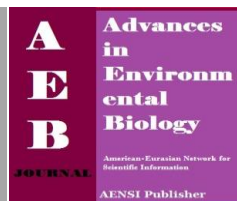




AENSI Journals

**Advances in Environmental Biology**

ISSN:1995-0756 EISSN: 1998-1066

Journal home page: <http://www.aensiweb.com/aeb.html>

## Effect of TiO<sub>2</sub> Concentration on Photocatalytic Degradation of Reactive Orange 16 Dye (Ro16)

<sup>1</sup>Khaled Mezughi, <sup>2</sup>Chedly Tizaoui, <sup>3</sup>Ma'an Fahmi Alkhatib

<sup>1</sup>Petroleum and Chemical Department, Faculty of Engineering, Azzawia University, Azzawia, Libya.

<sup>2</sup>College of Engineering, Swansea University, Singleton Park, Swansea, SA2 8PP.

<sup>3</sup>Department of Biotechnology Engineering, Kulliyah of Engineering, International Islamic University Malaysia.

### ARTICLE INFO

#### Article history:

Received 23 December 2013

Received in revised form 25

February 2014

Accepted 26 February 2014

Available online 25 March 2014

#### Key words:

Photocatalytic Degradation, Reactive Orange 16 Dye (RO16), TiO<sub>2</sub>

### ABSTRACT

Organic contaminants from industrial and/or domestic effluents may be harmful to humans directly or indirectly by degrading the quality of the environment. Consequently these contaminants must be reduced to levels that are not harmful to humans and the environment before disposal. Among the available chemical methods heterogeneous photocatalytic oxidation has been found particularly to be effective in removal of large number of persistent organics in water. Degradation of the organics was achieved by exposing synthetic effluents to UV light in a photocatalytic reactor in a dark compartment in the presence of catalyst. The degradation of RO16 was conducted at pH 5.5, 24 hr, 294 K and lamp power of 200 W. RO16 was prepared in 200 ml dye solution with concentrations of 20, 40 and 60 mg/L and the degradation took place in presence of TiO<sub>2</sub> at concentrations of (0.5-4.0) g/L. While photolysis (in absence of TiO<sub>2</sub>) was found to have no effect on the degradation of RO16, photocatalysis (in presence of TiO<sub>2</sub> catalyst) degraded the dye to 0.4 mg/L.

© 2014 AENSI Publisher All rights reserved.

**ToCite This Article:** Khaled Mezughi, Chedly Tizaoui, Ma'an Fahmi Alkhatib., Effect of TiO<sub>2</sub> Concentration on Photocatalytic Degradation of Reactive Orange 16 Dye (Ro16). *Adv. Environ. Biol.*, 8(3), 692-695, 2014

## INTRODUCTION

Contamination in water may lead to diseases, bacterial attack, fungal and sometimes even fatal consequences. For example there are many sources of ground water pollution that can cause nasty tastes and odors, and that may be a risk to human health. Contamination of surface and ground waters may occur naturally or as a result of human activities such as agricultural runoff, industrial discharges and chemical spills [1,2]. Water pollutants such as microorganisms, nitrates and nitrites and micropollutants are examples of health risk contaminants. Many industrial processes generate wastewater streams contaminated with organic compounds harmful to human health and the environment. Water pollution by micropollutants such as pesticides, textile, dioxins, and organic compounds and so on is a worldwide problem at present [3]. The low removal rates of textile dyes turn them into potentially toxic contaminants [4,5,6] and if not managed, textile dyes will become a long-term risk on health [7,8]. Azo dyes are ubiquitous commercial chemicals that present unique environmental problems. More than 300 million pounds of dyes are produced annually in the United States. Colored dye effluents poses a major problem for the manufacturing plant as well as water-treatment plants downstream. Quite apart from the aesthetic desirability of colored streams resulting from dye waste, the azo dyes in particular can undergo natural anaerobic degradation to potentially carcinogenic amines [9]. One of the promising technologies is photocatalysis, which was found to be effective in removing a wide range of organic and inorganic compounds [10] and have been applied successfully in treating both drinking and waste waters [11]. In this work photocatalytic degradation, employing TiO<sub>2</sub> as catalyst is used for removal of Reactive Orange 16 dye (RO16).

## MATERIALS AND METHODS

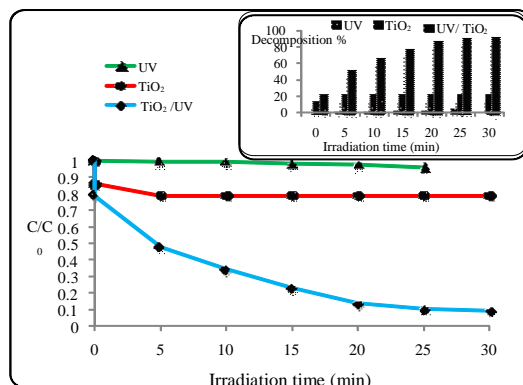
Azo dye RO16 prepared in 200 ml at different concentrations (20, 40 and 60 mg/L) was exposed to photocatalytic degradation using various concentrations of TiO<sub>2</sub> (0.5-4.0 g/L). The exposure time was varied from 0-90 min, depending on the initial concentration of RO16. All Photocatalytic degradation was carried out at pH 5.5, 24 hr, 294 K and lamp power of 200 W. Analyses of the dye by UV-Vis were made by measuring

**Corresponding Author:** Ma'an F.R. Alkhatib, Department of Biotechnology Engineering, Kulliyah of Engineering, International Islamic University Malaysia  
Phone number: +603 6196 4553, +601 6236 5704; Fax number: +603 6196 4442  
E-mail: maan@iiu.edu.my, dhakisalafi@live.com

the absorbance at  $\lambda_{max} = 494\text{nm}$ .

## RESULTS AND DISCUSSIONS

In order to investigate the effect of the presence of the photocatalyst, the decolorization of RO16 dye in aqueous solution was studied using only UV irradiation, only  $\text{TiO}_2$  photocatalyst in dark, and UV in the presence of  $\text{TiO}_2$ . The results are shown in Figure 1.



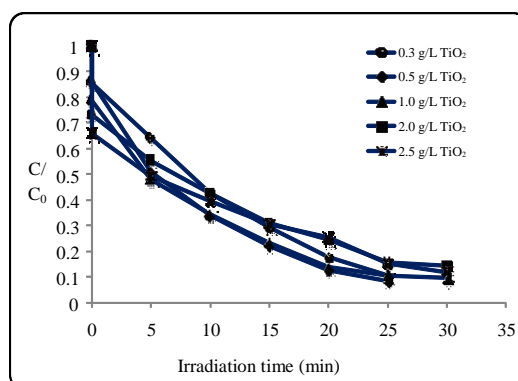
**Fig. 1:** Photodegradability of RO16 ( $C_0=20\text{ mg/L}$ ,  $C_{cat}=1\text{ g/L}$ ).

Figure 1 shows that no significant degradation (or dye removal) occurred when either the catalyst or UV irradiation (photolysis) used alone. However, when UV irradiation was combined with the photocatalyst, a clear decolorization of the dye took place. Indeed, 90% of the color was removed in only 30 minutes. This shows that the decomposition of RO16 is attributed to photocatalytic reactions that can effectively decolorize and degrade this dye. These results are in agreement with [12,13].

### *Effect of catalyst concentration:*

The effect of  $\text{TiO}_2$  concentration on the photocatalytic degradation of RO16 was studied. Figure 2 shows plots of the relative dye concentration as function of irradiation time at different catalyst concentrations. When  $0.5\text{ g/L TiO}_2$  was added, the degradation of the dye increased substantially giving a final concentration of RO16 of less than  $2\text{ mg/L}$  after 25 minutes irradiation. A further increase of  $\text{TiO}_2$  concentration decreased the degradation reaction. Therefore the optimum amount of catalyst required for the degradation of  $20\text{ mg/L}$  ( $3.24 \times 10^{-2}\text{ mM}$ ) RO16 was  $0.5\text{ g/L TiO}_2$ . Also it was found that increasing the catalyst concentration above the optimum concentration resulted in aggregation of the catalyst particles, hence the available surface area for contact between the reactant and the photocatalyst was reduced. This would result in reduction of the active sites and leads to lower photocatalytic degradation rates.

Also, when  $\text{TiO}_2$  was overdosed, the intensity of incident UV light was attenuated because of the decreased light penetration and increased light scattering, which embedded the positive effect coming from the dosage increment and therefore the overall performance reduced.

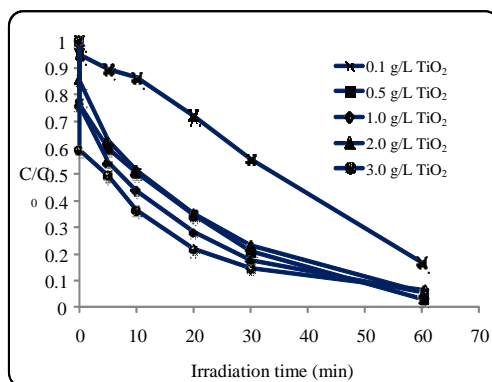


**Fig.2:** Effect of  $\text{TiO}_2$  concentration on RO16 decolorization ( $C_0=20\text{ mg/L}$ ).

The experiment at 40 mg/L ( $6.48 \times 10^{-2}$  mM) initial concentration of RO16 was carried out with various concentration of catalyst as seen from Figure 3. As catalyst concentration increased, the removal rate of RO16 reached a maximum at first 30 minutes (85.42%) when the high concentration of catalyst used (3 g/L).

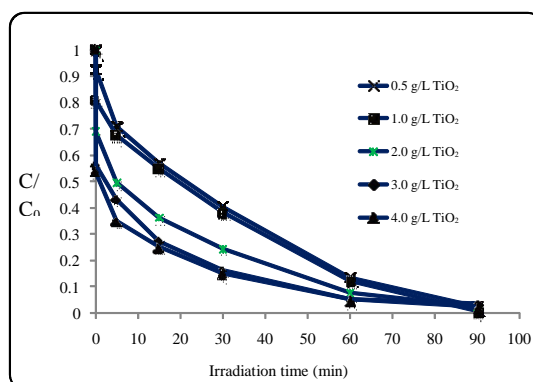
But when 0.5 g/L  $\text{TiO}_2$  was added, the degradation of the dye increased substantially giving a final concentration of RO16 of less than 1.5 mg/L after 60 minutes irradiation, which has reached a highly removal percentage of RO16 (96.83%). A further increase of  $\text{TiO}_2$  concentration decreased the degradation reaction. Therefore the optimum amount of catalyst required for the degradation of 40 mg/L ( $6.48 \times 10^{-2}$  mM) RO16 was 0.5 g/L  $\text{TiO}_2$ .

Furthermore, when  $\text{TiO}_2$  was overdosed, the intensity of incident UV light was attenuated because of the decreased light penetration and increased light scattering, which embedded the positive effect coming from the dosage increment and therefore the overall performance reduced.



**Fig. 3:** Effect of  $\text{TiO}_2$  concentration on RO16 decolorization ( $C_0=40$  mg/L).

Also a farther initial concentration of RO16 has been used with various different concentration of catalyst to investigate the effect of catalyst concentration on the degradation rate of RO16. Figure 4 shows the initial drop of RO16 concentration which caused by physical phenomena (adsorption) between the catalyst and dye before the suspension exposed to the UV light. As catalyst concentration increased, the removal rate of RO16 reached a maximum at first 60 minutes (94.87%) when the high concentration of catalyst used (4g/L). But when 1 g/L  $\text{TiO}_2$  was added, the degradation of the dye increased substantially giving a final concentration of RO16 of less than 0.5 mg/L after 90 minutes irradiation, which has reached a highly removal percentage of RO16 (99.34%).



**Fig.4:** Effect of  $\text{TiO}_2$  concentration on RO16 decolorization ( $C_0=60$  mg/L).

#### Conclusion:

Reactive orange 16 (RO16) was degraded by photocatalytic (UV/ $\text{TiO}_2$  and UV/ $\text{H}_2\text{O}_2$ ) process.  $\text{TiO}_2$  can efficiently catalyze the decomposition of dye RO16 in the presence of light and oxygen. The dye RO16 is resistant to direct photolysis and there was no degradation for RO16 in the dark and in the presence of  $\text{TiO}_2$ . The optimum conditions for fastest degradation for 20 and 40 mg/L RO16 are at catalyst concentration of 0.5 g/L. On the other hand for 60 mg/L the optimum catalyst concentration is 1 g/L.

## REFERENCES

- [1] Muszkat, L., D. Raucher, M. Magaritz, D. Ronen, 1994. In: U.Zoller, (Ed.), Groundwater Contamination and Control, Marcel Dekker, pp: 257.
- [2] Cohen, Z.Z., C. Eiden, M.N. Lober, 1986. In: W.Y.Gerner, (Ed.), Evaluation of Pesticide in GroundWater, ACS Symposium Series 315, American Chemical Society, Washington, DC.
- [3] Mumma, A., 1995. Environmental law: Meeting UK and EC requirements. McGraw-Hill (London and New York)
- [4] Easton, J.R., 1995. In: Cooper, P. (Ed.), In the Dye Maker's View of Color in Dye House Effluent, Woodhead Publishing Ltd., Bradford, UK.
- [5] Zollinger, H., 2003. Color Chemistry, Synthesis, Properties and Application of Organic Dyes and Pigments, 3rd ed., Wiley, Weinheim.
- [6] Gottlieb, A., C. Shaw, A. Smith, A. Wheatley, S. Forsythe, 2003. The toxicity of textile reactiveazo Dyes after hydrolysis and decolourisation. *J. Biotechnol.*, 101: 49-56.
- [7] Brown, M.A. and S.C. DeVito, 1993. Predicting azo dye toxicity. *Crit. Rev. Environ. Sci. Technol.*, 23(3): 249-324.
- [8] Jakpotisch, C., G. Regelsberger, P.G. Furtmueller, F. Rueker, G.A. Peschek, C. Obinger, 2001. Catalase-Peroxidase from *Synechocystis* Is Capable of Chlorination and Bromination Reactions. *Biochem. Biophys. Res. Commun.*, 287(3): 682-687.
- [9] Oztürk, A., M.I. Abdullah, 2006. Toxicological effect of indole and its azo dye derivatives on some microorganisms under aerobic conditions. *Sci Total Environ*, 358(1-3): 137-42.
- [10] Mohibbul Haque, M., D. Bahnemann and M. Muneer, 2012. In T.Puzyn, and A.Mostrag-Szlichtyng, Organic Pollutants Ten Years After the Stockholm Convention-Environmental and Analytical Update. InTech, Published., pp: 293.
- [11] Melemen, M., D. Stamatakis, N.P. Xekoukoulotakis, D. Mantzavinos And N. Kalogerakis, 2009. Disinfection of municipal wastewater by TiO<sub>2</sub> photocatalysis with UV-A, visible and solar irradiation and bdd electrolysis. *J.Global Nest* 11(3): 357-363.
- [12] Méndez-Arriaga, F., J. Gimenez and S. Esplugas, 2008. Photolysis and TiO<sub>2</sub> photocatalytic treatment of naproxen: degradation, mineralization, intermediates and toxicity. *J. Adv. Oxid. Technol.*, 11(3): 436-445.
- [13] Mijin, D., M. Radulović, D. Zlatić and P. Jovanjić, 2007. Photocatalytic degradation of textile C.I.dye Reactive Orange 16 in TiO<sub>2</sub> water suspension by simulated solar light. *CI&CEQ* 13(4): 179-185.