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Titanium dioxide as photocatalyst for processing textile wastewater under UV light

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Abstract:

The textile industries has been classified as one of the minor sources of pollution because it takes large quantities of water and bring large amounts of wastewater and colored dyes from multi stages of processing. The photo catalytic process is a very popular method of degradation and removal different dyes and one of most important agents of wastewater treatment in textile industries. In this research, dyes (Methyl Orange, Methylene blue, eriochrom black) degradation from the textile by product waste- water using commercial photocatalyst TiO_2 was investigated. Different operating conditions (catalyst , concentration , pH) were studied and catalyst concentration range was (0.1 – 3 g / l) ,in addition pH values (10.2 , 7 , 5 , 12). Based on the results of this work, it may found that the optimum catalyst concentration was 2 g/l since maximum degradation percentage 60% was obtained and the optimum pH value was 7 since maximum degradation percentage was obtained at this value.

Keywords: Degradation, textile wastewater, dyes, Photocatalysis, titanium.

Introduction

Increasing demand for pure water became a universal problem so, different methods for waste-water treatment were investigated around the world [1, 2] .Textile industries represent a major source of waste-water [3]. Textile industries produce 107 kg / year of dyes characterized with difficult degradability and dying process exhaust (10- 15%) of the dye as a contaminant during operation. [4, 5.].

Heterogeneous photocatalysis utilizing is very important method for waste-water treatment [6, 7]. Photocatalysis via TiO_2 method is characterized with: absence of mass transfer restrictions, operation at room conditions and using of sun lighting [8, 9]. The catalyst used in this method is characterized with cheap price, availability, non-toxicity and chemical stability. This method is efficiently used for organic contaminants removal from textile waste-water. [10, 11, 12].

Waste-water produced from textile industries characterized with huge amounts, high texture variety, relatively low biological oxygen demand and high oxygen demand [13, 14]. Reports indicate that more than half of produced organic colorants is textile dyes [15, 16]. According to the nature of textile effluents discoloration of these compounds requires a combination of physical, chemical and biological techniques. The most important techniques used in the textile contaminants treatment are : adsorption , activated carbon , coagulation , flocculation , sedimentation and dissolved air floatation , oxidation via chlorine and ozone , electrochemical oxidation , aerobic and anaerobic biological treatment [17,18]. In the present paper the photocatalytic degradation of (methyl orange, methylene blue and eriochrom black) dyes in aqueous solutions using a photocatalysts has been tested. The aim of the present work was to investigate the main factors affecting the photocatalytic treatment of an actual textile industries water and the main purposes was given on the photocatalytic are : efficiency of different crystalline forms of TiO_2, effect of catalyst concentration , effect of initial concentration of the dye and solution pH studying.

Experimental work:

Apparatus used in this work were (conical flasks , measuring cylinders , beakers pipettes , test tubes , funnels , magnetic stirrers , spectrophotometer , pH meter , oven , Millipore syringe , nylon filter and digital balance.

Chemicals used in this work were: methylene blue, methyl orange and eriochrom black dyes, ferrous sulphate, NaCl, EDTA, HCl , NaOH and buffer solution used to calibrate pH meter supplied by "E. Merck" company.

Procedure

The first step, was tools cleaning and rinsing with distilled water .Equal weights of 0.15 g of methylene blue, methyl orange and eriochrom black dyes were dissolved in 600 ml of distilled water .Another solution was prepared with 2.5 g/l NaCl, 0.15 g/l NaOH, 0.3 g/l EDTA and 0.15 g/l ferrous sulphate with 50 ml total volume. Both prepared solutions were mixed together, then the total volume of the new produced solution was completed to 1 liter.

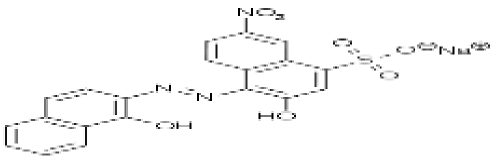
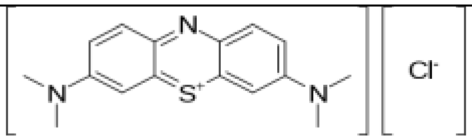
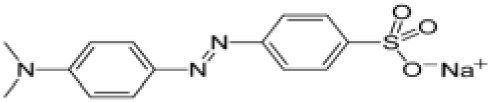
For each run, 100 ml of this solution was withdrawn and TiO_2 catalyst was added to these samples with different concentrations, then mixed continuously by magnetic stirrer .5 ml three samples were withdrawn from the last prepared samples at constant time intervals (5min.).These samples were indicated in to test tubes using syringe and nylon filters. After 15 minutes , 85 ml remained from the 100 ml samples were subjected to UV ray with continuous mixing via magnetic stirrer for 105 minutes .During this time period , 5ml was withdrawn at 5 , 10 , 25 , 45 , 75, and 105 minutes and analyzed by using double beam UV-spectrophotometer in the photon energy range of wavelength from 200 to 800 nm. Degradation percentage could be calculated by the following equation:

$$Deg.\% = \frac{X_{t=0} - Y_{t=t}}{X_{t=0}} * 100$$

Where Deg. % is the percentage of the degradation and $X_{t=0}$ is the absorbance before irradiation and $Y_{t=t}$ is the absorbance at time equal t. Different experiments have used similar catalyst concentration (0.1–3 g/l), to pick out the optimum concentration of the used catalyst (TiO_2) [19, 20].

Classification of used dyes in textile industries:

Various types of textiles are colored using different types of dyes. Moreover, dyes can be classified into different types depending on their chemical structure and properties, so the chemical structure of the main dyes were obviously in table below:

Dye	Chemical formula	Structure
Eriochrom black	$C_{20}H_{12}N_3O_7SNa$	
Methylene blue	$C_{16}H_{18}ClN_3S$	
Methyle orange	$C_{14}H_{14}N_3NaO_3S$	

Results and Discussion

Effect of pH value:

The value of pH may vary with respect to the type of dyes used. Thus the study of pH is an important factor in the degradation of dyes. The effect of pH was studied by regulating the pH value to different values by addition (1N) of HCl and NaOH in separate. After measuring pH of the solution. pH value was adjusted to three values (12, 7, and 5). The original pH value of the solution was 10.2.

Photocatalytic studies:

A comprehension of reaction rates and how the reaction rate is influenced by different parameters is important for the design and optimization of an industrial system. The rate of photocatalytic degradation depends on several factors including illumination intensity, catalyst type, pH, and presence of inorganic ions and the concentration of the organic reactant.

Influence of concentration:

. All these results configuration in a figures and it can be seen from figures that the percentage of degradation increased and reached to the 60% when the concentration of photocatalyst was increased and it can observed that the optimum concentration was 2 g/100ml because the change degree of color was clearly and have a highly degradation.

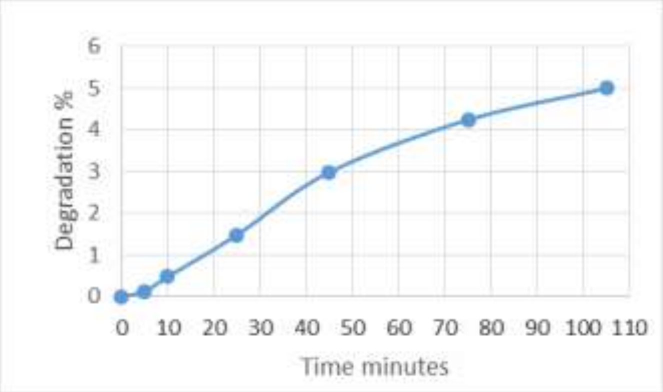


Figure (1) shows the degradation percentage of dyes using 0.15 g/l TiO2

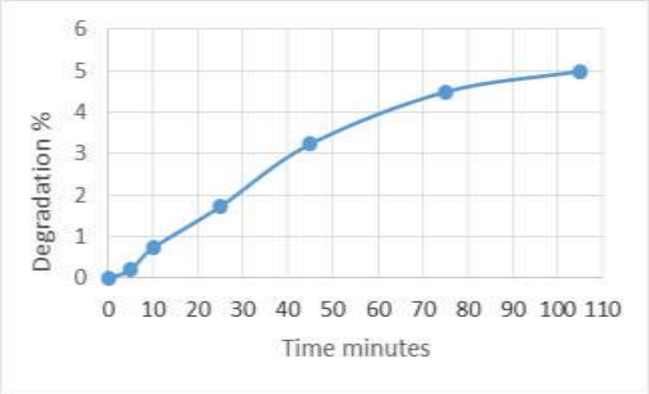
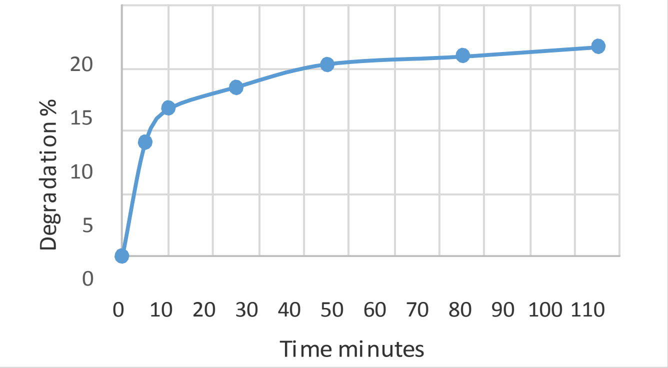


Figure (2) shows the degradation percentage of dyes using 0.15 g/l TiO2



F igure (3) shows the degradation percentage of dyes using 0.25 g/l TiO2

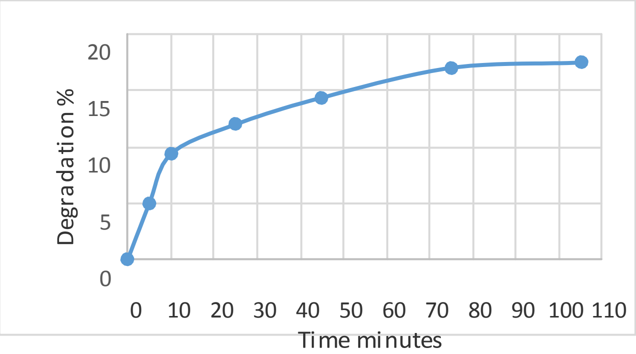


Figure (4) shows the degradation percentage of dyes using 0.35 g/l TiO2

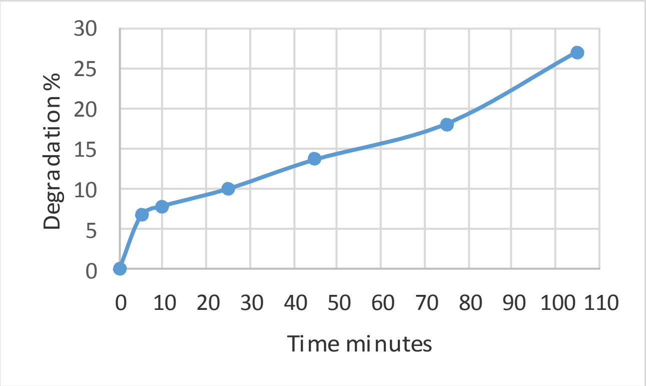


Figure (5) shows the degradation percentage of dyes using 0.7 g/l TiO_2

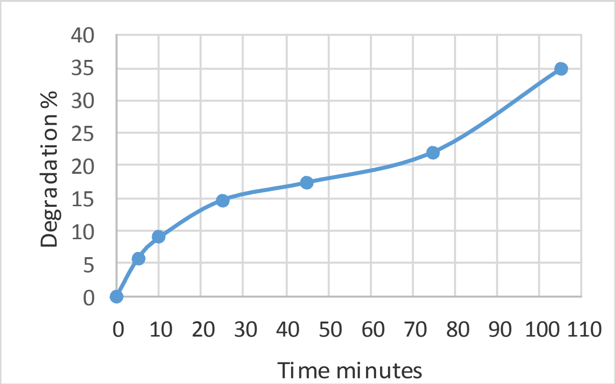


Figure (6) shows the degradation percentage of dyes using 1 g/l TiO_2

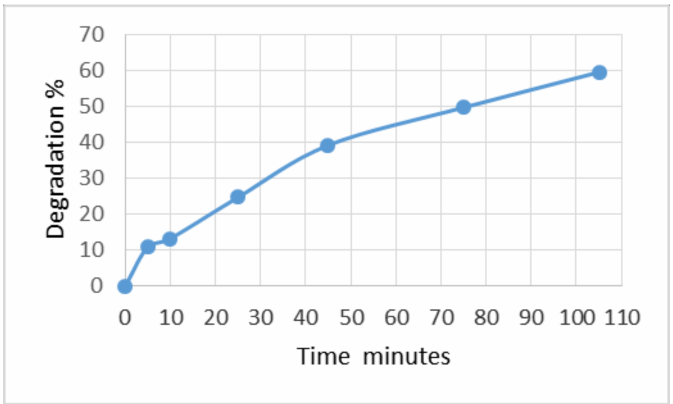


Figure (7) shows the degradation percentage of dyes using 2 g/l TiO_2

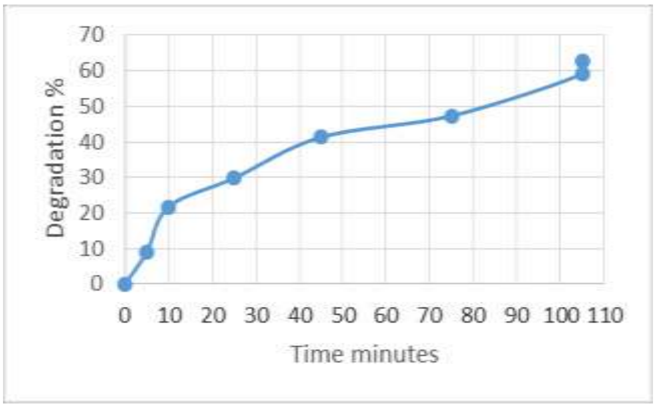


Figure (6) shows the degradation percentage of dyes using 3 g/l TiO_2

Above 2g/l TiO_2 concentration, agglomeration will be efficiently enhanced and this in turn will cause problems in filtering and injection and hence in spectrophotometer measurements. In addition, increasing the catalyst concentration above 2 g/l will slightly enhance degradation percentage as shown in figure (8).

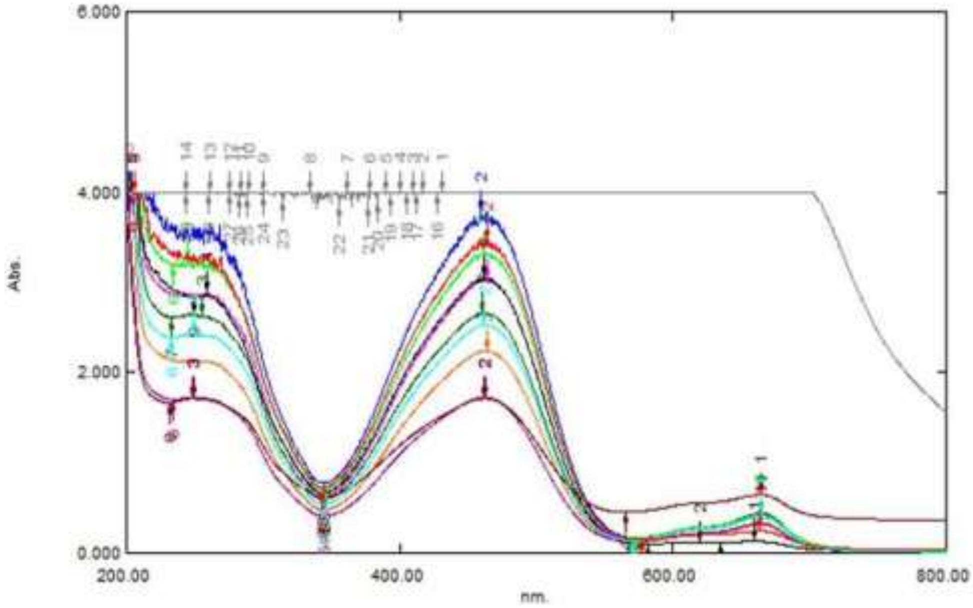


Figure (9) shows the instrument picture of Percentage Degradation of dyes using optimum concentration of 2 g/l TiO_2

Impact of pH:

The study of pH is an important parameter in the degradation of dyes and at a TiO_2 concentration of 2 g / 100ml exhibited to irradiation was obviously from results presented in the figures (15, 16,17,…..21) while ambient pH of solution which was 10.2 it is clearly that the efficiency of degradation changing after vary this value .Additional photocatalytic runs were conducted by varying the value of pH by increasing to 12 and decreasing that to 7 and then to 5

.So due to three runs of different pH it was found that the optimum pH was 7 because it have a high percentage of degradation and elimination of dyes from solution compared with other values.

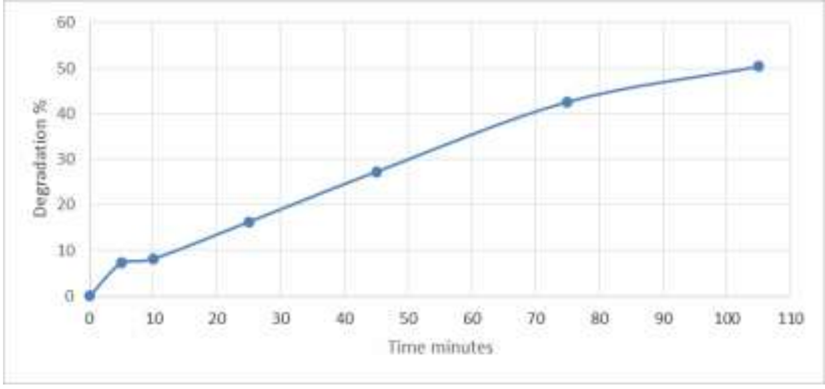


Figure (10) Show the effect of pH on the percentage of photodegradation (pH = 12)

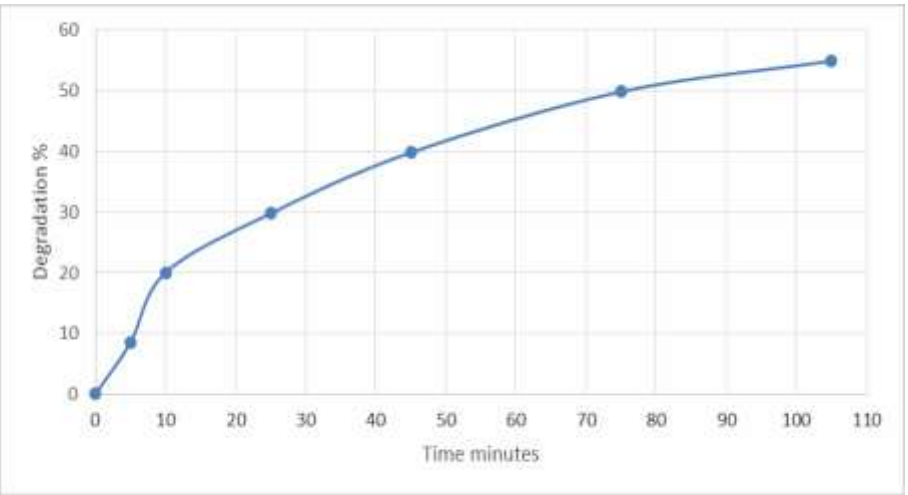


Figure (11) Show the effect of pH on the percentage of photodegradation (pH = 7)

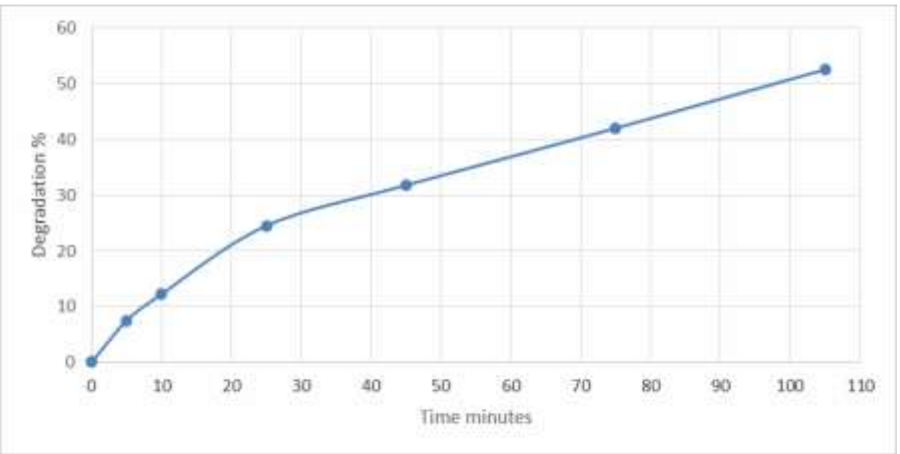


Figure (12) Show the effect of pH on the percentage of photodegradation (pH = 5)

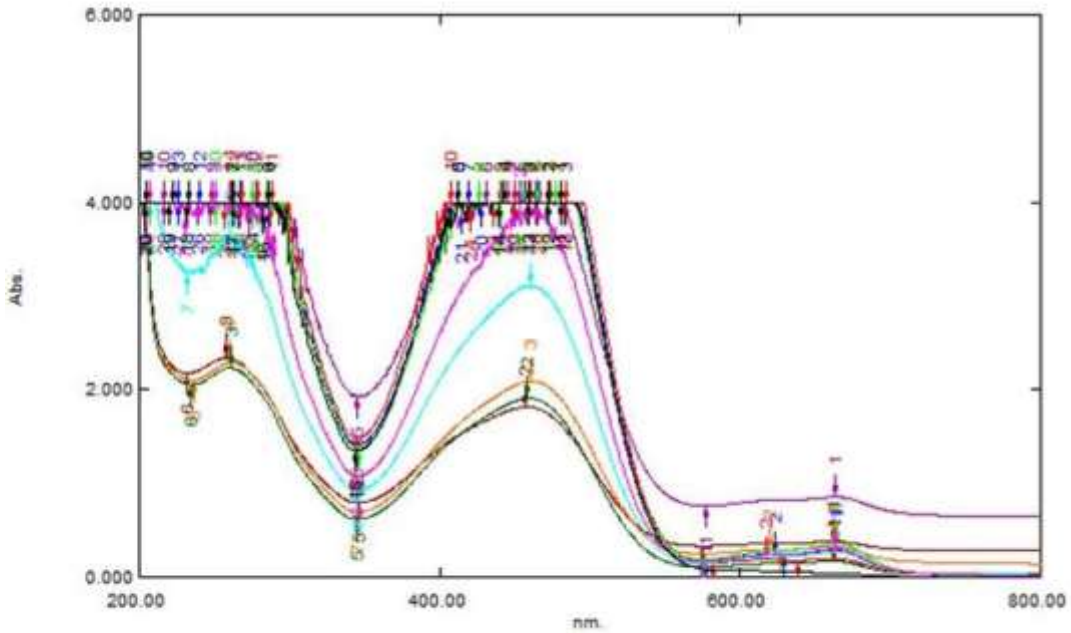


Figure (13) Shows the instrument picture of Percentage Degradation of dyes using optimum concentration of 2 g/l TiO_2, optimum pH = 7

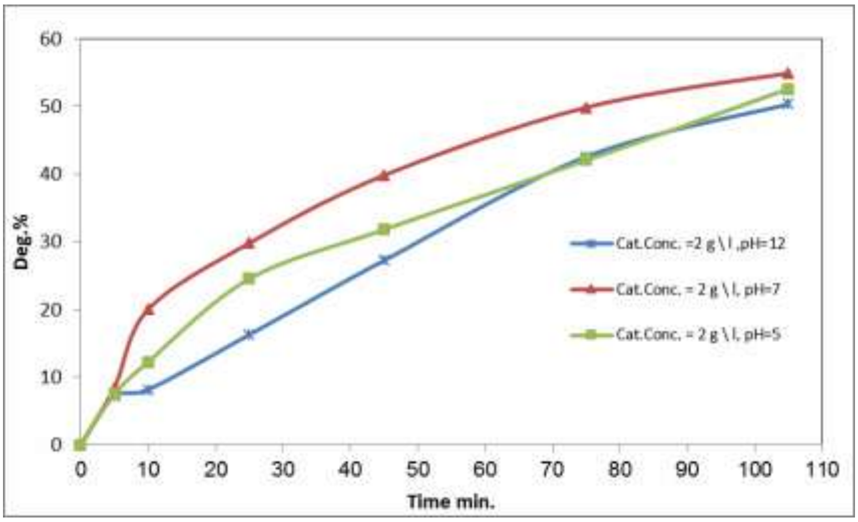


Figure (14) Show the effect of pH on the percentage of photodegradation at different pH values (5, 7, 12) and at optimum concentration of TiO_2 (2g/l)

Conclusions

(1) Photocatalyst titanium dioxide have the ability of degradation for different dyes and this is obviously in varying of color from the deep green color to the light yellow after 100 minutes nearly in addition, titanium dioxide was cheap and available .

(2) After different runs of various concentrations (in dark and in irradiation) can be seen that the optimum concentration was 2 g/l titanium dioxide because of a high degradation reached to 60%.

(3) The value of pH was an important parameter in this research because it gains another advantage of the optimum value of used pH and it was found 7 and this value was limited after different experiments of varying pH value by adding HCl

&NaOH

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