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Photodegradation of Carmine XIE Dye By Newly Synthesized Photocatalyts

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Abstract: The present study involves the photocatalytic decolorization of Carmine XIE (reactive) dye by employing newly synthesizes heterogeneous photocatalytic under laboratory condition. An attempt has been made to study the effect of process parameters viz., amount of catalyst, pH, and irradiation time of photocatalytic degradation of Carmine XIE dye Carmine XIE (reactive). The experiment was carried out by irradiating the aqueous solutions of Carmine XIE dye containing photocatalysts inside the batch reactor having UV light. The rate of decolorization was estimated from residual concentration by spectrophotometrically. Similar experiments were carried out by varying pH (2–14), the amount of catalyst (0.05–1 gm) time variation (2-30) minutes). The experimental results show that, the maximum decolorization of Carmine XIE (more than 90%) occurred at pH 7-11 using newly synthesized photocatalyts. The performance of catalyst was excellent throughout the experiment and excellent results are obtained.

Keywords: Carmine XIE, Photocatalyts, UV lamp.

I. INTRODUCTION

The United Nations World Water Development report, stated that about 2 million tons of waste per day is disposed within receiving waters body, including industrial wastes and chemicals, human waste, and agricultural wastes. Water pollution occurs when a body of water is adversely affected due to the addition of foreign materials in to the water. Environmental problems such as organic pollutants and toxic water pollutants produced by some industries are harmful and dangerous to human health and environment. The sources of water pollution can be divided in to two categories; direct and indirect contaminant sources. Direct sources include effluent outfalls from factories, refineries, waste treatment plant etc. Indirect sources include contaminants that enter the water supply form soil/groundwater system and from the atmosphere via rainwater. [V. K. Gupta et al., 2009; World Health Organization].

The textiles generate tremendous amount of waste waster i.e. colour water as a result of various processes. Water consumption is near about 100-200 L of water per kilogram of textile product. Considering an annual production of 40 million tons of textile fibers, the release of wasted water can be estimated to exceed 4–8 billion cubic meters per year. In Textile numerous stages are involved mechanical processing such as spinning, weaving, knitting, garment production and wet treatment processes like pretreatment, dyeing, printing, and finishing operations, but there is a strong interrelation between treatment processes in the dry state and consecutive wet treatments. [E. Burtscher et.,al 2004].

The release of dyes by different industries poses serious environmental problems not only for aesthetic reasons, but also due to low biodegradability and their toxicity affect aquatic life [E. Tatara et al., 2005; M. Lucas et al., 2008]. Existence of color and its causative compounds has always been unwanted in water used for either domestic or industrial needs [A.R. Khataee et al.,2009]. There are more than 100,000 dyes available commercially and over one million ton dyes are produced per year, of which 50% are textile dyes [H.A. Boyter 2007].

Dyestuffs such as azoic, vat, direct, acid, reactive, basic and sulphur are used for coloration of fabric in production. These dyes along with auxiliaries will finally go into the effluent due to spillage, incomplete exhaustion and hydrolysis. Dyes are released into the environment mainly from the rinsing and dyeing stages in textile mills. [**.** R.V. Shende et al., 1995]. Reactive dyes are mostly used in the textile industry. The fixation efficiency of reactive dyes ranges from 60% and 90% and therefore, large amounts of such dyes are released in the wastewater, which causes major environmental problems [**P**. Bansal et al., 2011]. Textile wastewater is one of the most polluted sources that have been rather difficult to study due to its highly variable composition such as various dyes, additives, detergents, etc. Reactive dyes have been a great concern for not protecting the water because many azo dyes and their breakdown product are present in it [S. Meric et al., 2005]. The ingestion or discharge of such untreated wastewaters by humans causes many effects such as skin irritation, vomiting, severe headaches and acute diarrhea. Such effluents are also responsible for water-borne diseases exhibiting symptoms such as hemorrhage, nausea, dermatitis, ulceration of the skin and mucous membranes and kidney damage [J. Bell et al., 2003.]

Removal of such toxic colour and organics by photocatalytic degradation is emerging as an effective treatment technique (Wang 2000; Neppolian et al 2002) hence, Heterogeneous photocatalysis is a technology based on the irradiation of a catalyst, usually a semiconductor, which may be photo excited to form electron donor site and electron acceptor site, providing great scope as redox reagent. The process is heterogeneous because there are two active phases; solid and liquid. The catalyst used in this process generally a solid semiconductor whose irradiation promotes the generation of radical species. Semiconductors are primary light absorbers.

Various types of methods have been developed for the removal of synthetic dyes from waters and wastewaters to decrease their impact on the environment. Different technologies involve adsorption on inorganic or organic matrices, decolorization by photocatalysis, and/or by oxidation processes, microbiological or enzymatic decomposition, etc. (Hao et al., 2000). It is reported that the photocatalysis is the most efficient technique for the degradation of color from dyes of industrial wastewater. (Li et al., 2003; Vione et al., 2003; Antharjanam et al., 2003; Fernandez-Ibanez et al., 2003; Liu et al., 2003; Ohno, 2004; Chen et al., 2004; Alkhateeb et al., 2005 & Attia et al., 2008).

Photocatalytic degradation of dyes from waste water by semiconductors is a new, effective and rapid technique for the removal of colour from water (Habibi,etal., 2001; Mirkhani at al., 2009). Many catalysts like TiO2 (Degussa P25), TiO2 (Merck), ZnO, ZrO2, WO3, SrO2, Fe2O3, CeO2, CdS and ZnS have been attempted for the photocatalytic degradation of a wide variety of environmental contaminants. However, only a handful of studies have been attempted which compare the efficiency of different catalysts for a particular organic compound under identical experimental conditions. Barrett (1997), suggested the Advanced Oxidation Processes, best as they have been proven to be effective in the removal of wide spectrum of organic and inorganic contaminants from wastewater. Also they addressed to researchers and professionals with a background in environmental science and engineering about the solar driven Advanced Oxidation Process and its multiple advantages

The aim of the present research work is to study the photocatalytic degradation of carmine dye, by using newly synthesized catalyst under laboratory condition for irradiation of dye sample in UV reactor. The effects of various parameters, such as time, catalyst dose and pH of the solution were observed on the degradation rate of aqueous dye solutions under the laboratory condition

II. MATERIAL AND METHODS

A. Photo catalytic Studies

The degradation of the synthetically prepared dye solution was evaluated in laboratory conditions under illumination of UV light in the photoreactor. The dyes used were carmine dye, Carmine XIE dye is reactive dye, and hence it was used for the experiments. The photo catalytic activity of new synthesized photocatalyts was observed in various conditions. The dye solutions were introduced into the photoreactor and at different time intervals the treated water was withdrawn from the reactor. All experiments were carried out under ambient conditions i.e., at room temperature.

$$\text{Dye} + \text{OH}\bullet \rightarrow \text{degradation products}$$

$$\text{Dye} + \text{hVB+} \rightarrow \text{oxidation products}$$

$$\text{Dye} + \text{eCB} \rightarrow \text{reduction products}$$

Where hv is photon energy required to excite the semi-conductor electron from the valence band (VB) region to conduction band (CB) region.

B. Degradation Studies of the Dye Solutions

The photocatalytic activity of newly synthesized catalyst under laboratory condition on to the caramine dye was determined by measuring the absorbance of the solutions before and after the irradiation inside the UV chamber.

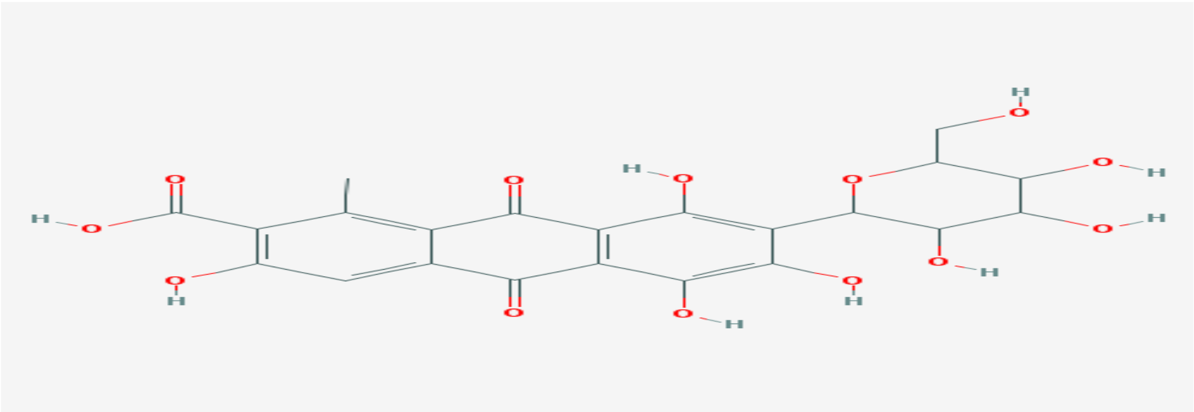

Fig. 1. Structure of Carmine Dye

C. UV Spectra

The absorbance of the prepared dye solutions were measured before and after degradation at different time intervals. Measurements were carried out using Evolution 201 UV-Visible Spectrophotometer in the photon energy range of wavelength from 200 to 600 nm. The colour removal of the dye solution was measured at the λ maximum at 539nm. The efficiency was calculated from a mathematical equation adapted from measurements of decolorization.

D. Photoreactor

The photochemical reaction was carried out in specially designed batch reactor. The UV reactor is fabricated for the experimental process. It is rectangular in shape having dimensioned 27 cm length, 29 cm width, and 40cm height and made up of wood. Reactor was black from inside. UV tube was attached with the roof and UV of 9w tube was used for the degradation. The height of tube and beaker was 18cm.Magnetic Stirrer was placed inside the reactor for artificial agitation.

III. EXPERIMENTAL SET UP AND PROCEDURE

For the experimentation a UV photocatalytic reactor was fabricated. Experiment was carries out in the batch reactor at room temperature. This experiment was performed in glass beaker (borosil) capacity of 500ml. The distance between beaker and lamp was fixed at 18 cm. The dye solution was prepared in laboratory by adding 0.5g og carmine XIE to 1000ml distilled water. The dye sample was prepared in 1000ml of borosil beaker having concentration of 500ppm. The catalyst dose was also fixed. The catalyst was synthesized under laboratory condition by using zinc sulphate, 8 hydroxychinolin and glucose. The concentration throughout the experiment was same.

The effect of pH was studied by adjusting the pH value to different range by addition of H_2SO_4 (1N) and NaOH (1N). The pH of the sample was measured with pocket pH meter (Hanna).During the irradiation of sample, agitation was maintained by magnetic stirrer to keep the suspension homogeneous the suspension was withdrawn at regular interval and immediately filtered with filter paper and the absorbance measured by UV Visible spectrophotometer (Double Beam Spectrophotometer 2203 systronic).The absorbance peak of carmine XIE dye was measured at 539nm.The degree of photodecolorization(X) as a function of time, was calculated by X= (C0-C)/C0 where C0 is the initial concentration of Carmine XIE dye, and C is the final concentration of Carmine XIE at given time t. Effect of catalyst dose, time, pH, were carried out in batch reactor throughout the experiment.

IV. RESULT AND DISCUSSION

The Photodegradation experiments were carried out under UV reactor. Carmine XIE dye solution was used. Newly prepared catalyst used as semiconductor throughout the experiment. The Experimental work were done in UV chamber/UV reactor entirely and the absorbance taken from double beam spectrophotometer. The whole Carmine XIE dye solution was irradiated under the specified condition.

A. Effect of Time

Effect of contact time on the removal of Carmine XIE dye from aqueous solution in presented in fig. 1 and 2**.** The experiments were carried out at 500 ppm of sample using photocatalyts at room temperature and the dye concentrations of Carmine XIE dye was fixed 500ppm for different time intervals up to 30 min. The efficiency of dye removal was increased as the contact time increased and lowers initial dye concentration [S.S. Azhar et al., 2005] It observed that initial removal was slow and after 15-20 min the removal is maximum it means the 95% removal observed at 20-30 min. It means that the adsorption is highly dependent on the initial concentration of dyes and times as well [M. Hema et al., 2007]. So it was found that 95% of efficiency was at 20-30 min with the newly synthesized catalyst.

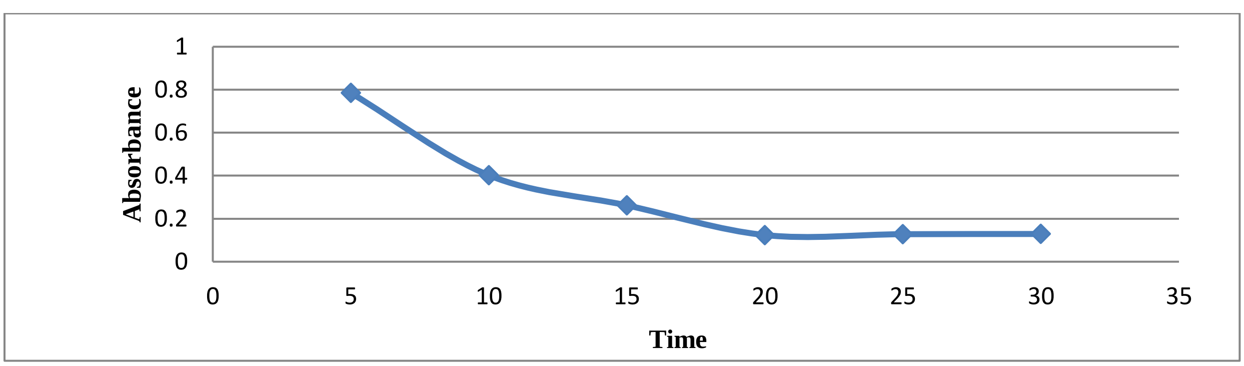

Figure 2: Time versus Absorbance.

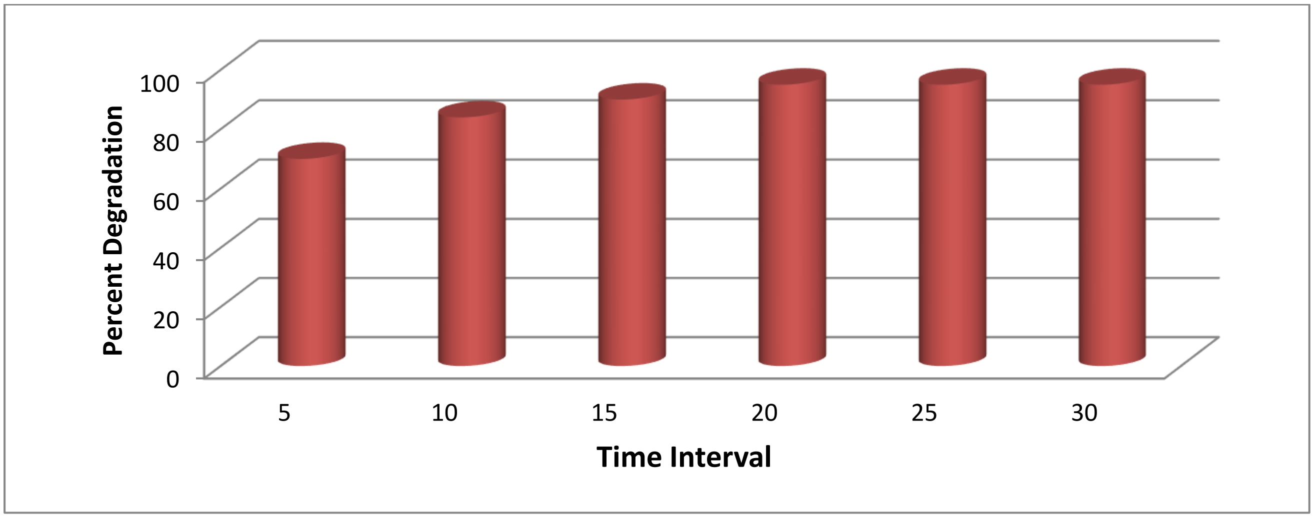

Figure 3: Percent Degradation Vs Time.

B. Amount of Catalyst Dose

Some dyes are degraded by direct UV radiation. Therefore, it should be examined to what extent the dyes are „photolyzed" if no catalyst was used. Blank experiments were carried out for dyes sample without catalyst for this purpose. It is also interesting to determine, the minimum amount of catalyst required to decolorize the maximum amount of dye at a particular experimental condition. For this, experiments were carried out varying the amount of newly synthesized photocatalysts for the degradation of carmine dye sample. In the absence of the catalyst, Carmine does not show any changes even after photolyzed at 5 hr. then catalyst was added with an increased catalyst loading from 0.05 to 1g in 100 ml in a set of runs, the percent of dye degraded after 15 min-30min increased from 60 to 95%. After that, the increase in catalyst loading did not affect the percent degraded significantly. From the figure 3 it is clear that the catalyst loading for maximum degradation of was 0.5g g in 100 ml solution under specified experimental conditions.

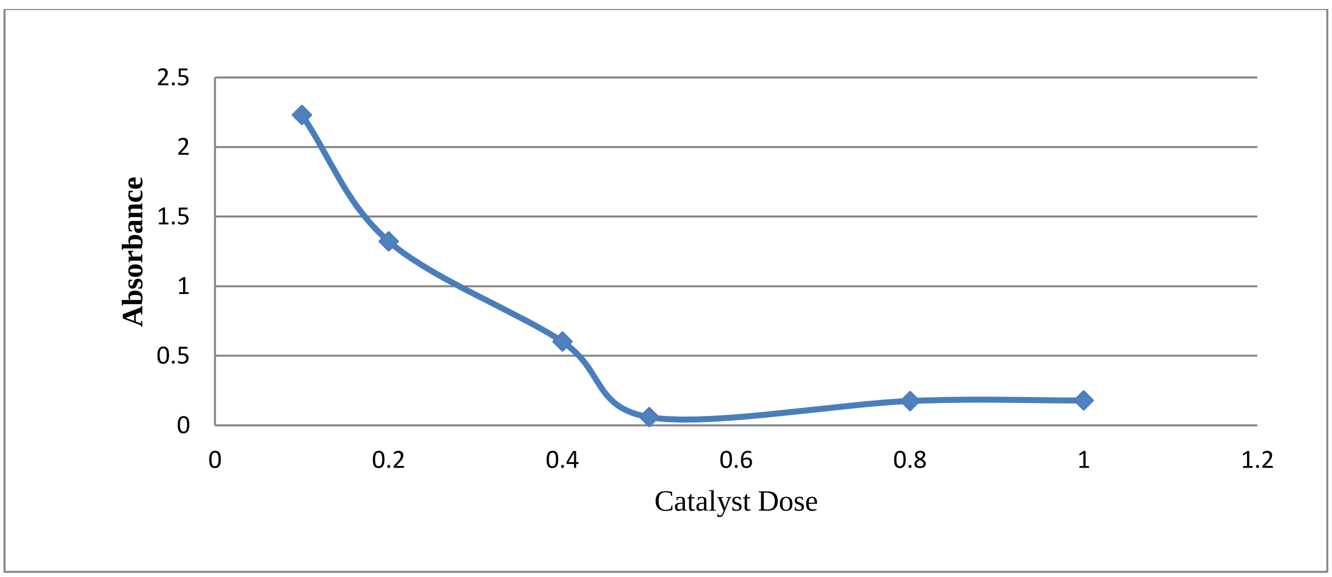

Figure 4: Absorbance Vs Catalyst Dose.

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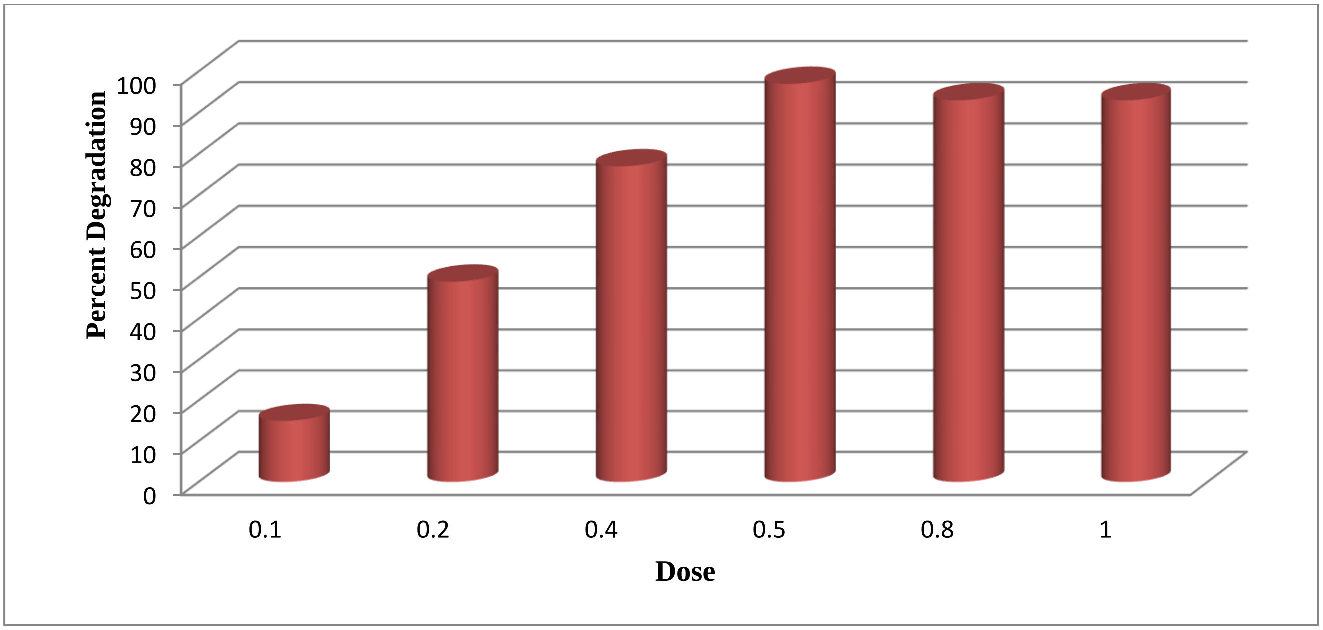

Figure 5: Percent Degradation Vs Catalyst Dose.

C. Effect of PH

Because of the amphoteric behaviour of most semiconductor oxides, an important parameter governing the rate of reaction taking place on semiconductor particle surfaces is the pH of the dispersions, since; it influences the surface-charge-properties of the photo catalysts [zhang et al., 1998]. Further, industrial effluents may not be neutral. Therefore study of pH is an important parameter in the degradation of dyes; the effect of pH on the rate of degradation needs to be considered. Experiments were carried out at various pH ranges from 2- 13 and from the result it's observed that pH range from 7 -11 are most suitable one for the degradation of Carmine dye solution.

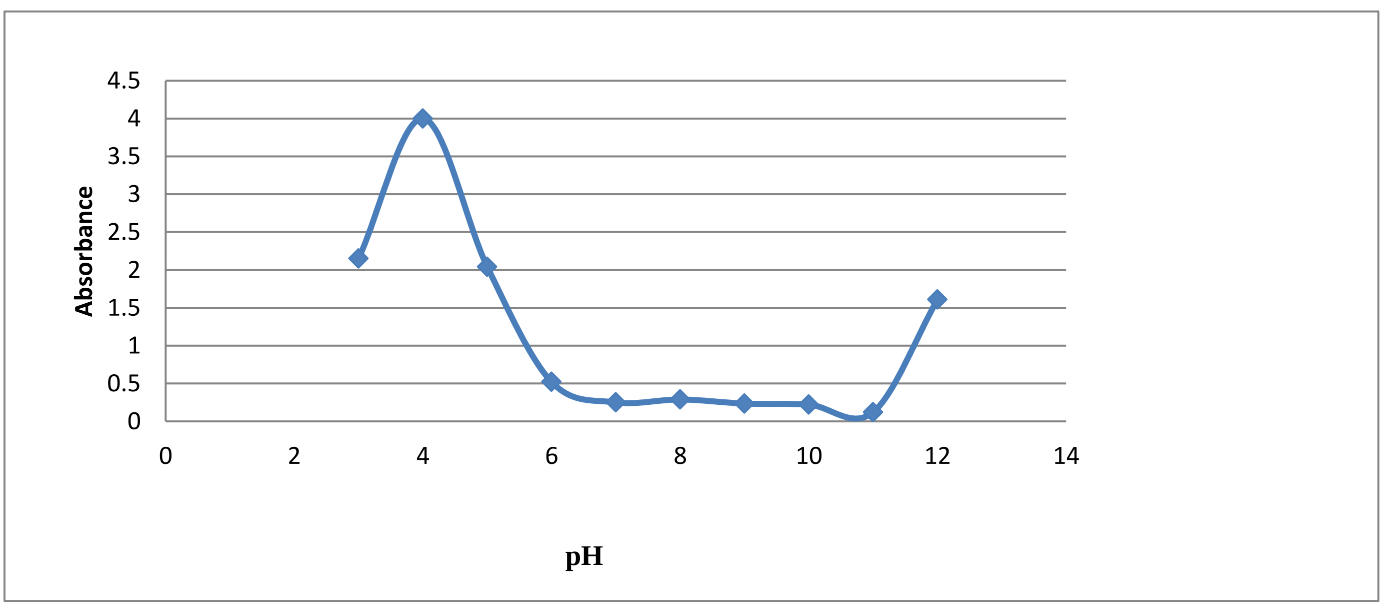

Figure 5: pH Vs Absorbance.

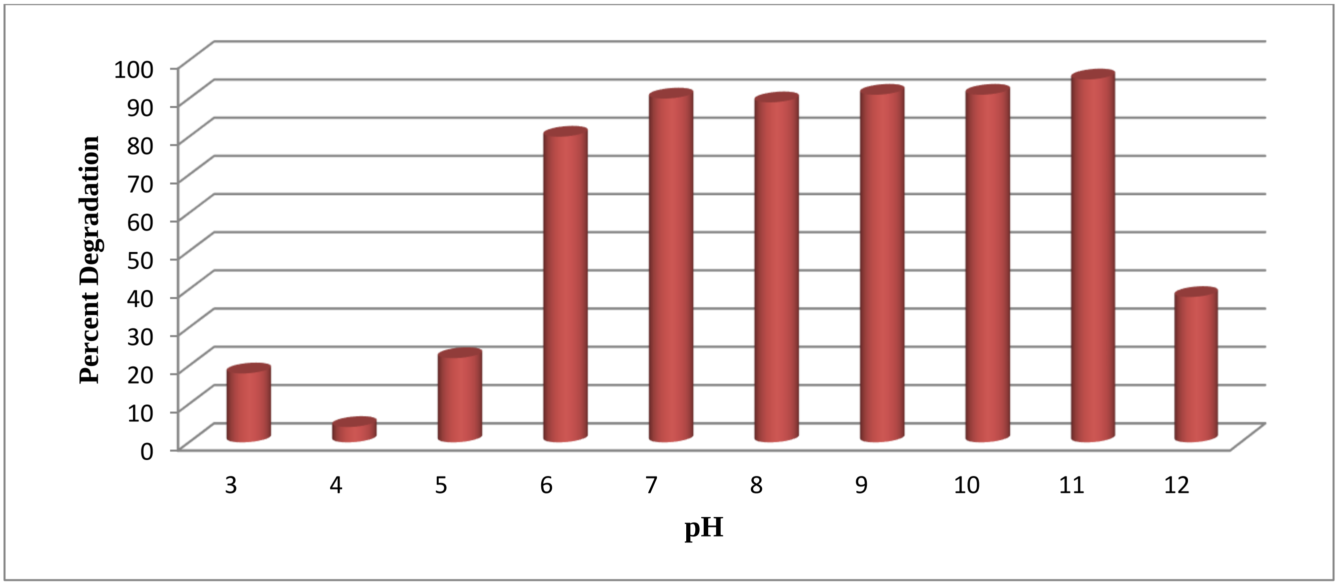

Figure 6: pH vs Percent Degradation.

V. CONCLUSION

The Photo Catalytic degradation of Carmine XIE dye using newly synthesized catalyst under laboratory condition was very effective in the removal of Carmine XIE dye from aqueous solution. In addition to the removal of colors Advanced Oxidation Process Suited the Best. The oxidation process required artificial air, a photocatalysts, and UV radiation. The Photo Catalytic degradation efficiency has been generally, found to increase with increase in catalyst loading up to a limiting value, decrease in initial concentration with respect to time, pH, and UV light intensity. Degradation Were Observed Much More better at 0.5g of Catalyst dose .The decolorization show a remarkable observation at 0.5 g in 100ml (500pm) of sample at 20-30 min of time shows 95 percent removal efficiency within 20 minutes of time interval and 0.5g of catalyst dose was sufficient for the decolorization of Carmine XIE dye. Therefore, this simple technology of Photo Catalytic degradation of the colored effluents containing Carmine XIE dye has the potential to improve the quality of the wastewater from textile and other industries.

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REFERENCES

[1]. Mills, Le Hunte, S., Journal of Photochemistry and Photobiology A, **1997,** 108, 1-35.
[2]. A.R. Khataee, V. Vatanpour and A.R. Amani Ghadim., J. Hazard. Mater., 161: 1225- 1233, 2009.
[3]. Abbas J. Attia, Salih H. Kadhim and Falah H. Hussein, E-J. Chem., **5**, 219 (2008).
[4]. Alkhateeb, A.; Hussein, F. & Asker, K. (2005). Photocatalytic Decolorization of Industrial Wastewater Under Natural Weathering Conditions. Asian J. Chem., Vol. 17, No. 2, pp. 1155- 1159.
[5]. Antharjanam, S.; Philip, R. & Suresh, D.(2003). Photocatalytic Degradation for Wastewater Pollutants, Ann. Chim., Vol. 93, No. 9-10 , pp.719-728.
[6]. Attia, A.; Kadhim, S. &. Hussein, F. (2008).Photocatalytic Degradation of Textile Dyeing Wastewater Using Titanium Dioxide and Zinc Oxide, E-J. Chem.,Vol. 5,pp. 219-223.
[7]. Barrett, K.L. (1997), The Effect of Advanced Oxidation Processes on Organics Removal from Wastewater, University of New Hampshire.
[8]. B Neppolian, Choi H C, Sakthivel S, Arabindoo B and Murugesan V 2002 J. Hazard. Mater. **89** 303
[9]. D Vione,.; Picatonitoo, T. & Carlotti, M.(2003). Photodegradation of Phenol and Salicylic acid by Coated Rutile Based Pigment, J. Cosmet Sci., Vol. 54,pp. 513-524.
[10]. Enrico Mendes Saggioro a, *, Anabela Sousa Oliveira b, c, Daniel Forsin Buss d,Danielly de Paiva Magalh~aes d, e, Thelma Pavesi a, Margarita Jimen_ez

f,Manuel Ignacio Maldonado f, Luis Filipe Vieira Ferreira b, Josino Costa Moreira Photo-decolorization and ecotoxicological effects of solar compound parabolic collector pilot plant and artificial light photocatalysis of indigo carmine dye Dyes and Pigments 113 (2015).

[11]. E M Saggioro, Oliveira AS, Pavesi T, Maia CG, Ferreira LFV, Moreira JC. Use of titanium dioxide photocatalysis on the remediation of model textile wastewaters containing azo dyes. Molecules 2011;16:10370e86.

[12]. E. Burtscher, Y-T. Hung and T. Bechtold., Handbook of Industrial and Hazardous Waste Treatment, CRC press USA, 379, 2004.

[13]. E. Tatara, K. Materna, A. Schaadt, H.J. Bart and J. Szymanowski., Env. Sci. Technol., 39 (9): 3110-3115, 2005

[14]. F. Zhang, J. Zhao, T. Shen, H. Hidaka, E. Pelizzetti, N. Serpone, Appl. Catal. B Environ. 15 (1998) 147–156.

[15]. Fernandez-Ibanez, P.; Planko, J.; Maitato, S. & de las Nieres, F.(2003). Application of Colloidal Stability of TiO2 Particles for Recovery and Reuse in Solar Photocatalysis, Water Res., Vol. 37, No. 13 , pp.3180-3188.

[16]. H.A. Boyter., Environmental legislations USA. In R. M. Christie (Ed.), Environmental aspects of textile dyeing. Woodhead, Cambridge, England, 2007.

[17]. H Lachheb,., Puzenat, E., Houas, A., Ksibi, M., Elaloui, E., Guillard, C. and Herrmann, J. (2002), Photocatalytic degradation of various types of dyes (Alizarin S, Crocein Orange G, Methyl Red, Congo Red, Methylene Blue) in water by UVirradiated titania. Applied Catalysis B: Environmental, 39: 75-90.

[18]. J. Bell and C. A. Buckley., Water SA. 29(2): 129-134, 2003.

[19]. J Chen,. ; Liu, M.; Zhang , J.; Ying, X. & Jin, L. (2004). Photocatalytic Degradation of Organic Wastes by Electrochemically Assisted TiO2 Photocatalytic System, J. Environ. Manage, Vol. 70, No. 1, pp. 43-47.

[20]. Klaus Hunger., Industrial Dyes Chemistry, Properties, Application, WILEY-VCH, 2003.

[21]. K . M. Shah., Hand Book of Synthetic Dyes Pigments., Vol. I, Multi-Tech Publishing Co., 229 p, 1998.

[22]. Liu, Y.; Chen, X.; Li, J. & Burda, C. (2005). Photocatalytic Degradation of Azo Dyes by Nitrogen-doped TiO2 Nano Catalysts. Chemosphere, Vol. 61, pp 11–18.

[23]. Li, X.; Liu, H.; Cheng, L. & Tong, H.(2003). Photocatalytic Oxidation Using a New CatalystsTiO2 Microspheresfor Water and Wastewater Treatment. Environ. Sc. Technol., Vol. 37, No. 37 ,pp. 3989-3994.

[24]. M. Lucas, V. Mertens, A.M. Corbisier and S. Vanhulle., Enzyme Microbial Technol., 42: 97-106, 2008.

[25]. M.H. Habibi, S. Tangestananejad, B. Yadollahi, “Photocatalytic mineralisation of mercaptans as environmental pollutants in aquatic system using TiO2 suspension”, Appl. Catal. B: Environ. vol. 33, no.1, pp. 57-63, Sept. 2001.

[26]. M Anbia., S. A. Hariri, S. N. Ashrafizadeh, Adsorptive removal of anioic dyes modified nanoporous silica SBA-3, Appl. Surf. Sci., 256 (2010) 3228–3233.

[27]. M. K. Purkait, S. D. Gupta, S. De, Adsorption of eosin dye on activated carbon and its surfactant based desorption, J. Environ. Management, 76 (2005) 135–142.

[28]. M. Hema, S. Arivoli, Comparative study on the adsorption kinetics and thermodynamics of dyes onto acid activated low cost carbon, Int. J. Phys. Sci. 2 (2007) 10–17.

[29]. O J Hao, Kim H, Chiang PC. Decolorization of wastewater. Crit Rev Environ Sci Technol 2000;30:449–502.

[30]. P. Bansal and D. Sud., Desalination., 267: 244–249, 2011 Reutergardh, L.B. and langphasuk, M. (1997), Photocatalytic decolourization of reactive azo dye; a comparison between Ti02 and CdS photocatalysis, Chemosphere, 35: 585-596.

[31]. R.V. Shende and V.V. Mahajani., Indian J. Chem. Technol., 2: 129-136, 1995.

[32]. S. Meric, H. Selcuk , M. Gallo and V. Belgiorno., Desalination., 173: 239-248, 2005.

[33]. S.S. Azhar, A.G. Liew, D. Suhardy, K.F. Hafiz, M.D.I. Hatim, Dye removal from aqueous solution by using adsorption on treated sugarcane bagasse, Am. J. Appl. Sci. 2 (2005) 1499–1503.

[34]. T Ohno,.(2004). Preparation of Visible Light Active S-doped TiO2 Photocatalysts and Their Photocatalytic Activities, Water Sci. Technol., Vol.49, No. 4 , pp. 159-163.

[35]. T.L. Vigo., Textile processing and properties: preparation, dyeing, finishing and performance. Amsterdam. Elsevier. 1994.

[36]. V. Mirkhani, S. Tangestaninejad, M. Moghadam, M.H. Habibi and A. Rostami-Vartooni, “Photocatalytic Degradation of Azo Dyes Catalyzed by Ag Doped TiO2 Photocatalyst”, J. Iran. Chem. Soc., vol. 6, no. 3, pp. 578-587, Sept. 2009 V. K. Gupta, P.J.M. Carrott, M.M.L. Carrott and R. Suhas., Crit. Rev. Env. Sci. Tech., 39: 783–842, 2009.

[37]. V. C. Srivastava, I. D. Mall and I. Mishra., Colloids and Surfaces A: Physicochem. Eng. Aspects., 260: 17–28, 2005.

[38]. V.K. Guptaa, R. Jain, S. Agarwal and M. Shrivastava., Colloids Surface A., 378: 22–26, 2011.

[39]. Wang Y 2000 Wat. Res. 34 990 World Health Organization. Health in water resources development. Available at: http://www.who.int.

[40]. Y-G. Zhang, L-L. Ma, J-L. Li and Y. Yu., Environ. Sci. Technol., 41(17): 6264-6269, 2007.

[41]. Y. Wang and W. Chu., Ind. Eng. Chem. Res. 50: 8734–8741, 2011.