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# Effect of Operating Parameters on Degradation of Eriochrome black T Dye

***Abstract-*** *Of the effect, the process parameters on photocatalytic degradation Eriochrome black T( EBT) dye has been degraded in a batch reactor under UV light in heterogeneous slurry utilizing various concentrations of two semiconductors commercial catalysts (Titanium dioxide and Zinc Oxide). The parameter has been studied (catalyst type, catalyst concentration, pH of dye solution and initial dye concentration). The results showed that the best dose of $TiO_2$ and ZnO are 1.5 and 1 g/l respectively and the optimum pH (6 and 11) using $TiO_2$ and ZnO respectively. Moreover, the comparative assessment of the photocatalytic efficiency was made for different photocatalytic powder. It was noticed that the best photocatalytic efficiency as ZnO > $TiO_2$ . The investigational results were also assessed in expressions of chemical oxygen demand (COD) and color reductions to study treatment efficiency. Maximum COD removed was observed to be around 95%. The decolorization and the oxidation efficiencies could achieve 95% and 88% for ZnO and $TiO_2$ respectively at the optimum conditions for both catalysts (30 ppm Eriochrome black T dye solution).*

***Keywords***- *Photocatalytic Degradation, Wastewater Treatment, Eriochrome Black T dye, Advanced Oxidation Process*

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## 1. Introduction

Water pollution is a severe problem facing the chemical production in the world. To decrease this problem many approaches, viz., physical, chemical and biological, are presented [1]. So the environmental problems as results of wide manufacturing and employment of dyes have been brought large interests [2].

For toxic and polluted water different methods have been reported, such as photo catalytic degradation process with several of semiconductors is an effective method. Even though most studies in this area have focused on $TiO_2$, additional examination has shown that not only ZnO has comparable efficiency of photo catalytic degradation, but it is a better substitution to $TiO_2$ in some uses [3-5].

The azo-based dyes EBT have been quite utilized in the fabric manufacture. Also, EBT is very much difficult to remove the color from an account of their complex structure. Consequently, EBT has been categorized. As a result dangerous dye because of their large amount of molecular structure and chemically stable [6,7].

The ecological issues found to give rise to the EBT become the concentrate of international research to break down. Papers concerning the photo-removal of EBT dye were as yet missing and insufficient, chiefly form quick and effective AOP (Advance Oxidation Process) Technically. Although all of the studies above studies display promising results of EBT photo-decolorization execution, however, the interaction between the processing parameters (catalysts loading, the concentration of dyes, pH, etc.) were not taking into arithmetic and the mechanism contributory was still lacking in /unclear. This work aims to remove the Eriochrome black-T dye (EBT) under UV light with two commercial semiconductors catalysts such as ZnO and $TiO_2$ by varying process parameters for example (semiconductor photocatalyst, concentration, pH, and feed concentration) to choice the optimum condition for all catalysts.

## 2. Experimental Work

*I. Materials*

Eriochrome black-T dye (EBT) with the molecular formula of $C_{20}H_{12}N_3O_7SNa$. The chemical structure of the dye is shown in (Figure 1) ZnO and $TiO_2$ (P-25) from was used (Merck / Germany) in all experiments. Eriochrome black T dye (Merck / Germany) was used to prepare feed dye solution samples. HCl and NaOH (Merck/ Germany) were used for pH adjustment.

*II. Tools and Instruments*

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Distilled waters have been used for reactions. 30 ppm of (EBT) dye solution is used for all experiments with different concentrations of (0.5, 1, 1.5, 2) g/l of both catalyst (ZnO and $TiO_2$)

The different amount (15, 30, 45 and 60) mg of EBT dye to be dissolved in one liter of distilled water at room temperature. To prepare feed dye solutions with different pHs (3, 5, 7, 9, and 12), the several drops of prepared solutions of (0.1 M) of HCl and NaOH to be added for varying pH of dye solution.

Photochemical degradation reaction of the solution compound occurred in the insulation walled reaction vessel to keep the temperature constant this reaction vessel has (800 ml) volume and it was instilled in the UV box contained (eight) UV tubes light (eighteen watts Philips of each) with 365 nm wavelength. The value of UV light intensity was estimated by special light meter "UVA light meter Model UVA-365 Lutron" and it was observed to be 0.5 $mW/cm^2$. The mixing of the solution at all period time of each experiment using a magnetic stirrer (a type of BOECO MSH-330N Germany). When the water circulating in the jacketed wall reactor, the temperature was kept steady during the reaction time. The absorption of spectrums were recorded utilize double beam spectrophotometer with distilled water using an indicative the percentage rate of degradation was noticing that in the condition of alteration in intensity at λmax of the dyes through irradiation time.

Percentage of photocatalytic degradation estimated according to the following formula:

$$\boldsymbol{Decolorization}\ \% = \frac{\boldsymbol{Initial\ Absorption - Absorption\ at\ time\ t}}{\boldsymbol{Initial\ Absorption}} \times \mathbf{100}$$

All photocatalytic degradation experiments were carried out under similar conditions of UV light. For the reaction vessel, an open small cylinder glass of 1 liter and a height of 20 cm and a diameter of 15 cm was used. The suspension consisting of a mixture of 150 ml of the feed dye solution and photocatalyst was exposed to UV light. At various time periods, the 5 ml of sample was drawn with the help of a syringe and then filtered over a miliporose syringe filter. At that point, the decolonization rate was noticed in expressions of change in consistency at λmax of the dye and the absorption spectra of the dye solutions were recorded.

## 3. Results and Discussion

Experiments have been done with two types of catalyst (ZnO and $TiO_2$) the concentration for each photocatalyst is vary to choice the best concentration of each catalyst for the treatment of eriochrome black T dye. The photoreaction runs were achieved using various catalysts at a concentration of dye equal to 30 ppm, and catalyst capacity ranges of (0.5, 1, 1.5, 2) g/l for each catalyst through 60 minutes of irradiation. The results in Figures (2, 3, 4 and 5) shows the photodegradation of solution was increased up to (1 and 1.5) g/l for the catalyst of (ZnO, $TiO_2$) respectively and then the photodegradation is decreased. This case can be clarified in terms of the UV light permeation through the solution and active sites availability on the catalyst surface. When increasing the concentration of catalyst, the total effective surface area will increases. At the same time, there is a decrease in light penetration in respect of the increase in the turbidity of the suspension because of the increase of scattering effect and for that reason, the photoactivation volume of the stop will decreases. Moreover, it is hard to keep up the stop homogenous at high catalyst ability because of particles agglomeration that decreases the number of effective sites [11-13]. The outcome also refers that zinc oxide (ZnO) give the best photocatalytic efficiency than the $TiO_2$. The quantum effectiveness of its powder is larger than titanium dioxide because zinc oxide band gap equal to 3.17 eV, here higher effectiveness was showed for zinc oxide [14]. Less photocatalytic effectiveness for degradation was noticed and the smaller band gap award fast recombination of hole and electron. Furthermore, the metal sulfide semiconductors are not suitable based on the constancy demands in that they easily undergo photoanodic corrosion. The order of degradation efficiency of various photocatalysts is Zn > $TiO_2$ for degradation for eriochrome black T. In addition to higher activity, which one zinc oxide and titanium dioxide is than low cost. Consequently, next runs were achieved with zinc oxide and titanium dioxide to improvement the various operational parameters viz. catalyst concentration, pH value, concentrated the begin of experiment and COD removal a substrate assuming photodegradation of feed mixtures [15,16]. Finally, the figures [2, 3, 4 and 5] shows a comparison of photocatalytic activity efficiency was observed that the better photocatalytic efficiency as ZnO > $TiO_2$ respectively.

The wastewater is produced at several pH. Therefore, research of pH is very significant on the photodegradation of dye. Experiments conducted at various values of pH varying from 3 to 12 for 30 mg/L dye solution concentration and the best of two catalyst concentration (1 and 1.5) g/l of ZnO and $TiO_2$ respectively. Figures 6 and 7

show the percentage photodegradation of eriochrome black Y against values of pH. Increase in pH up to 6 and 10 of ZnO and $TiO_2$ respectively cause increasing in photodegradation activity [17]. The use of ZnO such as the catalyst is more suitable of high pH values for the textile remains. The interpretation of pH effects on the efficiency of the decolonization is a complex subject many of reactions can happen to dye degradation like "hydroxyl radical reaction, direct oxidation using the positive hole and direct reduction by the electron in the execution band." The study of each catalyst based on the substrate nature and different values of pH.

The experiments also showed that mineralization behavior of Eriochrome black Y dye, the efficiency of chemical oxygen demand (COD) removal was studied under best conditions at 30 minutes of irradiation for both catalysts ($TiO_2$ and ZnO). Figure 8 shows the efficiency of COD removal as a function of irradiation time. The results also showed COD removal is lesser than percentage photodegradation using two catalysts ZnO and $TiO_2$. It indicates that it took longer irradiation time to obtain high removal mineralization of dyes. More reactive hydroxyl radical species will be photogenerated because of the higher concentration of hydroxide ions in the solution of dye [20,24].

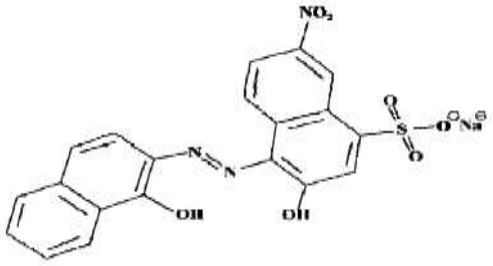


**Figure 1: Eriochrome black-T dye (EBT) chemical structure**

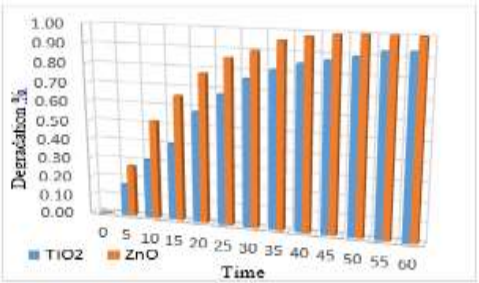


**Figure 2: Comparison of photocatalytic degradation behavior of Eriochrome balck T dye at two kind of catalyst (Natural pH=6.78 , catalyst dose = 0.5 g\l)**

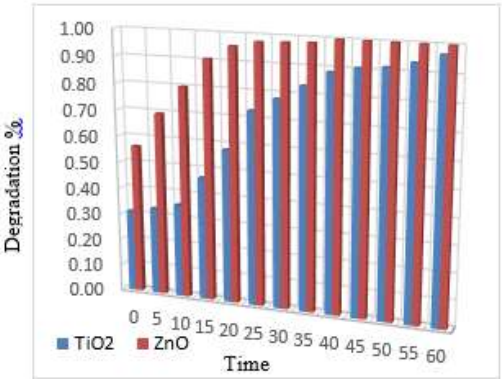


**Figure 3: Comparsion of photocatalytic degradation behavior of Eriochrome balck Y dye at two kind of catalyst (Natural pH=6.78, catalyst dose = 1 g\l)**

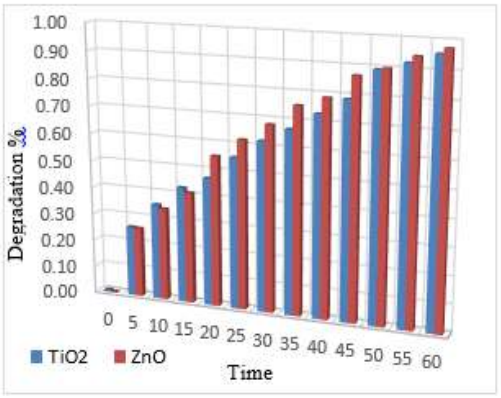


**Figure 4: Comparison of photocatalytic degradation behavior of Eriochrome balck T dye at two kind of catalyst (Natural pH= 6.78, catalyst dose = 1.5 g\l)**

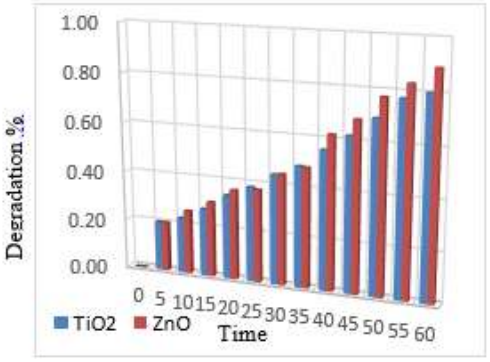


**Figure 5: Comparison of photocatalytic degradation behavior of Eriochrome balck T dye at two kind of catalyst (Natural pH=6.78, catalyst dose = 2 g\l)**

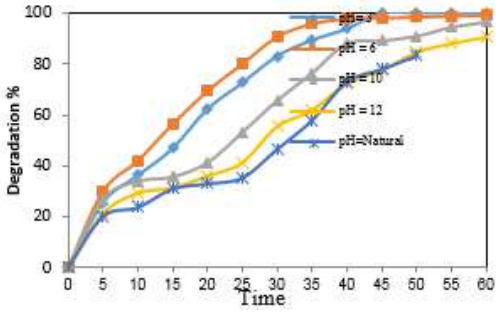


**Figure 6: Effect of pH on photocatalytic degradation behavior of Eriochrome balck Y dye solution using best concentration of TiO2**

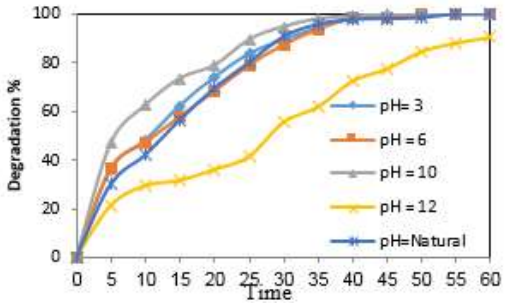


**Figure 7: Effect of pH on photocatalytic degradation behavior of Eriochrome balck Y dye solution using best concentration of ZnO**

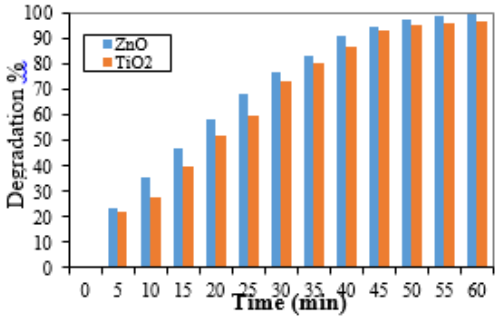


**Figure 8: Efficiency of COD Removal of Eriochrome balck T dye solution using best concentration of $TiO_2$ and ZnO**

## 4. Conclusion

The comparison of photocatalytic degradation efficiency and COD removal of different type of catalyst and parameters affecting on the photocatalytic degradation process of eriochrome black Y dye has been examined in a batch reactor under UV light in the heterogeneous slurry the catalysts like ($TiO_2$, ZnO ). Parameters have been studied like (catalyst type, catalyst concentration, pH of dye solution, and initial dye concentration). The difference was obviously when ZnO catalyst compared with $TiO_2$ catalyst as well as, that the ZnO presented better photocatalytic degradation efficiency and removal COD for Eriochrome black Y dye because the bandgap value for zinc oxide is equal to 3.17 eV, the powder quantum activity is larger than titanium dioxide and here higher activity appeared for zinc oxide.

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