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:

Volume 5 Issue VI, June 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Synthesis of TiO_2 Photocatalyst for Rhodamine B-Dye Degradation Under Solar Light

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Abstract: ***Photocatalysis is one of the advanced oxidation process used widely for the degradation of waste water.In the current study synthesis of TiO_2. 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_2 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_2, Solar light, Rhodamine B, Advanced oxidation process.***

I. INTRODUCTION

By the mid of the 20th 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_2) 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_2SO_4 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.

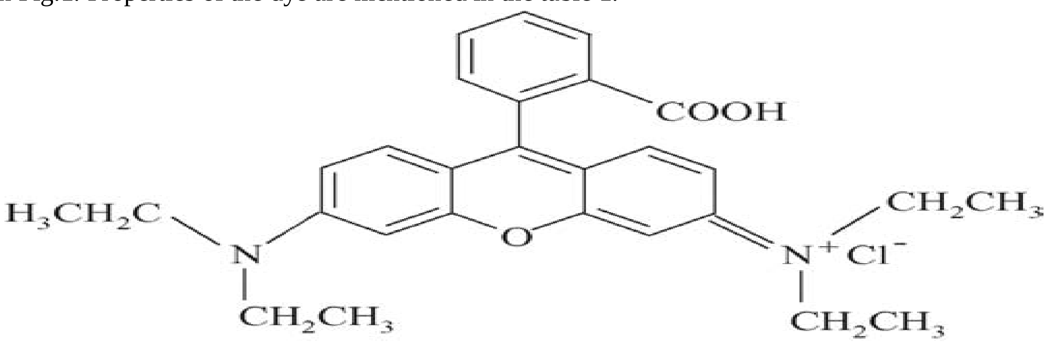

Fig 1. Chemical formula of RhB.

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TABLE I

PROPERTIES OF RHODAMINE B

Chemical Formula	$C_{28}H_{31}ClN_2O_3$
State	Divided Solid
Appearance	Red to Violet Powder
Molecular weight	479.02
pH	Acidic
Specific gravity	1.31

B. Synthesis of TiO_2

There are various methods available for the synthesis of TiO_2 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_2 has been synthesized using this technique[9]. Initially the precursor $TiCl_4$ was cooled down to the temperature of 0^0C then it was taken out of the bottle using pipette[10]. Then it was mixed with 10% H_2SO_4 solution. After adding the two quantities in proportion they were continuously stirred for 30 minutes. Later the mixture was heated to 71^0C and then ammonia solution was added to it. Addition of ammonia solution leads to the formation of $TiO(OH)_2$.These $TiO(OH)_2$ on further calcination at 400^0C leads to the formation of TiO_2 particles[11]. TiO_2 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_2. 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 decolorizaiton of dye which was analyzed using UV spectro photometer.The rate of degradation was calculated by using the formula:

% degradation= {(Co-C)/Co}*100

Were Co=Initial concentration;

C=Final concentration.

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A. Characterization:

1) *FT-IR :* FT-IR analysis of the synthesized 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 cm^{-1} are due to stretching and bending of -OH group. Peaks at 550cm^{-1} and 1450 cm^{-1} shows Ti-O and Ti-O-Ti stretching vibrations[12].

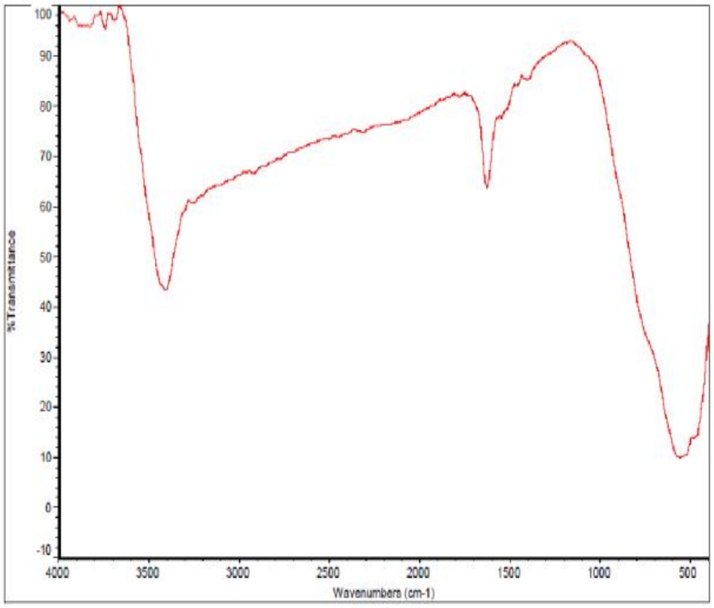

Fig 3.FT-IR spectra for TiO_2

2) *XRD:* XRD was carried out and the image for the same is shown in the Fig.4. Peaks were obtained at following points 25.3^0 ,37.9^0,48.1^0,54.2^0,55.2^0,62.9^0,69.5^0,70.6^0,75.4^0 indicating the substance formed is TiO_2[13],[14]. All peaks obtained are analogous to the standard peaks of polycrysatalline anatase phase of TiO_2 reported in (JCPDS-21-1272). Thus confirming that formed substance is anatase TiO_2.

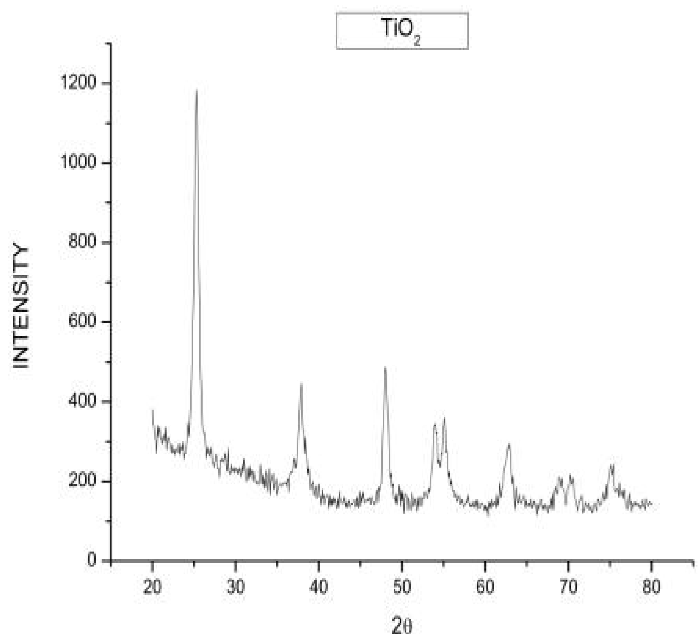

Fig 4. XRD pattern of TiO_2

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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 was22.24 % and increased to 25.52% for the value of 3 pH. Also on decreasing the value of pH to 2 rate decreased to23.15%.

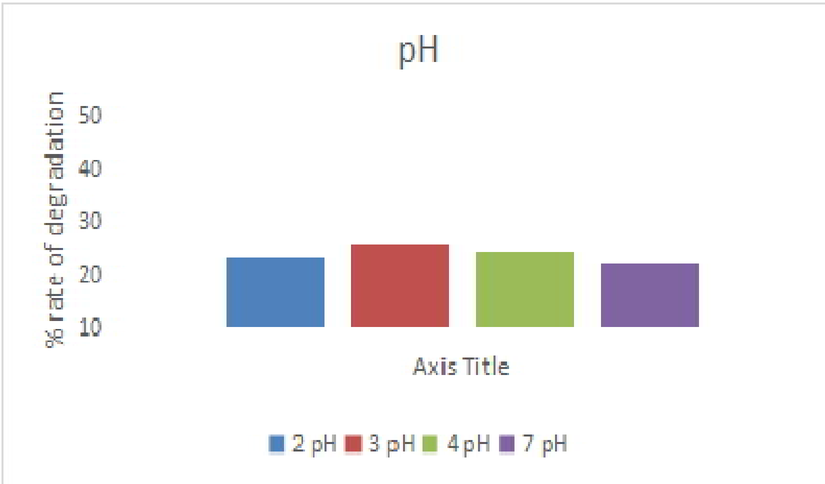

Fig 5. Effect of pH on Degradation

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 to36.76%. 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.

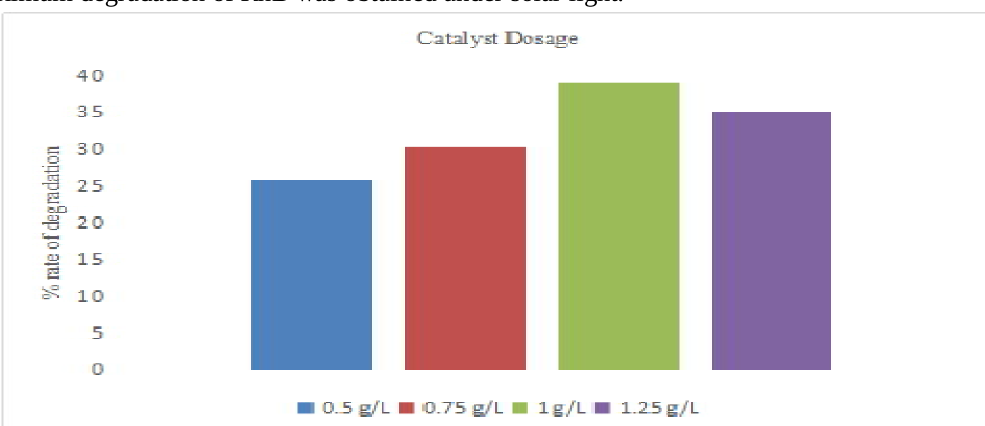

Fig 6. Effect of catalyst dosage

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_2 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_2 for the real world problems.

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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.

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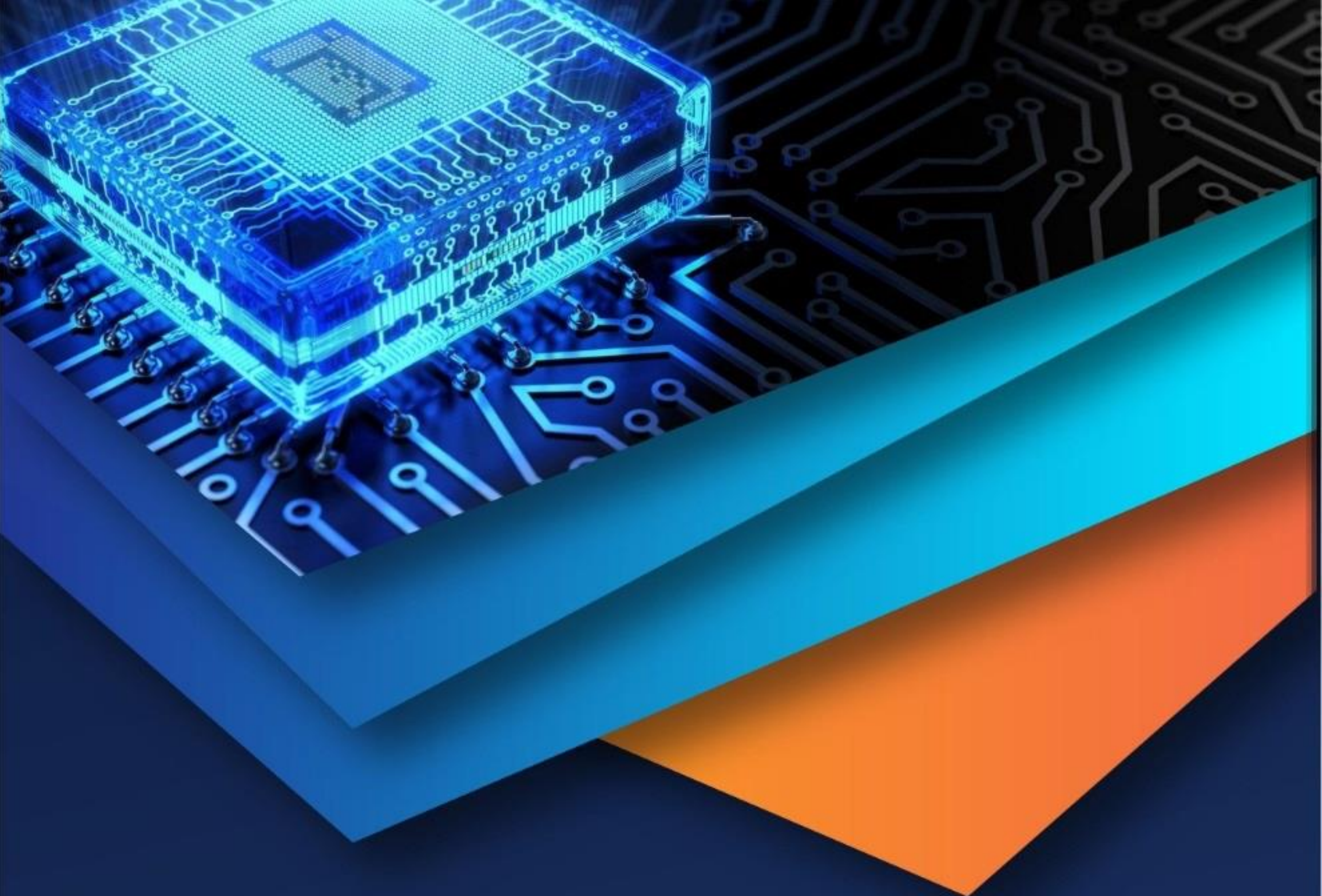

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