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Treatment of Textile Wastewater using Zinc Oxide under UV Light

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Decolorization;textile wastewater,dyes, Photocatalysis, zinc oxide.

ABSTRACT
In this research, the photocatalytic decolorization of textile wastewater, using zinc oxide as a photocatalyst was examined in the current method of removing dyes from wastewater as an ideal photocatalyst. All experiments were taken at room temperature in a batch reactor by using Ultra-Violet photo-oxidation process because of high effectiveness in color removal. The decolorization of wastewater using ZnO under various pH and different concentrations. Zinc oxide proved to be very effective catalysts in photocatalytic decolorization of real textile industrial water. The best decolorization achieved was 83% by using ZnO at room temperature, within 205 minutes of irradiations. At pH of 9.2, the maximum decolorization was 84%, so it can be called the best pH in this experiment. This study proves that real textile wastewater reacts effectively with catalyst and give good results of dyes degradation for the suspension.

أستعمال اوكسيد الزنك كعامل مساعد في معالجة مياه الصناعات النسيجية تحت اشعة UV

الخلاصة
في هذا البحث تم استخدام اوكسيد الزنك كعامل مساعد في معالجة مياه الصناعات النسيجية و مساهمته في تحلل الاصباغ حيث تم استخدام تراكيز مختلفة بالاضافة الى انه قد تم تغيير قيمة pH للوصول الى اعلى نسبة تحلل للصبغات كما وان اوكسيد الزنك قد اثبت هنا فعاليته العالية في تحلل الصبغات المتكونة في الصناعات النسيجية حيث ان اعلى نسبة تحلل تم الوصول اليها هي 83% بدرجة حرارة الغرفة وخلال 205 دقائق فقط.
تم الوصول اليها هي 9.2 حيث ان نسبة التحلل هي 84% كما و انه من خلال هذا البحث افضل قيمة pH
تم اثبات ان المخلفات النسيجية تتفاعل بفعالية عالية مع العامل المساعد المستخدم وتعطي نتائج جيدة في تحلل العالق النسيجي.

الكلمات المفتاحية
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Introduction

The textile industries consume large amounts of water, in addition at finishing and dying processes, large quantities of wastewater can be produce from various stages. Color in textile industries and finishing effluents is as a result of large amounts of dye stuff left during the dyeing steps and inefficient dyeing processes often resulting in unstable configurations.

In the Latin language, the word of texere means textile, so textiles can be achieved by the traditional way in both hand and different machines. Natural and synthetic fibers are classified as raw materials for textiles [1]. Animals, plants and minerals are considered the main sources of natural fibers. Fibers can be extracted now from chemicals over the development of technology. From the other hand, plant sources produce high amounts of fibers than those gained from mineral and animal sources. The spinning of fibers from the yarns caused most of the produced textiles [2,3].

The textile industries can be classified according to textile fiber into three types: cellulose fibers, synthetic fibers and protein fibers. Cellulose fibers are extracted from plant sources such as cotton, rayon, linen. [4,5]

Wastewater cause environmental pollution, so to reduce this risk before discharging it into the environment, it is high importance to treat them [6,7]. Many processes can be usually used to process the wastewater such as physical and chemical ways. From the other hand, these processes are more expensive and cannot be used effectively in a large area to process the high quantities of colored wastewater [8,9].

From the textile industries, most of the produced pollutants are obtained from the rest of the humid-processing operations like dyeing, scouring and bleaching [10]. Although the various operations, dyeing process usually uses large amounts of water for washing, dyeing and fixing processes [11]. As well as, textile wastewater treats a large amount of suspended solids, the high concentration of COD, widely changing in pH, strong color, high temperature and low biodegradability caused by changing pollutants through water [12].

At the present, because most of the textile wastewater contains toxic and non-biodegradable organic pollutants, the most interesting in development modern methods for treatment a textile wastewater was increasing gradually. Low decolorization percentage in biological treatment of textile wastewater caused by the attendance of biologically inert with high dye molecular weight [13, 14]. Most of these classical methods are becoming insufficient at this time because textile wastewater has a high complex composition [15].

One of the most important types used in treatment the textile wastewater was decolorization . Color removing from wastes is very significant and necessary more than removing of other chemicals [16,17]. However, some processes of the decolorization are not appropriate for contamination removal. The non-toxicity was demanded the degradation products or nearly less toxic than the degraded basic component [18, 19].

Current studies for utilizing ZnO in the photocatalysis operations proved that photocatalysis of reactions with multiple phases is the most effective process in the decolorization of waste chemicals [20, 21].

The unique properties of ZnO make this material extremely interesting for most applications.

The aim of this work was to processes the textile wastewater from colors and pollutants by using zinc oxide as a photocatalyst.

Experimental Part

1. Materials

In the present work it have used the Eosin yellowish dye and methyl violet dye as contaminated substances used in textile. In addition, other materials used in this work were beakers, magnetic stirrers, flasks, graduated cylinders, spectrophotometer, pH meter, digital balance, nylon filter and Millipore syringe.

As well as chemical substances used in this work were: ferrous sulphate, Calcium chloride, EDTA, hydrochloric acid, sodium hydroxide.

2. Preparation of Feed Solutions

The two dyes used, Eosin yellowish dye and methyl violet dye of amount 0.2 g (0.1 g for each dye) were dissolved in one liter of distilled water at room temperature and mixed with 0.1 g/l NaOH, 1.5 g / l CaCl, 0.2 g / l EDTA and 0.1 ferrous sulphates. In order to prepare feed dye solutions with different pHs (2.7, 4.3, 7.3, 9.2 and 10.5), the several drops of prepared solutions of HCl and NaOH to be added for varying pH of the dye solution.

3. Photocatalyic Experiments

All photocatalytic degradation experiments were carried out under similar conditions UV light. For the reaction vessel, an open small cylinder glass of 1000 ml was used. The suspension consisting of a mixture of 100 ml of the feed dye solution and ZnO catalyst was added to the mixture with different concentrations (0.2, 0.4, 0.6, 1, 1.3, 1.6) g/l photocatalyst was exposed to UV light. At various time periods, the 5ml was withdrawn at 10 , 20 , 35 , 50, 70, 100 ,130 ,160 and 205 minutes and analyzed by using double beam UV-spectrophotometer with a range of wavelength from 200 to 800 nanometer. At this point, the decolorization rate was noticed in expressions of change in consistency at λ_{max} of the dye and the dye solutions absorption spectra were kept.

4. Absorbance Measurements

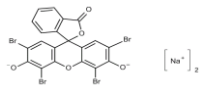
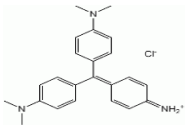
The absorption spectrum was recorded using double beam UV-1800 Shmadzo spectrophotometer compared with distilled water as a reference liquid and the percentage rate of decolorization was noticed in terms of change in intensity at λ_{max} of the dyes during irradiation time.

The percentage of photocatalytic decolorization estimated according to the following formula [22, 23]:

$$\%\ \text{Decolorization} = \frac{\text{Absorption}(t=0) - \text{Absorption}(t=t)}{\text{Absorption}(t=0)} \times 100$$

5.Classification of used dyes in textile industries:

Various types of dyes used for coloring textiles. Moreover, dyes can be divided into different groups depending on their chemical structure and particular properties, so the chemical structure of the main dyes was obviously in the table below:

Dye	Chemical formula	Structure
Eosin yellowish	C20H6Br4Na2O5	
Methyl violet	$C_{23}H_{26}N_3Cl$	

Results and Discussion:

1. The best Photocatalyst Concentration

Tests have been done by different concentrations of ZnO catalyst, so as to choose the best concentration of catalyst for the treatment of used dyes. The photoreaction runs were achieved using various concentrations ranges of (0.2 , 0.4 , 0.6 , 1 , 1.3 and 1.6) g/l for each run through 205 minutes of irradiation. The results in Figures (1, 2,3,4,5 and 6) shows the photodegradation of solution was increased and the maximum value of degradation percentage reached to 83%, so the optimum concentration was 1.3 g/l. This case can be clarified in terms of the UV light permeation through the solution and active areas availability on the surface of catalyst. When increasing the concentration of catalyst, the total effective surface area will increases. At the same time, there is a decrease in solar light permeation because of an increase in the turbidity of the suspension as a result of increased scattering impact and for that reason, the photoactivated size of suspension will decrease. Furthermore, it is hard to keep up the suspension homogenous at high catalyst capacity because of agglomeration of the particles that contracts the number of the active areas [24, 25].

2. Influence of concentration:

All these results configuration in figures and it can be seen from figures that the percentage of decolorization increased when the concentration of photocatalyst was increased and it can observe that the optimum concentration was 1.3 g/l because the change degree of color was clearly and have a reasonable decolorization.

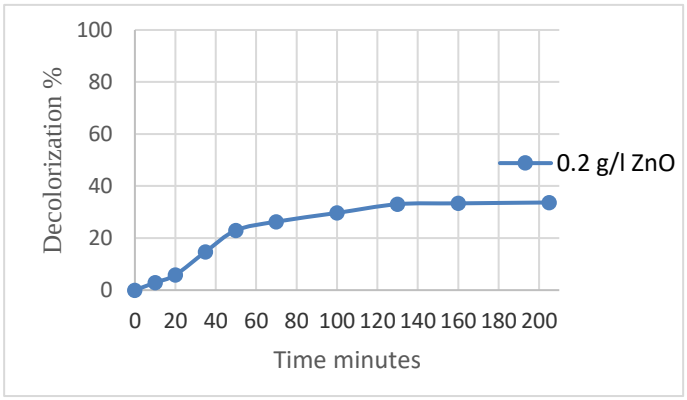


Figure (1) The decolorization percentage of dyes using 0.2 g/l ZnO

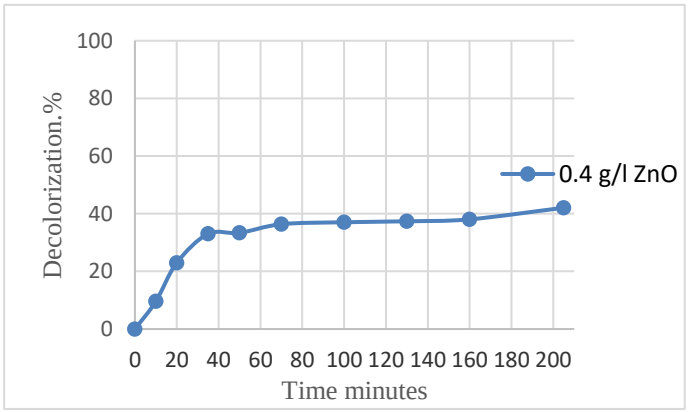


Figure (2) The decolorization percentage of dyes using 0.4 g/l ZnO

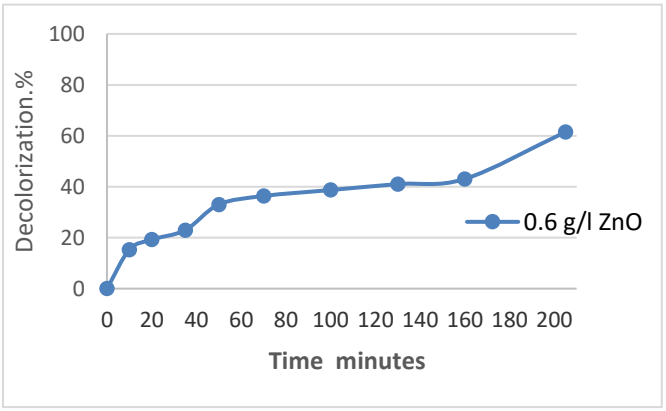


Figure (3) The decolorization percentage of dyes using 0.6 g/l ZnO

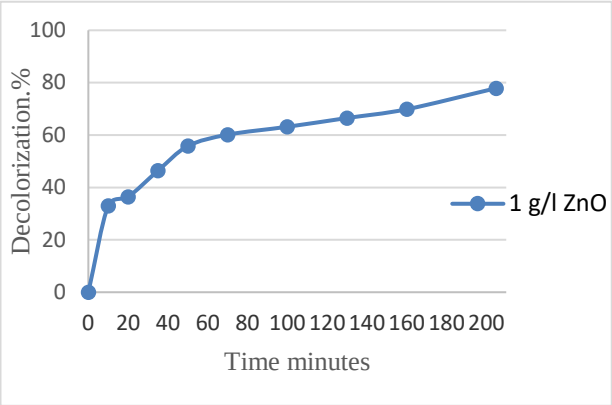


Figure (4) The decolorization percentage of dyes using

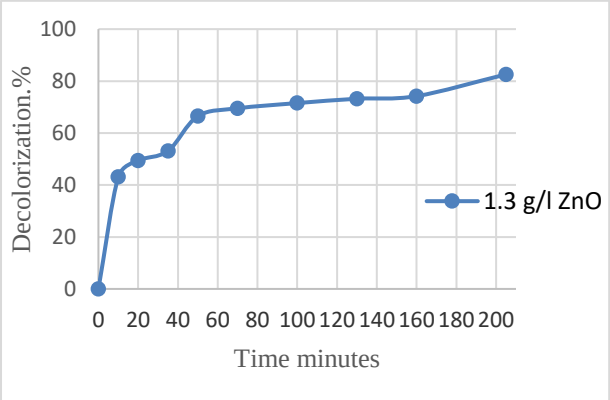


Figure (5) The decolorization percentage of dyes using 1.3 g/l ZnO

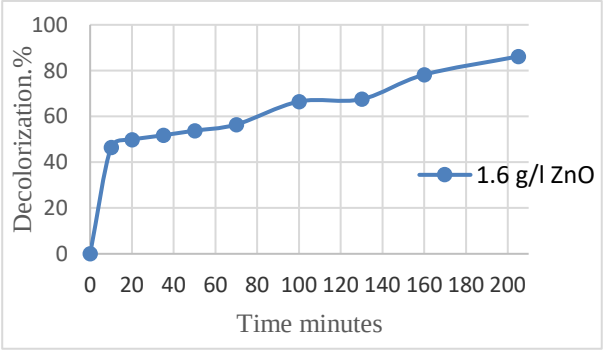


Figure (6) The decolorization percentage of dyes using 1.6 g/l ZnO

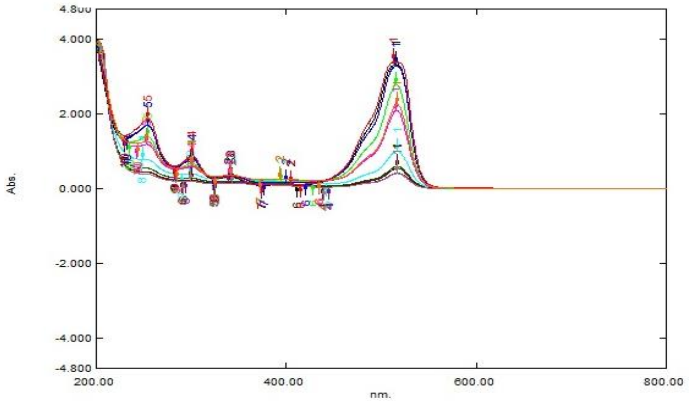


Figure (7) The instrument picture of percentage decolorization of dyes using optimum optimum concentration of 1.3 g/l ZnO

3. Effect of pH value on solution treatment

The wastewater is produced at different pHs, therefore, the study of pH is very important on photodegradation of dye. Experiments have been done at different values of pH varying from 2.7 to 10.5 for 1.3 g/l dye solution concentration which selected the best concentration of ZnO. Figures 7, 8, 9, 10 and 11 shows the percentage photodegradation of dyes against values of pH. It is clearly increasing in pH up to 9.2 and 10.5 for ZnO cause increasing in photodegradation activity so, the utilizing of ZnO as the catalyst is more appropriate at high pH values with the textile effluent.

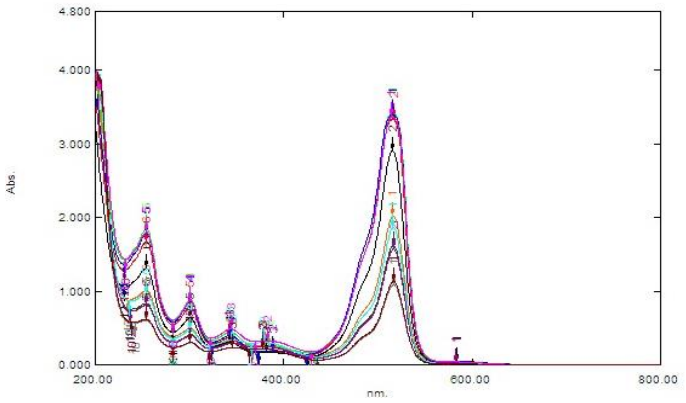


Figure (8) The instrument picture of percentage decolorization of dyes using optimum concentration of 1.3 g/l ZnO , pH = 2.7

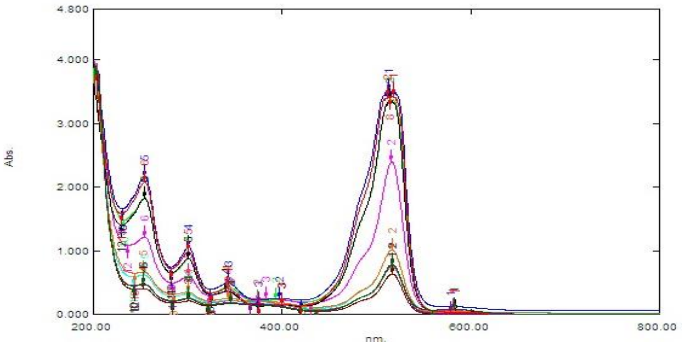


Figure (9) The instrument picture of percentage decolorization of dyes using optimum concentration of 1.3 g/l ZnO, pH = 4.3

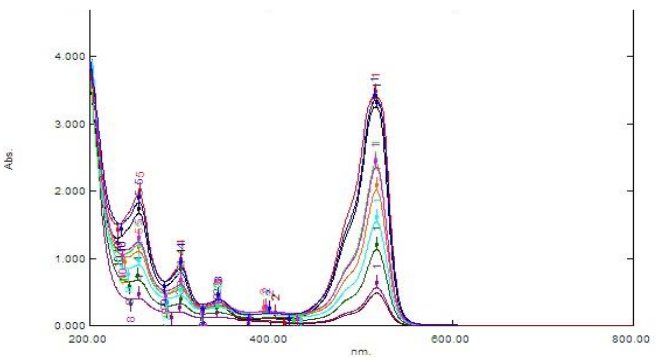


Figure (10) The instrument picture of percentage decolorization of dyes using optimum concentration of 1.3 g/l ZnO, optimum pH = 9.2

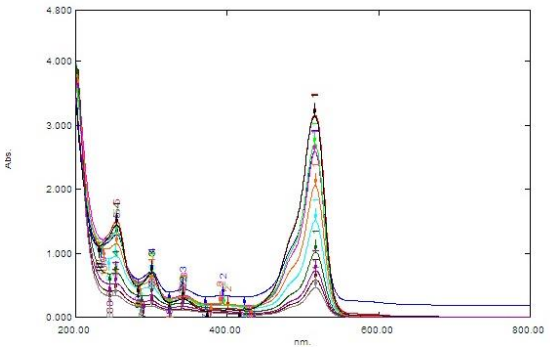


Figure (11) The instrument picture of percentage decolorization of dyes using optimum concentration of 1.3 g/l ZnO, pH = 10.5

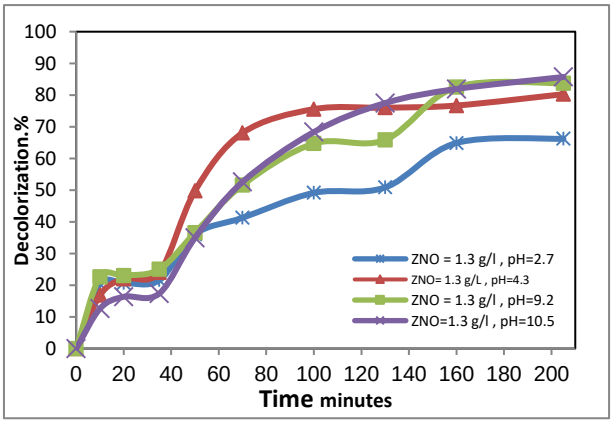


Figure (12) Show effect of pH on photodecolorization percentage at different pH values and at optimum concentration of ZnO

Conclusions

The performance of photocatalytic decolorization efficiency using catalyst ZnO at different concentrations. The parameters affecting the photocatalytic decolorization process has been examined in a batch reactor under UV light through heterogeneous slurry. The best concentration was 1.3 g/l and the decolorization percentage was 83%, in addition the best pH was 9.2. Parameters have been studied like catalyst concentration and dye solution pH.

It was obviously that ZnO presented better photocatalytic decolorization efficiency for dyes because the bandgap value for zinc oxide is equal to 3.17 eV and here higher activity appeared for zinc oxide.

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