



# IJRASET

International Journal For Research in  
Applied Science and Engineering Technology



---

# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

---

**Volume: 5      Issue: VI      Month of publication: June 2017**

**DOI:**

**[www.ijraset.com](http://www.ijraset.com)**

**Call:  08813907089**

**E-mail ID: [ijraset@gmail.com](mailto:ijraset@gmail.com)**

# Synthesis of TiO<sub>2</sub> Photocatalyst for Rhodamine B-Dye Degradation Under Solar Light

Tushar M. Thite<sup>1</sup>, S. M. Jadhav<sup>2</sup>

<sup>1,2</sup>Department of Chemical Engineering, Bharti Vidyapeeth Deemed University, College of Engineering, Pune-43

**Abstract:** Photocatalysis is one of the advanced oxidation process used widely for the degradation of waste water. In the current study synthesis of TiO<sub>2</sub>. Titanium Dioxide photocatalyst has been synthesized using Titanium tetrachloride as precursor. Titanium Dioxide thus obtained was used for degradation of Rhodamine B dye. pH of solution and dosage of the catalyst were optimized during the experimental work. TiO<sub>2</sub> thus synthesized was characterized using FT-IR and XRD. Optimized conditions of 3 pH and 1.0 g/L of catalyst dosage lead to degradation of dye as 39.18% under solar light.

**Keywords:** TiO<sub>2</sub>, Solar light, Rhodamine B, Advanced oxidation process.

## I. INTRODUCTION

By the mid of the 20<sup>th</sup> century the world population was increasing at a very high rate and so were the number of industries. And with this increase in number of industries the problem of air and water pollution become a matter of serious concern. The major contributor to water pollution problem were textile, leather, paper printing and plastic industries[1]. The various dyes used for purpose of printing, dyeing and many other processes are major source of pollution that emerge out in the effluent. This effluent when mixed with the source of water causes serious damage to the water ecology and are also harmful to human health as they are carcinogenic and mutagenic in nature.[2]. Dyes especially azo dyes are very toxic in nature and can have long term effects on the individuals.

Treating such waste water is a difficult task and conventional techniques like adsorption, coagulation, biological treatment, filtration etc cannot be used. Such conventional techniques can either remove part of impurities and dirt or the dissolved impurities which impart color to effluent[3]. Hence the search of new, economical and effective technique began. Advanced oxidation process(AOP) are found to be a good alternative to conventional techniques[4]. AOPs include photocatalysis, sonication, photolysis, fenton process etc. These techniques are more efficient as compared to conventional techniques and they do not produce any secondary waste after the treatment of waste water[5]. Among the AOPs mentioned above here we shall discuss about photocatalysis. Photocatalysis is the technique used to degrade the organic waste using a catalyst which gets activated in presence of light[6].

In the present study a major candidate in world of photocatalysis viz titanium dioxide(TiO<sub>2</sub>) synthesis is discussed. After synthesis various parameters like pH and concentration of catalyst will be optimized. Ultimately it will be used to study degradation of a azo dye.

## II. EXPERIMENTAL

### A. Chemicals

All the chemicals were used as received without any further purification in it. Titanium tetrachloride used as precursor was obtained from the spectrochem chemicals. Ammonia solution and Sulphuric acid used was of Thomas Baker's. H<sub>2</sub>SO<sub>4</sub> was used by diluting it to 10% with distilled water. Rhodamine B dye used for degradation study was obtained from HPLC. The chemical formula of the dye is as shown in Fig.1. Properties of the dye are mentioned in the table 1.

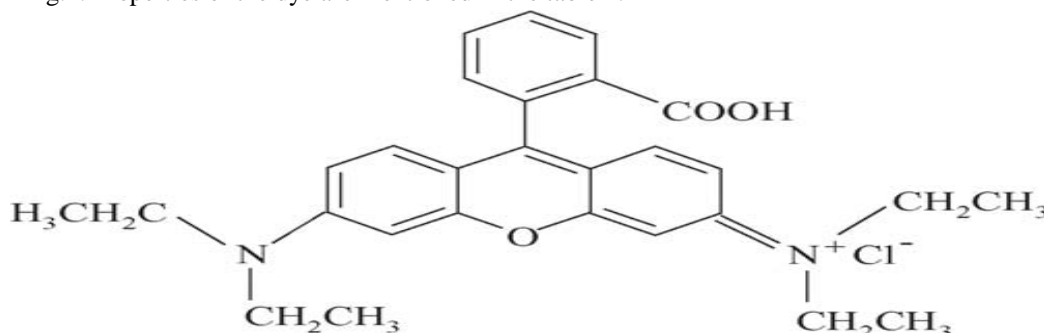


Fig 1. Chemical formula of RhB.

# International Journal for Research in Applied Science & Engineering Technology (IJRASET)

TABLE I  
PROPERTIES OF RHODAMINE B

Chemical Formula	C <sub>28</sub> H <sub>31</sub> ClN <sub>2</sub> O <sub>3</sub>
State	Divided Solid
Appearance	Red to Violet Powder
Molecular weight	479.02
pH	Acidic
Specific gravity	1.31

### B. Synthesis of TiO<sub>2</sub>

There are various methods available for the synthesis of TiO<sub>2</sub> like sol-gel technique, hydrothermal method, precipitation technique etc[7],[8]. Among all the mentioned techniques precipitation technique is the most convenient and simple. So in the present work TiO<sub>2</sub> has been synthesized using this technique[9]. Initially the precursor TiCl<sub>4</sub> was cooled down to the temperature of 0°C then it was taken out of the bottle using pipette[10]. Then it was mixed with 10% H<sub>2</sub>SO<sub>4</sub> solution. After adding the two quantities in proportion they were continuously stirred for 30 minutes. Later the mixture was heated to 71°C and then ammonia solution was added to it. Addition of ammonia solution leads to the formation of TiO(OH)<sub>2</sub>. These TiO(OH)<sub>2</sub> on further calcination at 400°C leads to the formation of TiO<sub>2</sub> particles[11]. TiO<sub>2</sub> particles thus obtained were further characterized by FT-IR and XRD tests.

### C. Experimental work for dye degradation

To evaluate efficiency of the as prepared photocatalyst degradation of dye was carried out using it. Degradation of dye was carried out in the presence of solar light. Solar light was used as a source of light to activate TiO<sub>2</sub>. Dye solution of optimum concentration was prepared, photocatalyst was added to it and with a provision of continuous stirring it was placed in the bright sunlight. All experiments were carried out during summer season when the intensity of sun light is very high and so is the UV index. Actual experimental setup is as shown in the Fig 2..



Fig 2. Experimental setup

### III. ANALYSIS

Photocatalyst synthesized using above method was characterized using FT-IR and XRD. Also to evaluate the efficiency of photocatalyst dye was degraded. Degradation of dye was confirmed from decolorization of dye which was analyzed using UV spectro photometer. The rate of degradation was calculated by using the formula:

$$\% \text{ degradation} = \left\{ \frac{C_0 - C}{C_0} \right\} * 100$$

Where C<sub>0</sub>=Initial concentration;

C=Final concentration.

## International Journal for Research in Applied Science & Engineering Technology (IJRASET)

### A. Characterization:

- 1) **FT-IR** : FT-IR analysis of the synthesized  $\text{TiO}_2$  powder was carried out using Brukers instrument. Image for the same is being depicted in the Fig. 3. Peaks obtained at  $3400$  and  $1650\text{ cm}^{-1}$  are due to stretching and bending of  $-\text{OH}$  group. Peaks at  $550\text{ cm}^{-1}$  and  $1450\text{ cm}^{-1}$  shows  $\text{Ti-O}$  and  $\text{Ti-O-Ti}$  stretching vibrations[12].

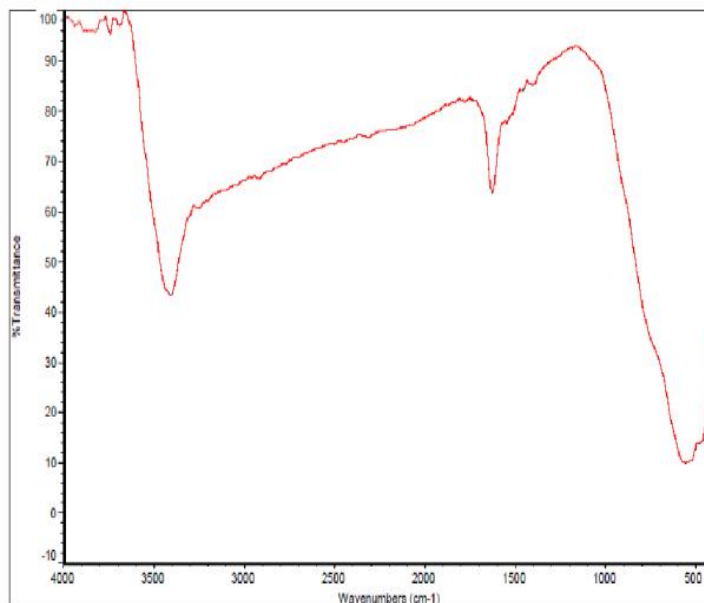


Fig 3.FT-IR spectra for  $\text{TiO}_2$

- 2) **XRD**: XRD was carried out and the image for the same is shown in the Fig.4. Peaks were obtained at following points  $25.3^\circ, 37.9^\circ, 48.1^\circ, 54.2^\circ, 55.2^\circ, 62.9^\circ, 69.5^\circ, 70.6^\circ, 75.4^\circ$  indicating the substance formed is  $\text{TiO}_2$ [13],[14]. All peaks obtained are analogous to the standard peaks of polycrystalline anatase phase of  $\text{TiO}_2$  reported in (JCPDS-21-1272). Thus confirming that formed substance is anatase  $\text{TiO}_2$ .

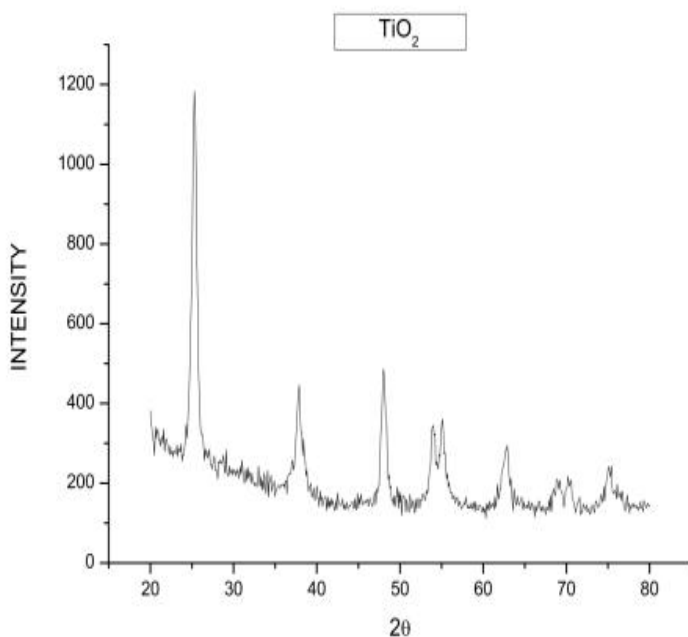


Fig 4. XRD pattern of  $\text{TiO}_2$



# International Journal for Research in Applied Science & Engineering Technology (IJRASET)

## IV. RESULT AND DISCUSSION

### A. Effect of pH

To study the effect of pH on the dye solution the pH of the solution was varied from 2 to 7[15]. It was observed that on decreasing the pH from basic to acidic, the rate of degradation increased until a optimum value was reached. In the present work it was found that when pH was decreased from 7 to 3 the rate of degradation was continuously increasing but with further decrease in value of pH the rate of degradation decreased. It was observed that initially degradation rate was 22.24 % and increased to 25.52% for the value of 3 pH. Also on decreasing the value of pH to 2 rate decreased to 23.15%.

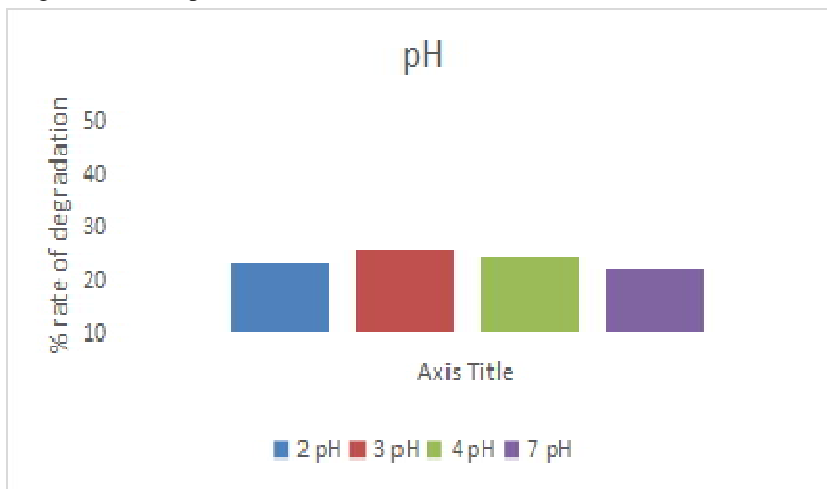


Fig 5. Effect of pH on Degradation

### B. Effect of catalyst concentration

The most important factor is catalyst concentration[16]. The catalyst concentration was optimized by varying the catalyst dosage from 0.5 g/L to 1.25 g/L[17]. It was observed that with an increase in the catalyst concentration the rate of degradation of RhB increases. The degradation value was found to be 26.01% for 0.5 g/L and it increased to 39.18% for 1.0 g/L. But with further increase in catalyst concentration to 1.25 g/L this value decreased to 36.76%. Thus from above observation we can conclude that 1.0 g/L and at 3 pH maximum degradation of RhB was obtained under solar light.

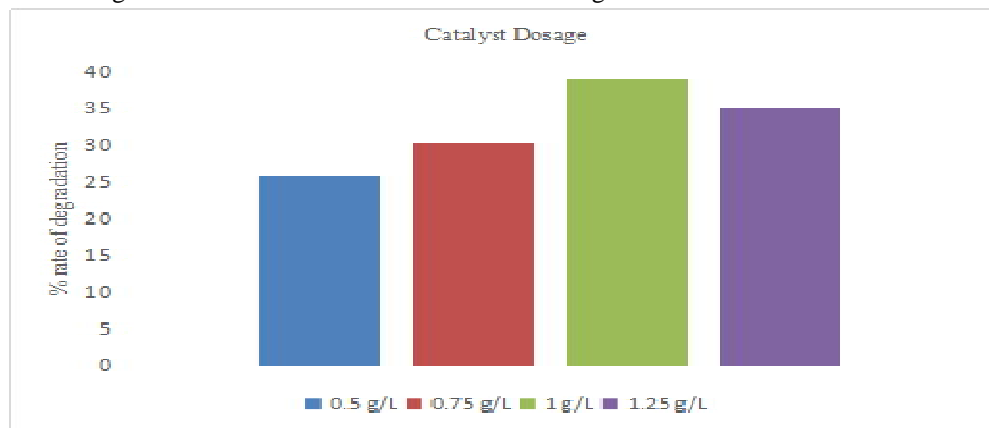


Fig 6. Effect of catalyst dosage

## V. CONCLUSION

From the above experimental work we can conclude that maximum rate of degradation of 39.18% is obtained at optimized conditions of 3 pH and 1.0 g/L of catalyst dosage under solar light. Huge amount of research work is being carried out in the field of photocatalysis, but most of the photocatalysts including TiO<sub>2</sub> operate in the UV region hence their application to real world problem is not possible in most of the cases[18].

Thus by optimizing the conditions in visible solar light an attempt is being made through this work to utilize the photocatalyst TiO<sub>2</sub> for the real world problems.

# International Journal for Research in Applied Science & Engineering Technology (IJRASET)

## VI. ACKNOWLEDGMENT

Author would like to thank Department of Chemical Engineering, Bharti Vidyapeeth Deemed University, College of Engineering Pune, for making experimental facilities available for research work.

## REFERENCES

- [1] Zhiming Sun, Chunquan Li, Guangyuan Yao, Shuilin Zheng, "In situ generated g-C<sub>3</sub>N<sub>4</sub>/TiO<sub>2</sub> hybrid over diatomite supports for enhanced photodegradation of dye pollutants," *Materials and Design* 94 (2016) 403-409.
- [2] C.S.D.Rodrigues, L.M.Maderia, R.A.R.Boaventura, "Synthetic textile dyeing wastewater treatment by integration of advanced oxidation and biological processes- performance analysis with costs reduction," *J.Environ. Chem, Eng.* 2(2014) 1027-1039
- [3] Bizani E, Fytianos K, Poullos I, Tsitridis V, "Photocatalytic decolorization and degradation of dye solutions and wastewaters in the presence of Titanium dioxide," *J.Hazard Matter* 2006,136,85-94
- [4] Chen C, Lu C, Chung Y, "Photocatalytic degradation of ethyl violet in aqueous solution mediated by TiO<sub>2</sub> suspensions," *J.Photochem. Photobiol. A Chem.* 2006,181,120-125
- [5] V.K.Gupta, R.Kumar, A.Nayak, T.A. Saleh, M.A.Barakat, "Adsorptive removal of dyes from aqueous solution onto carbon nanotubes: a review," *Adv. Colloid interf. Sci.* 193-194(2013) 24-34
- [6] A.Mittal, D.Kaur, A.Malviya, J.Mittal, V.K.Gupta, "Adsorption studies on the removal of coloring agent phenol red from wastewater using waste materials as adsorbents," *J.Colloid interface Sci.*337(2009) 345-354
- [7] A.Mittal, J.Mittal, A.Malviya, V.K.Gupta, "Adsorptive removal of hazardous anionic dye "Congo red" from wastewater using waste materials and recovery by desorption ," *J. Colloid Interface Sci.* 340(2009) 16-26
- [8] D.Morshedi, Z.Mohammadi, M.M.Akbar Boojar, F.Aliakbari, "Using Protien nanofibrils to remove azo dye from aqueous solution by the coagulation process," *Colloids Surf. B: Biointerfaces* 112(2013) 245-254
- [9] P.L.Chaudhari, V.G.Joshi, P.B.Patil, K.S.Kulkarni, "Nano CaCO<sub>3</sub> nanocomposite for the adsorption of RhB dye," *Int.Journal of adv.tech. in engg. and sci.*03(2015)
- [10] D.C.Romero, G.T.Torres, J.C.Arevalo, R.Gomez, A.A.Elguézabal, *J.Sol-Gel Sci.Technology* 56 (2010) 219-226
- [11] Tatiana Giannakopoulou, Ilias Papailias, Nadia Todorova, Nikos Boukos, Yong Liu, Jianguo Yu, Christos Trapalis, "Tailoring the energy band gap and edges potentials of g-C<sub>3</sub>N<sub>4</sub>/TiO<sub>2</sub> composite photocatalysts for NO<sub>x</sub> removal," *Chemical Engineering Journal* 310(2017) 571-580
- [12] K.Thangavelu, R.Anamalai, D.Arulnandhi, "Preparation and characterization of nanosized TiO<sub>2</sub> powder by sol-gel precipitation route,"<sup>3</sup>(2013)
- [13] Xue-Song Zhang, Jian-Yang Hu, Hong Jiang. "Facile modification of a graphitic carbon nitride catalyst to improve its photoreactivity under visible light irradiation," *Chemical Engineering Journal* 256 (2014) 230-237
- [14] Miranda,C., Mansilla,H., Yanez,J., Obregon,S., Colon,G. , "Improved photocatalytic activity of g-C<sub>3</sub>N<sub>4</sub>/TiO<sub>2</sub> composites prepared by a simple impregnation method," *Journal of Photochemistry and Photobiology A: Chemistry* 253(2013) 16-21
- [15] Chao Wang, Wenshuai Zhu, Yehai Xu, Hui Xu, Ming Zhang, Yanhong Chao, Sheng Yin, Huaming Li, Jianguo Wang. "Preparation of TiO<sub>2</sub>/g-C<sub>3</sub>N<sub>4</sub> composites and their application in photocatalytic oxidative desulfurization," *Ceramic International* 40 (2014) 11627-11635
- [16] Chao Wang, Wenshuai Zhu, Yehai Xu, Hui Xu, Ming Zhang, Yanhong Chao, Sheng Yin, Huaming Li, Jianguo Wang, "Preparation of TiO<sub>2</sub>/g-C<sub>3</sub>N<sub>4</sub> composites and their application in photocatalytic oxidative desulfurization," *Ceramic International* 40 (2014) 11627-11635.
- [17] Y.He, J.Cai, T.Li, Y.Wu, H.Lin, Zhao, M.Luo, "Efficient degradation of RhB over GdVO<sub>4</sub>/g-C<sub>3</sub>N<sub>4</sub> composites under visible-light irradiation," *Chemical Engineering Journal* 215-216(2013) 721-730
- [18] Si-Zhan Wu, Yu-Xiang Yu, Wei-De Zhang, "Processing graphitic carbon nitride for improved photocatalytic activity," *Material Science in semiconductor processing* 24 (2014) 15-20.



10.22214/IJRASET



45.98



IMPACT FACTOR:  
7.129



IMPACT FACTOR:  
7.429



# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089  (24\*7 Support on Whatsapp)