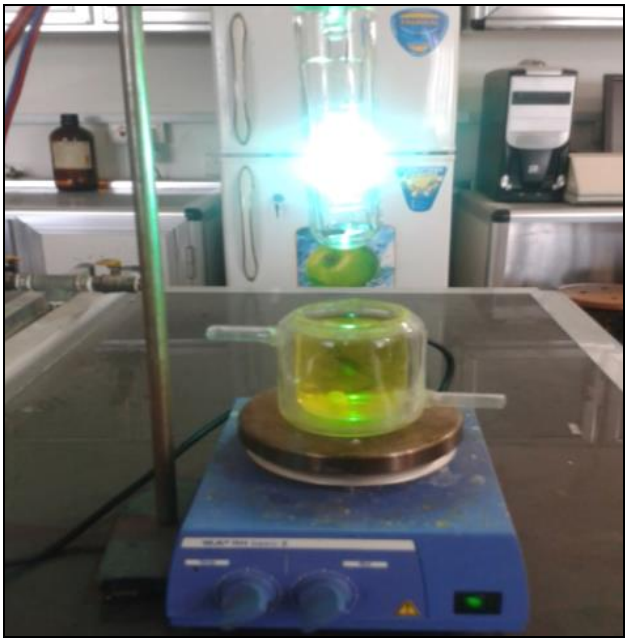


Fig 1: Main parts of the photocatalytic cell used in Photocatalytic degradation of Rohdamine b dye.

Results and Discussion

1. The Effect of titanium dioxide mass on photo catalytic degradation of Rohdamine b

The effect of mass of titanium dioxide on Photocatalytic degradation of Rohdamine b, was studied using 1 ppm of Rohdamine b, flow rate of air 10 ml/min, room temperature 298 K. Figure (2) represent photo catalytic degradation processes of Rohdamine b at different loaded mass of titanium dioxide. Photocatalytic degradation of Rohdamine b. gradually increases as the masses of titanium dioxide increases until reach to the mass titanium dioxide 0.13gm/100ml, then gradually decreases. When the mass of titanium dioxide equal 0.13 gm /100ml the semiconductor titanium dioxide can be provide the highest absorption of light. The decrease in the efficiency of phtodegradation process at the masses of titanium dioxide higher than 0.13 gm /100ml due to the light absorption will be limited only to the first layers of Rohdamine b and the other layers of solution do not receive light photons. Moreover light scattering at high titanium dioxide loading, this lead to decrease the photon intensity, so the strong absorption of light through the first successive layers of solution and prevent light from passing through all other layers in the reaction vessel. Many workers studied this effect [9-11]. At the loading mass of titanium dioxide below the optimum value 0.13 gm /100 ml the rate of photodegradation of Rohdamine b also decrease due to the quantity of mass of titanium dioxide decrease that mean the surface area decrease which lead to decrease of light absorption of light by titanium dioxide which cause lower photodegradation rate of Rohdamine b.

The mass of TiO_2 0.13 gm/100 ml gives the optimum photo degradation efficiency which is equal to 91.82%. The results of the change in photo degradation efficiency (P.D.E) with catalyst concentration plotted in figure 3.

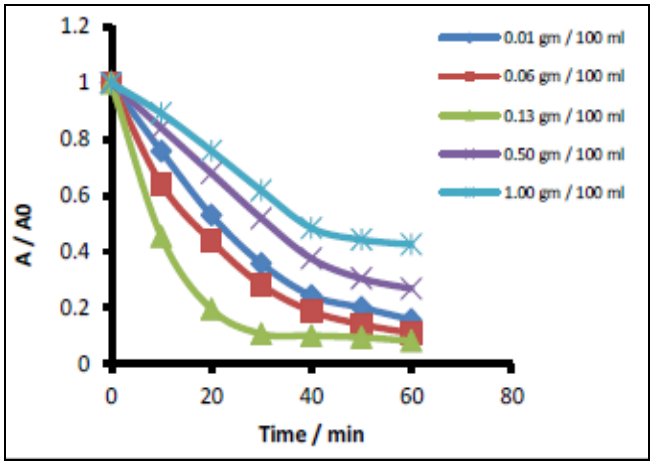


Fig 2: The effect masses of titanium dioxide on Photocatalytic degradation of Rohdamine b

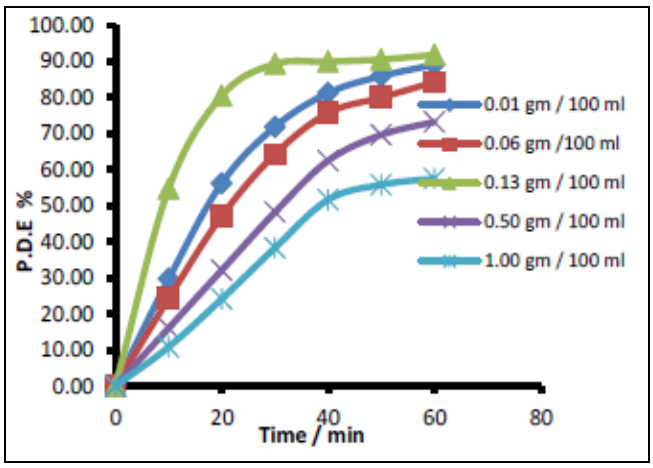


Fig 3: The change of Photocatalytic Degradation Efficiency with irradiation time of different types of catalyst

2. The Effect of initial Rohdamine b concentration on photo catalytic degradation processes

A serious of experiments have been done, the effect of change initial (1-10 ppm) on photocatalytic degradation process of Rohdamine b was studied using 0.13 gm / 100 ml, the light intensity equal to 8.22 mW/cm^2, and temperature equal to 298 K. The results are listed in Table 3 and plotted in figure 4. It has been observed that the rate of photocatalytic degradation gradually decreases with the increasing of initial Rohdamine b concentration. This behaviours could be explained, the concentration 1ppm was the optimum concentration to cover the largest area of the titanium dioxide particles, therefore absorbed maximum exciting photons to generate higher concentration of the activated titanium dioxide semiconductor. Another reason for this behaviour is the strong absorption of light by the Rohdamine b in the sample which contain high concentration that 1 ppm, Rohdamine b on 0.13 gm /100 ml of titanium dioxide. The excess of Rohdamine b prevent the penetration of light through the successive layers of Rohdamine b on the titanium dioxide surface is weak to generate the required excited state of the Rohdamine b adsorbed on titanium dioxide [12-14]. The concentration of Rhodamine b 1ppm gives the optimum photo degradation efficiency which is equal to 91.82%. The results of the change in photocatalytic degradation efficiency (P.D.E) with concentration of Rhodamine b plotted in figure 9.

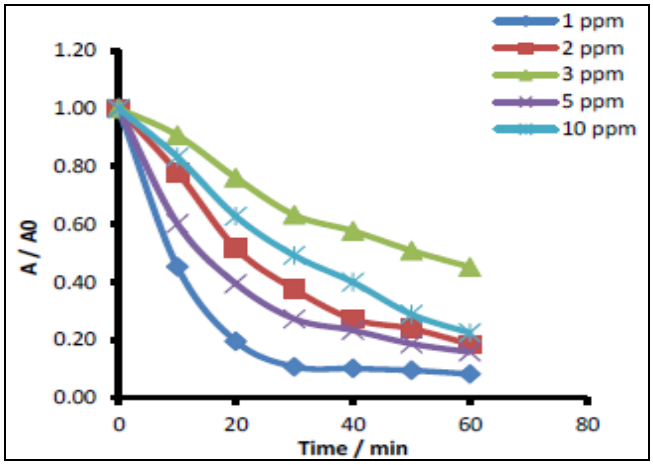


Fig 4: The change of (A/A0) with irradiation time at concentration of Rohdamine b

3. Effect of light intensity on photocatalytic degradation process of Rohdamine b

A serious of experiment were carry out to study the effect of light intensity rang (2.15-8.22) mW/cm2 from high mercury lamp 160 watts, all experiments was studied using optimum condition the weight of loaded of titanium dioxide 0.13 gm / 100 ml and the initial concentration of Rohdamine b 1 ppm, with flow rate of air bubbling is kept constant at 10ml/min, at room temperature 298K.

Table 5 and figure 10, illustrate the effect of light intensity on the photocatalytic degradation of Rohdamine b. The results indicate that the photocatalytic degradation of Rohdamine b increases with the increase of light intensity, the maximum value of light intensity 8.22 mW/cm2. In general the used lamp production photons this photons increase electrons transfer from valance band to conduction band in the titanium dioxide this process lead to increase photocatalytic process of Rohdamine b [15-17].

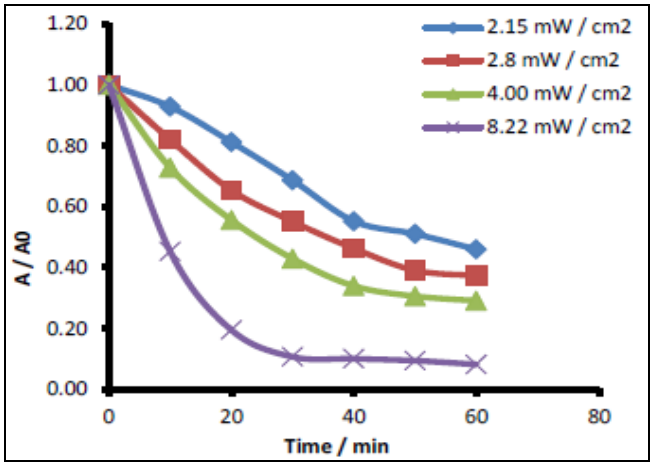


Fig 5: The change of (A/A0) with irradiation time at different light intensity with 0.13 gm/100 ml TiO_2 ANATAS on photocatalytic degradation of Rhodamine b

4. Comparison between photolysis process and photocatalytic process of photocatalytic degradation of Rohdamine b

Different experiments were carried out using photolysis process and photocatalytic degradation of Rohdamine b with optimum condition were mass of TiO_2 0.13 gm / 100 ml, 1 ppm of Rohdamine b and 298 k room temperature. Photolysis process experiments were carried out in the

absence of the catalyst and the existence of the UV light. The results are shown in figure 6 show that the photolysis of Rohdamine b is under UV (A) light and photocatalytic degradation process. From the figure 6 clear that the photocatalytic degradation of Rohdamine b using photocatalytic process more than photolysis process because the presence of TiO_2 catalyst lead to increases of photocatalytic degradation of Rohdamine b.

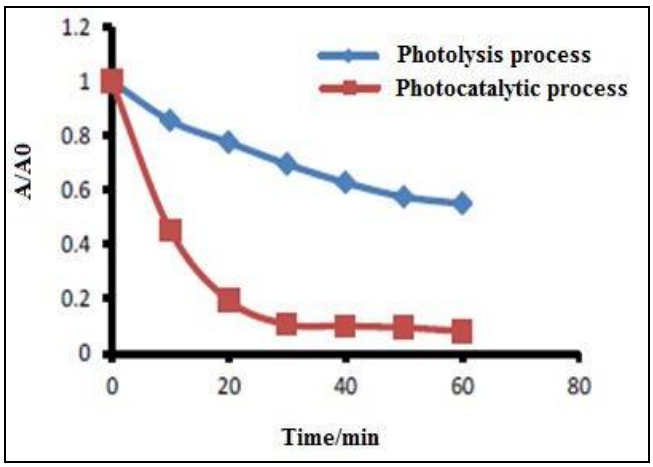


Fig 6: The change of (A/A0) with irradiation time for Photolysis process and Photocatalytic process

Conclusion

1. The photo degradation of Rohdamine b 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 Rohdamine b (0.13 gm / 100 ml mass of TiO_2 and 1ppm concentration of Rohdamine b.
4. Photocatalytic Degradation Efficiency (P.D.E%) was 91.82%.

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