

## Photodegradation of Rhodamine 6G Molecules Using TiO<sub>2</sub> Photocatalyst

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**Abstract:** In this work the photodegradation of Rhodamine 6G was studied by adding different amounts of semiconductor (TiO<sub>2</sub>), as a photocatalyst, to fixed concentration of Rhodamine 6G in water and the mixture was irradiated by UV light in the range from 270 to 280 nm. The UV light has energy of 750 mJ and spot size of 4 cm<sup>2</sup> and the irradiation was done in different exposure times. The absorption spectra of Rhodamine 6G with different amounts of catalyst, before and after irradiation, were recorded and compared. The results showed that the efficiency of the photodegradation process was increased with increasing the amount of semiconductor (TiO<sub>2</sub>) and irradiation time. The percentage of Rhodamine 6G degradation was 16% when 100 mg of TiO<sub>2</sub> was added and irradiated for 10 min, while 82% of Rhodamine 6G was removed when 600mg of TiO<sub>2</sub> was added and irradiated for 30 min. This study concluded that the degradation of Rhodamine 6G is increased with increasing the amount of semiconductor (TiO<sub>2</sub>) and with increasing the irradiation time.

**Keywords:** photocatalysis, photodegradation, Rhodamine 6G, TiO<sub>2</sub>.

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### I. Introduction:

The word photocatalysis is a composite word which is composed of two parts, “photo” and “catalysis”. Catalysis is the process where a substance participates in modifying the rate of a chemical transformation of the reactants without being altered or consumed in the end. This substance is known as the catalyst which increases the rate of a reaction by reducing the activation energy [1].

Generally, photocatalysis is a reaction which uses light to activate a substance which modifies the rate of a chemical reaction without being involved itself. In other words, the photocatalyst is the substance which can modify the rate of chemical reaction using light irradiation without being altered or consumed in the end [2, 3]. Toxicology and carcinogenesis studies of Rhodamine 6G were conducted because of potential human exposure resulting from it when used as a dye for natural and synthetic fibers and in biomedical research and because of the absence of information on Rhodamine 6G toxicity and potential carcinogenicity. Rhodamine 6G can cause severe eye irritation, respiratory tract and skin irritation, might be harmful if absorbed through skin or if swallowed, may be harmful if inhaled, and the laboratory tests indicate that this material may be carcinogenic. Rhodamine 6G is toxic to eukaryotic cell mitochondria and it depending on cellular concentration. In two-stage skin models of carcinogenesis, activation of protein kinases C by a promoter, such as 12-O-tetradecanoylphorbol-13-acetate (TPA), it is considered to be an integral event associated with the promotion and development of skin neoplasms (papillomas or carcinomas). O'Brian and Weinstein in (1987) found that Rhodamine 6G inhibited rat brain protein kinases C after activation with the tumor promoter TPA, presumably through a chemical-lipid interaction and the induction of cytotoxicity, but not in the absence of lipid cofactor. There is no reported evidence that Rhodamine 6G inhibits protein kinases C isolated from epidermal cells. However, inhibition of rat brain protein kinases C in vitro suggests Rhodamine 6G should not induce skin neoplasms or promote spontaneously occurring skin neoplasm's [4,5].

The aims of this work are:

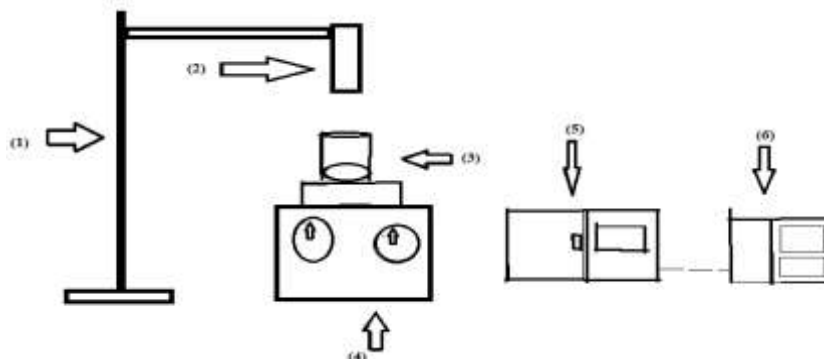
- To study the effect of the amount of TiO<sub>2</sub> on the process of photodegradation of Rhodamine 6G in waste water.
- To study the effect of the exposure time of UV light on the process of photodegradation of Rhodamine 6G in waste water.

### II. Materials and Methods:

The samples under study were prepared by dissolving 7mg from Rhodamine 6G in 100 ml of distilled water then 100 mg of the catalyst (TiO<sub>2</sub>) was added to the first sample. Similarly 300mg from the same semiconductor was added to the second sample and finally 600mg of TiO<sub>2</sub> was added to the third sample. After that, a small portion of the first sample was put in quartz cell and placed in the compartment of the UV spectrometer and the absorption spectrum was recorded and used as reference. Similarly this step was repeated for the second and the third samples, separately.

The first sample was irradiated with 750 mJ of UV light with wavelengths of (270-280 nm) and spot size of 4cm<sup>2</sup> for 10 minutes, then the absorption spectrum of this sample was recorded using the UV spectrometer. The above step was repeated with irradiation time of 20 and 30 minutes. The absorption spectra were recorded for the two cases. The above steps were repeated for samples two and three. The effects of TiO<sub>2</sub> amount and irradiation times were deduced from the comparison between the intensity of the absorption bands of Rhodamine 6G in each case.

Figure (1) shows a schematic diagram of the setup arrangement.



**Figure (1):** Schematic diagram of setup used in this work

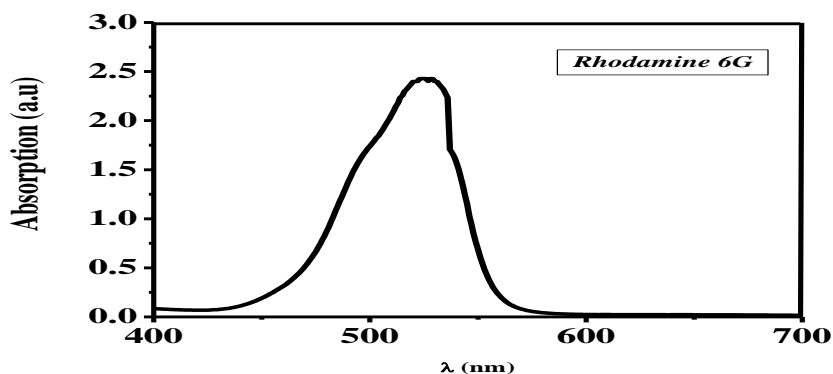
- (1) Holder, (2) The UV light source, (3) the glass beaker, (4) Themagnetic stirrer, (5) The UV/Vis. spectrometer and (6) The printer.

### III. Results:

The results are classified into two categories: The effect of the amount of the semiconductor and The dependence of the degradation of Rhodamine 6G on the irradiation time.

#### The absorption spectrum of Rhodamine 6G in 100 ml of water without irradiation:

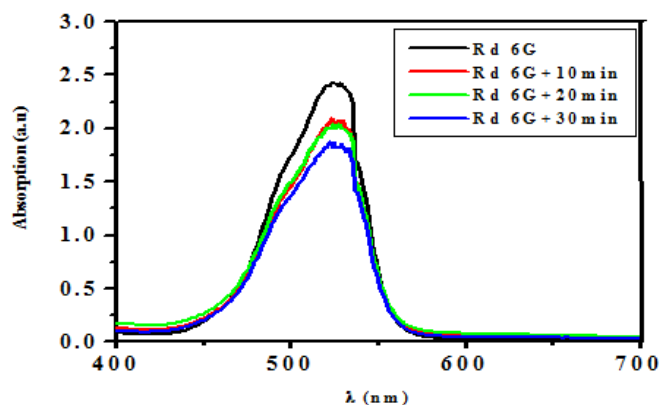
Figure (2) shows the absorption spectrum of Rhodamine 6G without addition of semiconductor and without irradiation. It can be observed in the figure a strong absorption band at 525nm.



**Figure (2):** The absorption spectrum of Rhodamine6G without irradiation and semiconductor

#### The Absorption spectra of Rhodamine 6G mixed with 100 mg of TiO<sub>2</sub> irradiated by UV light source for different times:

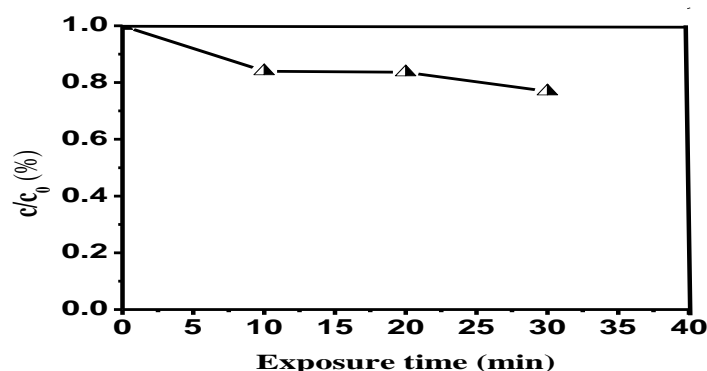
Figure (3) shows the absorption spectra of Rhodamine 6G mixed with 100 mg of TiO<sub>2</sub> at different exposure times.



**Figure (3):** The absorption spectra of Rhodamine 6G mixed with 100 mg of  $TiO_2$  irradiated by UV light for different exposure times

It can be observed from figure (3) that the intensity of the absorption peak of Rhodamine 6G at 525 nm is not significantly decreased with increasing the irradiation time.

Figure (4) shows the effect of irradiation times of the UV light on the ratio of the amount of Rhodamine 6G after and before irradiation.

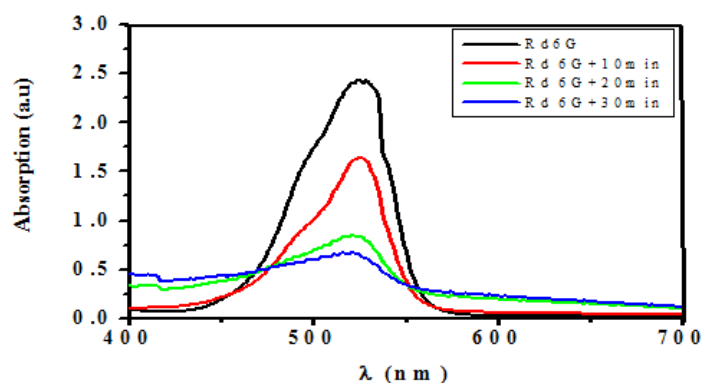


**Figure (4):** The effect of exposure time on the ratio of the amount of Rhodamine 6G after and before irradiation

From figure (4) it can be seen that the exposure time was slightly affect the ratio between the amount of Rhodamine 6G after and before irradiation when the catalyst was 100 mg only.

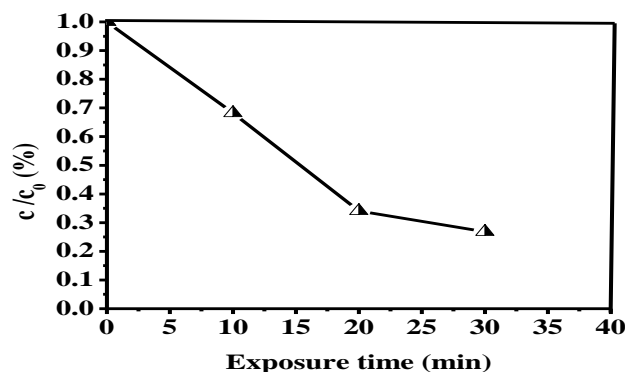
**The absorption spectra of Rhodamine 6G mixed with 300 mg of  $TiO_2$  irradiated by UV light for different times:**

The absorption spectra of Rhodamine 6G mixed with 300 mg of  $TiO_2$ , after irradiation for different exposure times, are shown in figure (5). The effect of the irradiation time on the degradation of Rhodamine 6G can be noticed through the decrease of the absorption intensity of Rhodamine 6G at 525nm with time increasing.



**Figure (5):** The absorption spectra of Rhodamine 6G mixed with 300 mg of  $TiO_2$  irradiated by UV light for different times

Figure (6) shows the effect of irradiation times of UV light on the ratio between the amount of Rhodamine 6G after and before irradiation.

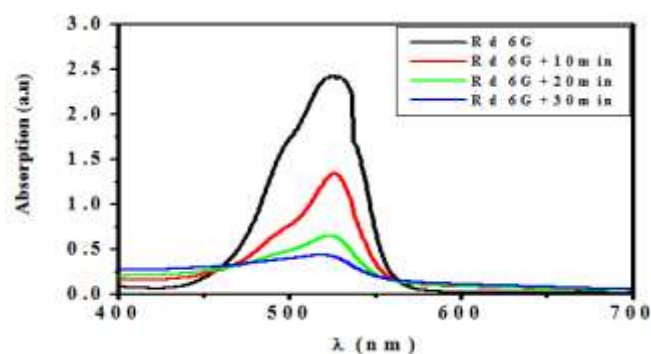


**Figure (6)** The ratio between the amount of Rhodamine 6G after and before irradiation mixed with 300 mg of  $TiO_2$  and irradiated for different exposure times.

One can noticed that the ratio of the amount of Rhodamine6G after and before irradiation was decreased significantly with the increasing of expoure times when 300 mg of  $TiO_2$  was used.

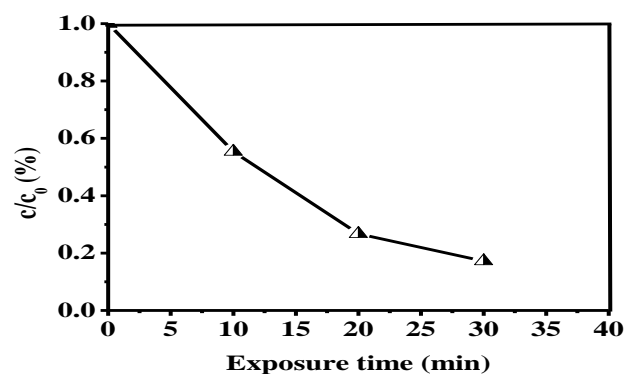
**The absorption spectra of Rhodamine 6G mixed with 600 mg of  $TiO_2$  irradiated by UV light source for different times:**

Figure (7) shows the absorption spectra of the Rhodamine 6G mixed with 600 mg of  $TiO_2$  after irradiation with different exposure times, The effect of the irradiation time on the degradation of Rhodamine 6G can be noticed through the decrease of the absorption intensity at 525nm.



**Figure (7):** The absorption spectra of Rhodamine 6G mixed with 600 mg of  $TiO_2$  irradiated by UV light for different exposure times.

Figure (8) shows the effect of irradiation times of UV light on the ratio between the amount of Rhodamine 6G after and before irradiation.

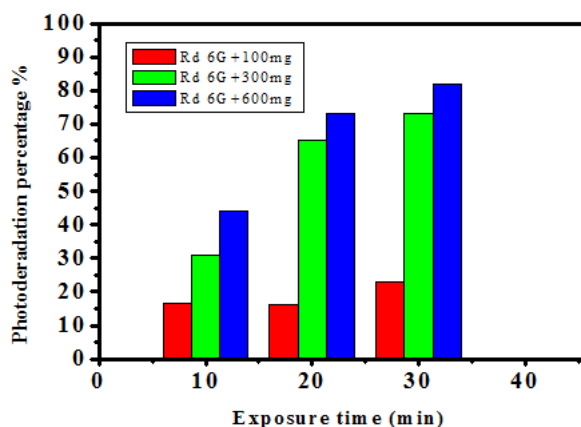


**Figure (8):** The ratio between the amount of Rhodamine 6G after and before irradiation mixed with 600 mg of  $TiO_2$  and irradiated for different exposure times.

As can be seen from figure (8) the ratio of the amount of Rhodamine 6G after and before irradiation is approximately decay too much with 30 min. irradiation time.

#### Comparison of the degradation rate of Rhodamine 6G with different irradiation times and different TiO<sub>2</sub> weights:

Figure (9) shows the degradation percentage of Rhodamine 6G at different exposures times and different weights of TiO<sub>2</sub>.



**Figure (9):** The degradation percentage of Rhodamine 6G at different exposure times with different weight of TiO<sub>2</sub> catalyst.

#### IV. Discussion:

The photodegradation percentage of **Rhodamine6G** mixed with 100mg of TiO<sub>2</sub> was 16% when irradiated for 10 minutes and it was slightly increased to 16.5% when irradiated for 20 minutes and finally increased to 23% at 30 minutes. The amount of TiO<sub>2</sub> mixed with **Rhodamine6G** and the exposure time are not efficient for photodegradation process in this case.

For the case of **Rhodamine6G** mixed with 300mg of TiO<sub>2</sub> shown in figure (5), one can see that the number of **Rhodamine6G** molecules absorbing light is decreased significantly. The percentage of photodegradation process was increased to 31%, 65% and 73% at 10, 20 and 30 minutes, respectively.

As it can be observed from figure (7), the absorption spectra of **Rd 6G** mixed with 600mg of TiO<sub>2</sub> showed the highest decreasing of **Rd 6G** and there was a significant increase in the percentage of photodegradation process which was 43% when irradiated for 10 minutes, 73% for 20 min and was 82% for 30 minutes. The photodegradation process for **Rd 6G** mixed with 600mg of TiO<sub>2</sub> was more efficient than those with 100 mg and 300mg.

These results are in agreement with the results of M. Qamar, M.A. Gondal, and Z.H. Yamani [6], where they studied the removal of **Rd 6G** induced by laser and WO<sub>3</sub> nanocomposite, and the results of Tanmay K. Ghorai, Niladri Biswas [7], in their studies of photodegradation of **Rd 6G** in aqueous solution via SrCrO<sub>4</sub> and TiO<sub>2</sub> nano-sphere mixed oxides. Moreover, here is a good agreement with the results of Ashish Bansal, Deependar Sharma, Rakshit Ameta and Hari S. Sharma where they studied the photodegradation of rhodamine-6G in presence of ammonium phosphomolybdate and the results of Sandip P. Patila, V.S. Shrivastava & G.H. Sonawane where they studied the Photocatalytic degradation of **Rhodamine 6G** using ZnO-montmorillonite nanocomposite [8, 9].

#### V. Conclusions

From the results obtained in this work the followings can be concluded that:

1. The degradation of **Rhodamine 6G** increased with the increasing of exposure time.
2. The degradation of **Rhodamine 6G** increased with the increasing of semiconductor weight.
3. The degradation is very efficient in the case of **Rhodamine 6G** mixed with 600mg TiO<sub>2</sub> irradiated with UV light for 30 minutes.

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**NOTES:**

- [1]. The proposal of the study was approved by the research council of the institute of laser / Sudan University of Science and Technology.
- [2]. No animals were used in the study, so there was no need for licenses and approvals from animal ethics committee.
- [3]. There wasn't fieldwork in the study.
- [4]. We have no competing interests.
- [5]. Authors contribution:
  - First author: design of the study, results analysis and revision of the manuscript.
  - Second author: laboratory work and writing the draft of the manuscript.
- [6]. There was no fund from any part.