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Photocatalytic Degradation of the Industrial Wastewater using a Newly Synthesized Catalyst

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Abstract: **The Textile industries pose a significant environmental difficulty because of their huge water consumption. The discharge of colored wastewater represents a severe environmental and community health problem. The present study involves the Photocatalytic decolorization of industrial wastewater by employing newly synthesizes heterogeneous photocatalyst under laboratory condition. An experimental trial has been made to study the effect of parameters viz., amount of catalyst, pH, and irradiation time of photo catalytic degradation of wastewater. The experiment was carried out by irradiating the textile wastewater containing photocatalyst inside the batch reactor having UV light. The rate of decolorization was estimated by spectrophotometrically. Similar experiments were carried out by varying pH (2–12), the amount of catalyst (0.2–1.5 gm) time variation (5-30) minutes). The experimental results show that, the maximum color removal of wastewater (more than 95) occurred at pH 7-11 using newly synthesized catalyst. Catalyst play excellent role for the degradation of dyes from the wastewater and the performance of catalyst in the UV Batch Reactor was excellent throughout the experiment.**

Keywords: **Textile Wastewater, decolourisation, photocatalyst, UV light.**

I. INTRODUCTION

The discharge of colored wastewater has serious environmental problem and community health problem. Color taking away from textile wastewater has turn out to be a huge challenge over the previous decades, and until now, there is no single and inexpensively eye-catching cure way that can successfully decolorize the wastewater (M. A. Boda1 et al., 2017). Textile industries represent an important environmental problem due to their high consumption of raw water (J. Zafrilla, et al., 2007). Waste water quality that depends on process step, sample and textile material (cotton, synthetic fabric, silk, etc.) (C. Suksaroj, et al., 2004). Wastewater-based effluent generated in the various activities of wet processing of textiles.

Textile industries placed in the first position in using of samples for coloration of fiber (Vital RK, et al.,2016). In fact, it has been found that 45% material in preparatory processing, 33% in sampling and 22% are re-processed in finishing (Sivaramakrishnan, C.N., 2004). Synthetic samples are extensively used in many fields e.g., in various branches of the textile industry (Gupta et al., 1992; Shukla and Gupta, 1992; Sokolowska-Gajda et al., 1996), Synthetic samples exhibit considerable structural diversity. The chemical classes of samples use most frequently on industrial scale are the azo, anthraquinone, sulfur, indigoid, triphenylmethyl (trityl) derivatives. These wastewaters may also be toxic to aquatic flora and fauna due to the presence of metals or chlorides, and breakdown products of samples (Khlifia R et al., 2009).

The textile industry has difficulty in meeting wastewater discharge norms (X. Chen et al., 2005). 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). The discharges of toxic synthetic samples into the environment cause and are a serious challenge to public concern and environmental scientists.

The removal of synthetic samples from waters and wastewaters to decrease their impact on the environment (Tunay et al., 1996).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).Chemical oxidation found

very effective but the efficiency strongly influenced by the type of oxidant due to their commercial importance, the impact (Guaratini and Zanoni, 2000) and toxicity (Walthall and Stark, 1999; Tsuda et al., 2001) of samples that are released in the environment have been extensively studied (Hunger, 1995; Calin and Miron, 1995)).

AOPs include photocatalysis systems such as combination of semiconductors and light, and semiconductor and oxidants 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. It is reported that the photocatalysis is the most efficient technique for the degradation of color i.e. samples from industrial wastewater. (Alkhateeb et al., 2005 & Attia et al., Vione et al., 2003; Li et al., 2003; Antharjanam et al., 2003; Fernandez-Ibanez et al., 2003; Liu et al., 2003; Ohno, 2004; Chen et al., 2004; 2008).

Photocatalytic decolorization of waste water samples by semiconductors is advance effective and rapid technique for the removal of colour from water (Habibi,etal., 2001; Mirkhani at al., 2009). Heterogeneous photo catalysis has emerged as an important destructive technology leading to the total mineralization of most of the organic pollutants including organic reactive samples (Hoda Roushdy Guendy (2009); Priti Bansal (2011); M.A. Barakat (2010); I. Poulios & I. Aetopoulou 20). Also they addressed to researchers and professionals with a background in environmental science and engineering about the solar driven Advanced Oxidation. It is reported that the photocatalysis is the most efficient technique for the degradation of color from samples of industrial wastewater. (Fernandez-Ibanez et al., 2003; Liu et al., 2003;Li et al., 2003; Antharjanam et al., 2003; Vione et al., 2003; Ohno, 2004; Chen et al., 2004; Alkhateeb et al., 2005 & Attia et al., 2008).

The aim of the present research work is to study the photo catalytic degradation of the textile wastewater by using a newly synthesized catalyst under laboratory condition for irradiation of sample in UV reactor. The effects of parameters such as time, catalyst dose and pH of the solution were observed on the degradation rate of waste water sample under the laboratory condition.

II. MATERIAL AND METHODS

A. Photo catalytic Studies:

The degradation of the textile wastewater was evaluated in laboratory conditions under illumination of UV light in the photo reactor. The photo catalytic activity of new synthesized photocatalyst was observed in various conditions. The wastewater was introduced into the photo reactor and at different time intervals the treated water was withdrawn from the chamber. All experiments were carried out under ambient conditions i.e., at room temperature.

Sample + OH• → degradation products

Sample + hVB+ → oxidation products

Sample + eCB → 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:

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

C. UV Spectrum:

The absorbance of the wastewater sample was measured before and after degradation at different time intervals. Measurements were carried out by using double beam Evolution 201 UV-Visible Spectrophotometer in the photon energy range of wavelength from 200 to 1100 nm. The colour removal of the sample solution was measured at the λ maximum at 364nm. Decolorization efficiency (DE) was calculated from a mathematical equation adapted from measurements of decolorization used as reported earlier. D. Hongre (1996) P. Anaral (2004).

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D. Photoreactor chamber:

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 photo catalytic 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 wastewater sample was collected from the textile industry. The catalyst dose was also fixed. The catalyst was synthesized under laboratory condition.

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 waste water sample was measured at 364nm.The degree of photodecolorization(X) as a function of time, was calculated by X= (C0-C)/C0 where C0 is the initial concentration of Waste water sample, and C is the final concentration of Waste water at given time t. Effect of catalyst dose, time, pH, were carried out in batch reactor throughout the experiment.

IV. RESULT AND DISCUSSION

The Photo degradation experiments were carried out under UV reactor. Wastewater sample was used throughout the experiment. Newly prepared catalyst used as semiconductor for decolourisation of wastewater. The Experimental work were done in UV chamber/UV reactor entirely and the absorbance taken from double beam spectrophotometer. The whole wastewater sample solution was irradiated under the specified condition.

A. Effect of Time:

Effect of contact time on the removal of Waste water sample from aqueous solution in presented in fig. 1 and 2**.** The experiments were carried out using photocatalyst at room temperature and different time intervals up to 45 min. The efficiency of sample removal was increased as the contact time increased and lowers initial sample concentration [S.S. Azhar et al., 2005]. It observed that initial removal was slow and after 20-35 min the removal is maximum it means the 95% removal observed at 20-30 min. It means that the adsorption is highly dependent on irradiation time [M. Hema et al., 2007]. So it was found that 95% of efficiency at 20-30 min with the newly synthesized catalyst. Therefore, 25 min is considered as the optimum contact time for the adsorption. The rate of decolorization was found to increase significantly with time of irradiation. Under optimal conditions, the extent of decolorization was about 100% after different periods of time ranging from 10 to 100 minutes depending on type of catalyst. **(**Falah H. Hussein ; Thekra A. Abassa 2010).

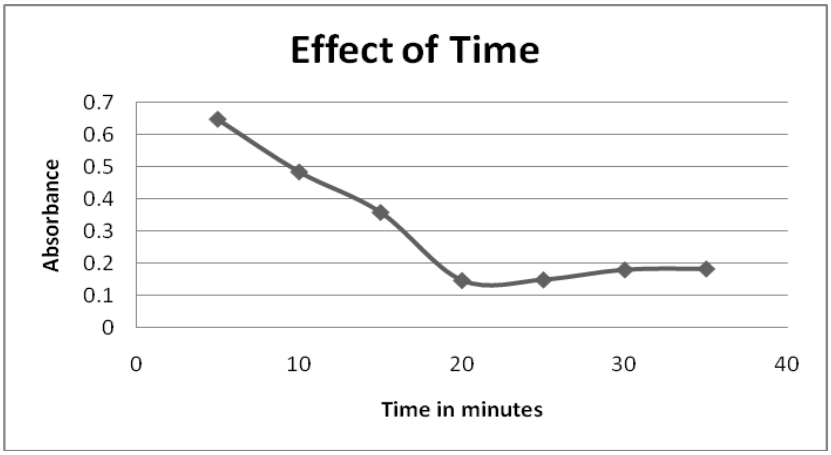

Figure 1: Time Vs Absorbance at Room Temperature

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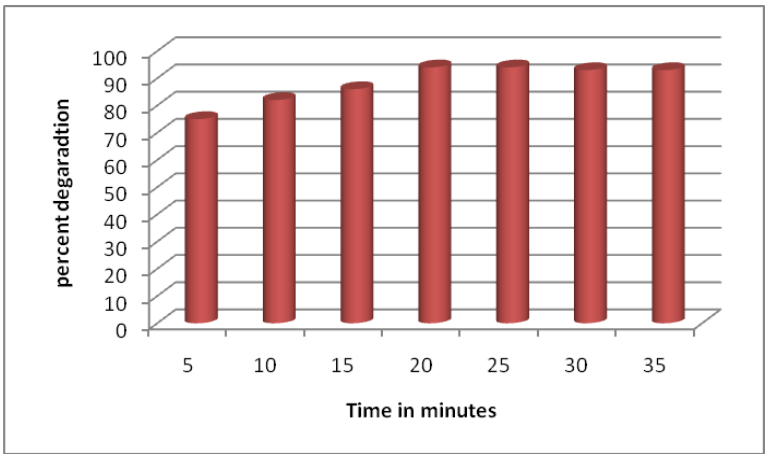

Figure 2: Time Vs Percent Degradation at Room Temperature

B. Amount of Catalyst Dose:

Some samples are degraded by direct UV radiation. Therefore, it should be examined to what extent the samples are photolyzed if no catalyst was used. Blank experiments were carried out for samples sample without catalyst for this purpose. It is also interesting to determine, the minimum amount of catalyst required to decolorize the maximum amount of sample at a particular experimental condition. For this, experiments were carried out with varying amount of newly synthesized photocatalyst for the degradation of industrial wastewater sample. The catalyst was added with an increased catalyst loading from 0.05 to 1.5g in 100 ml in a set of runs, the percent of sample degraded after 15 min-30min increased from 70 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 1.5g g in 100 ml solution under specified experimental conditions.

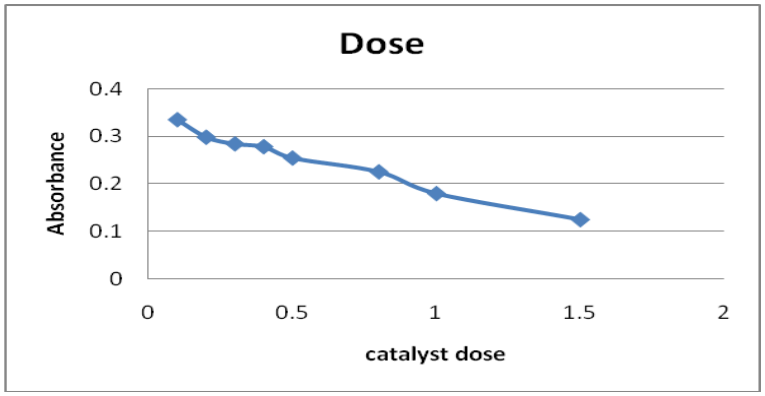

Figure 3: Catalyst Dose Vs Absorbance

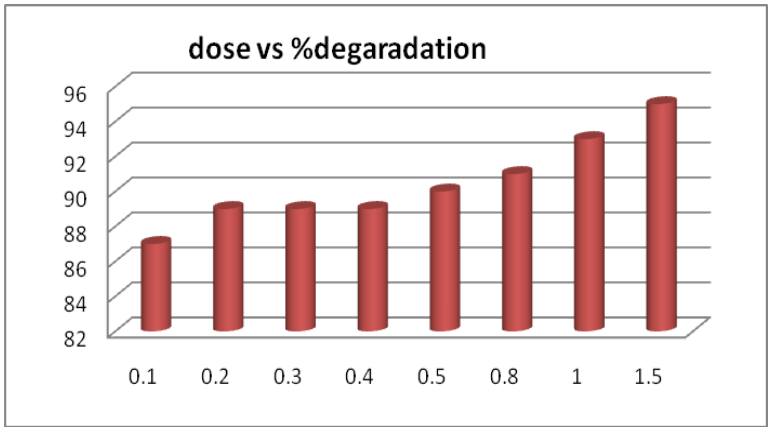

Figure 4: Dose Vs Percent Degradation

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C. Effect of PH:

Because of the amphoteric behavior 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 samples; 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 7-10 are most suitable one for the degradation of wastewater sample.99% of degradation of waste water sample was observed at pH 7 which shows that the catalyst used for the degradation was excellent at this range .

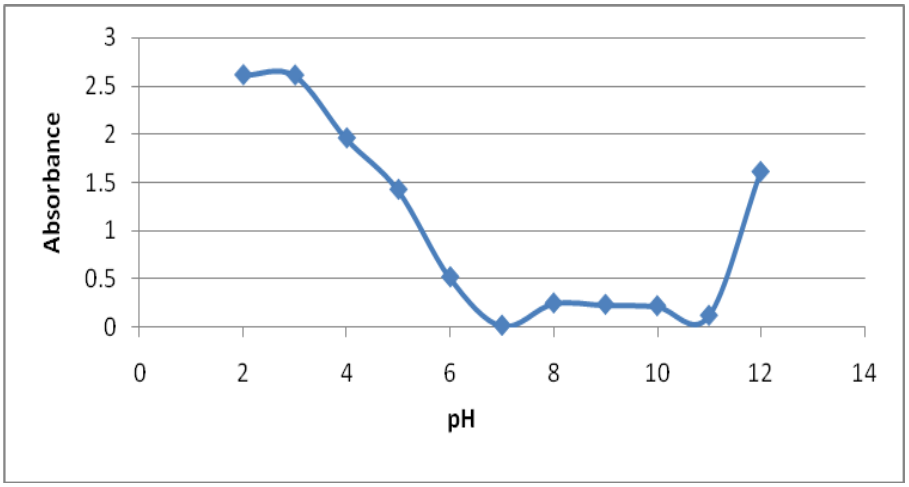

Figure 5: pH Vs Absorbance

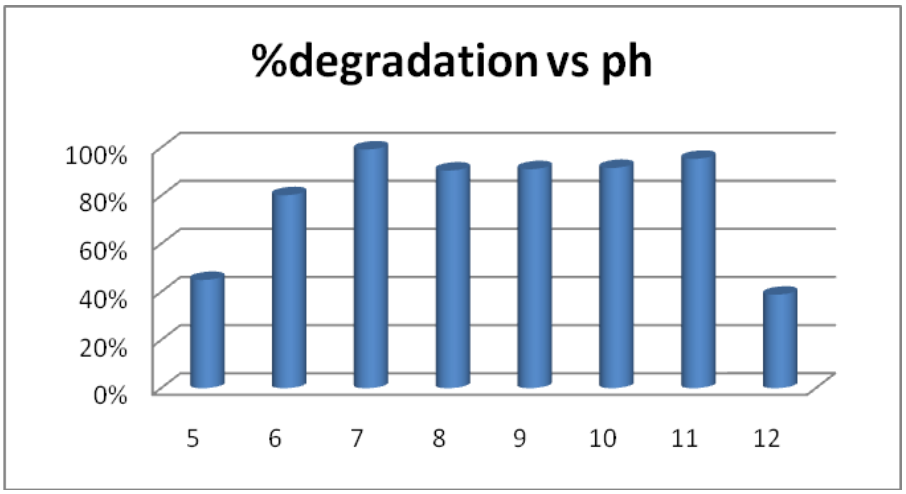

Figure 6: Percent degradation Vs pH

V. CONCLUSION

The Photo Catalytic degradation of Waste water sample using newly synthesized catalyst under laboratory condition was very effective in the removal of Waste water sample from aqueous solution. In addition to the removal of colors from industrial waste water the process adopted i.e Advanced Oxidation Process Suited the Best. The oxidation process required artificial air, a photocatalyst 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, dose and UV light intensity. Degradation were observed much more better at 1.5g of Catalyst dose .The decolorization show a remarkable observation at 1.5 g in 100ml of wastewater sample at 20-30 min of time shows 95 percent removal efficiency within 30 minutes of time interval and at pH range 7-9 shows 99% removal. Photo Catalytic degradation of the colored effluents containing dye or other content has the potential to improve the quality of the wastewater from textile and other industries.

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