Photocatalytic Decolorization Simulated Textile Dyebath Effluent under Solar Light and Reuse it for Industrial Propose

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Abstract. In this work, the photocatalytic is related to simulated wastewater as well as recycling for industrial uses. Photocatalytic degradation of simulated wastewater content (Eosin Yellowish, Eriochrom Black T, Methyl Violet, EDTA, FeSO₄.7H₂O, NaCl, and NaOH) was utilized as a treatment approach in batch reactors within solar light in a heterogeneous slurry with the use of many concentrations regarding the commercial powder ZnO as photocatalysts semiconductors. We have tested many operation conditions like (catalyst concentration, pH, initial dye concentration and final water treated properties). The water quality related to treated wastewater is based on the nature of waste added during usage, the industrial water supply quality, and the treatment degree which is received via wastewater. After that, the quality data of wastewater is evaluated and indicated at waste-water treatment plant majorly for the disposal of the treated effluents or discharge requirements with regard to gross pollution parameter.

Keywords: Textile Wastewater Degradation; Reuse Industrial Water; Solar Energy (Solar Light)

1. Introduction
The textile industry is known as releasing huge amounts of wastewater contaminated by a large spectrum of chemicals. [1]. As a result, the wastewater composition varies significantly in concentration and time. Due to this, textile wastewater treatment can be very complicated. The recent trend in the textile industry is on-site wastewater treatment and the process of water recycling. [2]. Titanium dioxide (TiO₂) can be defined as a very commonly utilized oxide semiconductor material because of its low-costs, strong oxidizing power, wide bandgap (3.2eV), non-toxic nature, increased resistance to the photo-induced or chemical corrosion, also a maximal scattering of the light with virtually no absorptions, also it is majorly utilized in cosmetics, sensors, PVs, photocatalysis, solar energy conversion, paints, textiles and so on. [3]. In addition, the textile and the dyeing mills are using large water amounts and discharging of the coloured waste-waters which were increasingly polluted with the auxiliaries of the textile, dyes with other types of the chemical [4]. The composition of the
wastewater from the dyeing and textile processes are considerably varying hourly and daily, based on fabric, dyestuff, and the concentration related to the added fixing compounds [5]. The procedure of dyes’ heterogeneous photocatalytic degradation is examined thoroughly in [6, 7, and 8]. The process of PV degradation was prompted via nano photocatalyst, that catalyst has been suspended in a solution or being immobilized on adequate supports. With regard to the system of the suspension, the photo-catalytic reactions were specified as surface processes, whereas in terms of the immobilized system, there’s a continuous discussion if the photo-catalytic reactions of the oxidation were solution or surface processes.

In the present paper, the photocatalytic degradation of simulated textile dyebath effluent under solar energy (solar light) and reuse it for industrial propose using commercial powder TiO$_2$ as a photocatalyst has been tested and recycle wastewater has been treated for industrial uses. The fundamental objective of the present work is to compare the changes of the following parameters with respect to the degradation efficiency, impact of pH, impact of catalyst concentration; the impact of dye’s initial concentration, and kinetic of reaction.

2. Materials and Methods

2.1 Materials
In the presented work, commercial TiO$_2$ powder is obtained from Merck Co. (Company in Germany), Eosin Yellowish, Eriochrom Black T, Methyl Violet, EDTA, FeSO$_4$·7H$_2$O, NaCl and NaOH) are breaches from Merck and has been utilized with no more purification. Furthermore, distilled water has been utilized to prepare many solutions, NaOH (0.10N) and HCl (0.10N) were utilized in order to change the solution pH.

2.2 Instruments
The photochemical degradation has been conducted in uniquely developed insulation walled reaction containers with 1000ml volume within solar light, thus the spectra have been taken with the UV-visible spectrophotometer (Shimadzu UV-2101PC). However, a continuous stirring of the solution has been covered via utilizing magnetic stirrers. After that, the temperature is kept constant throughout the time of the reaction through spreading water in photocatalytic reactor vessels.

2.3 Experiments of the Irradiation
For a dye solution (35 ppm) of 250 ml, a photocatalyst has been added with various concentrations and a suspension exhibits irradiation, whereas the experiments are conducted under the solar light. In addition, the aqueous suspension is stirred (magnetically) over the experimentation. At various periods of time, aliquot has been taken out by means of a syringe and after that filtered via Millipore syringe filter of 0.45μm (9, 10).

2.4 Absorption Measurements
The absorption spectrum is recorded with the use of double beam UV2101 (Shmadzo spectrophotometer) in comparison to distilled water as reference liquid, while the rate of the degradation percentage has been indicated with regard to intensity change at $\lambda_{max}$ of dyes throughout irradiation time (11,12). Also, the degradation efficiency (%) was evaluated as follows:

\[
\text{% Degradation} = \frac{\text{Abs}_0 - \text{Abs}_t}{\text{Abs}_0} \times 100
\]

In which:
- % Degradation represents the percentage regarding the dye’s disappearance.
- Abs$_0$ represents the dye’s initial absorption (at time = 0 minutes)
- Abs$_t$ represents the dye absorption (at time = t minutes)

Thus, comparable experimentations utilized distinctive catalyst concentrations (2–5g/l) for selecting the optimal catalyst TiO$_2$ concentration at the same dye concentration of a solution (35 ppm).
3. Results and Discussion

3.1 Effects of the Photocatalyst Dose

The effects of the concentration of the catalyst on simulated textile dyebath effluent (35ppm) degradation has been researched with the use of the commercial TiO$_2$ between 3g/l and 7g/l keeping other parameters such as the temperature, pH, and concentration of the dye unchanged. Results from Figure 1 show that the percentage of the degradation has been increased with increasing the commercial concentration of the TiO$_2$ to 5g/l for the Titanium dioxide. That observation may be explained based on the active sites’ availability on the surface of the catalyst and solar light permeation in suspension. The entire active surface area increases with the increase in the dose of catalyst. Simultaneously, as a result of increasing suspension turbidity, there has been a reduction in the permeation of the solar-light due to the increase in the effect of scattering and as a result, the photo-activated suspension volume is decreased. In addition to that, at the high loading of the catalyst, there is a difficulty in the maintenance of suspension which is homogenous as a result of the agglomeration of particles, resulting in a decrease of the number of the active sites (13, 14). Moreover, results have shown as well the maximal photodegradation for the commercial Titanium dioxide 5g/l accomplished 90 min later has been 95% (Figure 1).

![Figure 1](image-url)

Figure 1. Effects of the dose of the catalyst of the TiO$_2$ on the Simulated Textile Dyebath Effluent degradation within 90 min.

3.2 Effects of the pH on Treatment of the Solution

Waste-water is produced at a variety of the pH values, which is why studying the pH is of high importance on photodegradation of simulated textile dyebath effluent dye. So the experimentations were performed at a variety of the pH values that vary between 5 and 11 for 35mg/L concentration of the simulated dye solution and for optimal catalyst concentration of 5g/l of titanium dioxide. However, figure 2 shows the percentage photodegradation against pH values. It clearly increases in the pH up to 6.5 for the titanium dioxide, due to the increase in the activity of the photodegradation (15). While utilization of titanium dioxide as the catalyst is more suitable at the high values of the pH with textile effluent. Interpretation of impacts of pH on de-colonization efficiency is one of the very complicated subjects, due to the fact that numerous reactions may happen to the degradation of the dye like the “direct oxidation by positive hole, hydroxyl radical reaction, and the direct reduction by the electron in conduction bands”. Which is why, the significance of everyone is depending upon substrate nature and values of pH (16, 17).
Figure 2. Effects of pH on the Degradation of the Simulated Textile Dyebath Effluent within 90 min.

3.3 Effect of Simulated Textile Dyebath Effluent Initial Concentration

The photodegradation of simulated textile dyebath effluent has been carried out by the variation of the initial dye concentration from 15.0mg/l so as to specify the effects of the initial dye concentrations on the optimal type of catalyst and TiO₂ dosage. With the increase of dye concentration, the degradation percentage has been reduced, which indicates either the increase of the concentration of the catalyst or the time span for full removal. The figure3 exhibits time-dependent degradation graphs of the simulated textile dyebath effluent at a variety of the concentration values of the solutions of the dye 25–75mg/l. But in the case of the solutions of 25mg/L and 35mg/L, 100% degradation occurred in 70 and 90 minutes respectively. While in 50mg/L and 75mg/L case, the degradation with 150 minutes is 75% and 60% respectively, for full degradation of dye as well as the degradation of the percentage has been further reduced on the increase in dye concentration. Finally, the reason behind such behaviour was the length of the path of photons that enter the solution reduces in the high concentration of dye, meaning the photo-chemical reaction has been reduced, however, the number of the photons that have been absorbed by the catalyst becomes high at the low initial dye concentrations, the number of the photons that have been absorption by the catalyst in the lower (18,19).
3.4 Wastewater Treated Properties

The wastewater reuse guidelines enacted in California in 1918 may have been the first ones of their kind. Table 1 lists a comparison of the actual to waste-water treated characteristics. Results have shown that wastewater treated characteristics near the actual industrial water, meaning the fact that the treated waste-water has been proper to be reused for the industrial proposes [20-22].

| Properties                      | Actual Water | Treated Water |
|---------------------------------|--------------|--------------|
| Salinity (ds/m)                 | > 3.0        | 1.53         |
| ECw (ds/m)                      | > 2000       | 1350         |
| TDS (mg/l)                      | > 30         | 20           |
| Miscellaneous Effects (mg/l)    | > 8.5        | 7.3          |
| Nitrogen (NO\textsubscript{3} - N) (mg/l) | > 8.5    | 7.3          |
| Bicarbonate (HCO\textsubscript{3}) (me/l) | > 8.5    | 7.3          |
| pH                              | 6.5          |              |

*Table1. Interpretation Guidelines of Quality of Water for Industrial*
4. Conclusions

The photo-catalytic aqueous solution degradation of the Methylene Blue dye was observed using a solar-light-irradiated catalyst of the titanium dioxide. It was discovered that this procedure results in the de-colorization and, in the end to full dye solution mineralization. In addition to that, the intermediates’ evolution and the final products on the surface of the photo-catalyst and solution was observed with a variety of the approaches, enabling to identify of the pathway of the reaction, from dye molecule adsorption on the surface of the photo-catalyst to final product formations.

5. References

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