

SOLAR PHOTOCATALYTIC DEGRADATION OF TEXTILE EFFLUENTS BY USING TITANIUM DIOXIDE

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ABSTRACT

In the present study, an effluent from textile industry is photo degraded under sunlight using TiO_2 as photo catalyst. The process has been carried out at different pH, amount of catalyst and the doses of oxidant. Comparison of various advanced oxidation processes (AOP), (Sunlight, Sunlight/ H_2O_2 , Sunlight/ $\text{H}_2\text{O}_2/\text{TiO}_2$) for the chemical oxygen demand (COD) and color removal from the effluent are under taken. The degradation of the wastewater has been studied at pH 3, 7, 9, 11 and 0.3, 0.5, 0.7, 0.9 gm/100 ml of hydrogen peroxide doses. The effect of catalyst doses are also studied at 1, 3, 5 and 7 mg. The result showed that Chemical Oxygen Demand of the effluent substantially decreased. The solar photocatalytic method is effective for degradation of COD of the effluent.

Keywords: H_2O_2 , TiO_2 , pH, advanced Oxidation processes, Chemical oxygen demand.

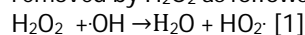
INTRODUCTION

Textile industry is very important because its products including clothes are used in varying ways for wearing and also affected by the styles in clothing wears, changes with the season & the trends in fashion¹. But environmental pollution is one of the main results of this industry². Textile industry effluents can be classified as dangerous for receiving waters, which commonly contains high concentrations of recalcitrant organic and inorganic chemicals and is characterized by high chemical oxygen demand (COD) and total organic carbon (TOC), high amounts of surfactants, high content of dyes, salts, dissolved solids, strong color fluctuating pH & temperature, possibly heavy metals³⁻⁴.

In developing countries dye-contaminated wastewater from various steps of dyeing process has caused environmental pollution⁵. Dyes have hydrophilic nature caused to introduce into the aquatic environment through natural and man-made activities without any alteration in structure⁶. Nowadays textile industries are used substantial amount of water to color their products, in their process to form highly colored effluents which are toxic and not easily destructed by biological method, most of the

dyes used are of complex structured polymers and realize azo dyes which cause special environmental concern due to their degradation to as aromatic amines, which is carcinogenic. The use of hydrophilic nature dyes the result in the discharge of toxic waste into natural water bodies. These industries are facing profitable level of production thereby reducing the fresh water. Therefore it is necessary to develop a new and good method for destruction the toxic pollutants into nontoxic materials⁷. Advanced Oxidation Processes (AOPs) are based on the generation of more reactive free radicals, especially hydroxyl radicals, have been used with an increasing interest due to their more oxidant power⁸. During the recent past, ZnO and TiO_2 were the most widely investigated⁹⁻¹⁰ semiconductors. Titanium dioxide is an effective photo catalyst for removal of chemical pollutants from waste water¹¹. TiO_2 is one of the most important transition metal semiconductor material that has been widely used as material in fuel cell, solar energy conversion, photocatalysts, white pigment in paints and paper, bone implant material, UV absorber in sunscreen cream and in cosmetic products, and food products¹². The broad application of the TiO_2 is due to its outstanding properties such as

harmless, cheaper, chemically highly stable and eco friendly¹³. It has bandgap about 3.2 eV matches the output of a wide variety of readily available lamps. In addition to this it has higher photo reactivity owing to its slower electron hole recombination as compared to ZnO, ZnS, CdS, Iron (III) sulphide¹⁴. Addition of H₂O₂ and irradiation by sunlight in combination with TiO₂ resulted in enhancement in the degradation of pollutants. The enhancement is due to generation of additional free radical¹⁵. However, the enhancement is not significantly high which may be due to ·OH free radicals are removed by H₂O₂ as follows:



The electrons are also scavenged by the oxygen adsorbed on the surface of TiO₂. On Irradiation the dye behaves like an electron donor at the excited state and injects electrons directly to the conduction band¹⁸.

Although it is a free, renewable and eco friendly energy source.it is not widely used in tropical countries like India. In this study photocatalytic degradation of textile effluent using TiO₂and solar energy was investigated.

MATERIAL AND METHODS

2. Experiment

2.1 Chemicals

Textile effluent was collected from the nearby textile industry and used as it is without any processing. 30% w/v of hydrogen peroxide (Qualigens) was used in the present study as an oxidant. Effluent was stored in amber colored light resistant pyrex glass bottles. Sodium hydroxide (1N) and Sulphuric acid (1N) were used for pH adjustments. All the chemicals used were of the analytical grade.

2.2. Experimental procedure

The original colour of the effluent was pale red in colour. The kinetic studies carried out under different experimental conditions were Photolysis, Per-oxidation, sunlight + H₂O₂ + effluent (Optimisation of pH), sunlight + H₂O₂ + effluent (optimisation of oxidant H₂O₂), sunlight + H₂O₂ + substrate (optimisation of photo-catalyst doses TiO₂).

The solar photocatalytic degradation study of 100ml effluent was carried out in flat glass vessel provided with an aquarium pump for the continuous agitation of the sample. During the reaction, the solution was stirred by magnetic pellet to ensure its homogeneity. Photocatalytic activity of TiO₂ was evaluated between 10 am to 4 pm during all sunny days by exposing the effluent solution to direct sunlight. The suspended TiO₂ solution was mixed very well using stirrer for 30 minutes in dark so that

adsorption equilibrium was reached. The mixture was then exposed to the sunlight by adding the oxidant, H₂O₂. The time at which the vessel was kept in sunlight was considered time zero or the beginning of the experiment. The change in the chemical oxygen demand (COD) was monitored by withdrawing 20ml of the aliquot from the reaction beaker at successive interval of time. Then a centrifugation process was applied to separate TiO₂ catalyst particles after photocatalysis.

2.3. Analysis

The pH of the solution was measured using Elico pH meter LI-120 equipped with a combined calomel-glass electrode. The aliquot was analysed by Chemical Oxygen Demand (COD) determination. COD analysis was done by using Unifos COD digester and analyzer. The percentage of demineralization was calculated by

$$\text{Percentage degradation} = \frac{(\text{COD})_0 - (\text{COD})_t}{(\text{COD})_0} * 100$$

Where,

(COD)₀ = the initial chemical oxygen demand

(COD)_t = final chemical oxygen demand at a given time.

RESULTS AND DISCUSSION

3. 1. Effect of pH

pH is one of the most important factor for the generation of hydroxyl radicals. An attempt has been made to study the effect of pH on the degradation of textile effluent under sunlight. It has been observed that the rate of degradation increases with an increase in pH showing maximum degradation at pH-7. But further increases in pH decreases the reaction rate as shown in Fig-1.

This may be due to the generation of more hydroxyl radicals. These radicals are produced due to reaction between OH⁻ ions and hole (h⁺) of the semiconductor.

3. 2. Effect amount Catalyst

Fig. 2 shows the effect of photo catalyst loading on the rate of degradation of dye at an optimized pH=7. The photo degradation was studied by varying catalyst dose from 1to7mg/100ml. The percentage degradation of the dye increases with an increase in the dosage of the photo catalyst. However with further increase in photocatalyst doses decreases the percentage degradation of the dye. The maximum degradation efficiency was attained with 1mg of TiO₂ photo catalyst and thereafter the rate of degradation decreased

The increase in degradation rate may be explained by the fragmentation of catalyst which

produces higher surface area. Thereafter with further increase in catalyst loading the degradation rate starts declining. This nature may be due to the screening effect i.e., above a certain amount of catalyst loading, the turbidity of the solution increases and ultraviolet rays start getting scattered, hence reducing the optical path¹⁹. The aggregation of catalyst particles, which reduces the interfacial area between the textile solution and the photocatalyst, may be other reason for the decrease in the degradation²⁰.

3.3 Effect of dose of H₂O₂

By carrying out a series of experiments with oxidant H₂O₂ namely 0.3, 0.5, 0.7 & 0.9 mg; the optimum H₂O₂ dose was found to be 0.9 (Fig. 3). Further increase in H₂O₂ concentration lowered the degradation rate. This is because of the excess H₂O₂ reacts with the hydroxyl radicals earlier formed and hence acts as an inhibiting agent of degradation by consuming the hydroxyl

radicals responsible for degrading the pollutant molecule²¹.

CONCLUSION

The photocatalytic oxidation processes shows excellent result for the decolourisation and demineralization of textile effluent in the direct sunlight. pH, amount of oxidant and photocatalytic doses are the important parameters for the decolourisation of textile effluent. In this study it is concluded that sunlight can be successfully used as light source for photocatalytic treatment of dye in the country like India where sunlight is available throughout the year.

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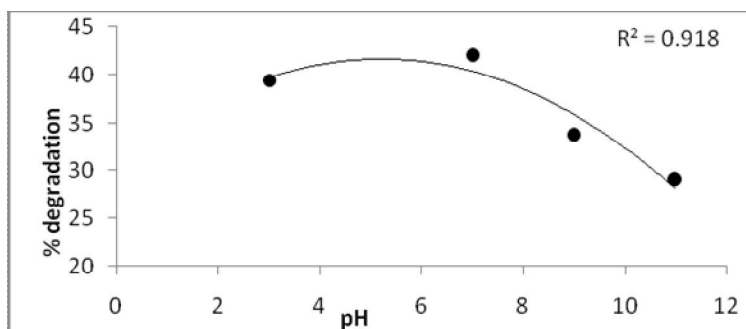


Fig. 1: Effect of pH on the degradation of effluent

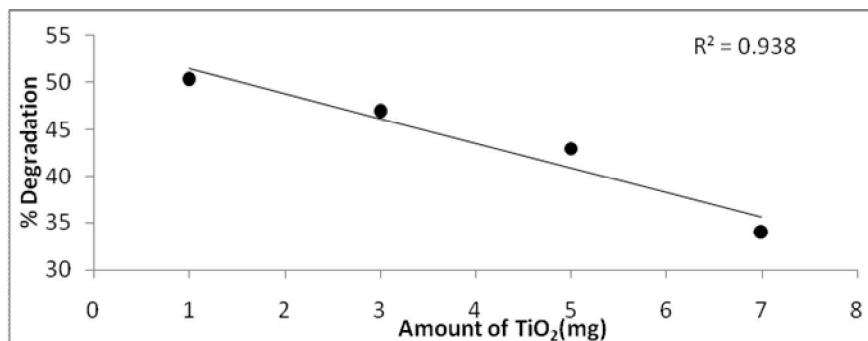


Fig. 2: Effects of TiO₂ doses on the degradation of effluent

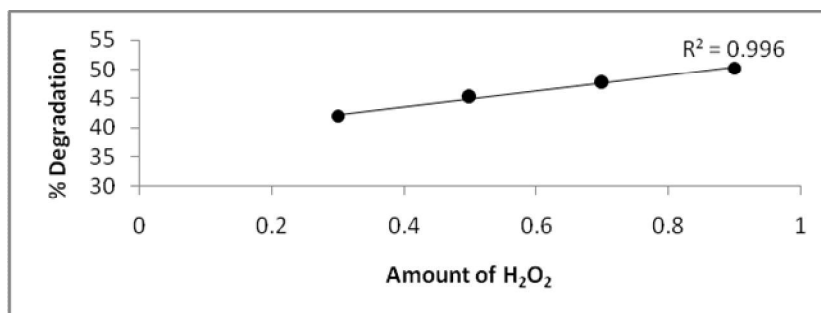


Fig. 3: Effect of amount of oxidant on the degradation of effluent

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