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Received on: 16 /04/2017
Accepted on: 12/10/2017

Study the Dye Decolorization of Wastewater Using Bentonite, H_2O_2, Ultrasonic and Laser Techniques

***Abstract**-The bentonite is an adsorbent material that is used frequently in industrial fields. bentonite was used with laser to treat wastewater, when laser is a new technique that has ability to remove the dye. Using of laser as a source to refresh with high efficiency has the important in industrial field.In this study laser diode with power 50 mw, He-Ne laser with power 10 mw and DPSSL with power 500 mw were used with the help of ultrasonic bath and H_2O_2 to promote the work of the laser. AFM and FTIR testing were made to bentonite to study the characteristics of it. Minitab program was used to facilitate calculations and choose the optimum parameters of experiments. The optimum input conditions of experiments to remove the dye from wastewater were chosen. The best concentration of bentonite is 4 g/l, the best temperature of wastewater is 42°C, the best time of work is 27 min and the best concentration of H_2O_2 is 10%. It found from study that the increase of each parameters cause decrease in output concentration of wastewater. The accuracy of work was determined from Minitab program, it was 94.54%.*

***Keywords**- bentonite, adsorption, wastewater, hydrogen peroxide, pigment, diode laser.*

How to cite this article: A.Z. Mohammed, A.Sh. Hamadi, and H.A.M. Redha, "Study the Dye Decolorization of Wastewater Using Bentonite, H_2O_2, Ultrasonic and Laser Techniques," *Engineering and Technology Journal*, Vol. 36, Part A, No. 1, pp. 41-45, 2018.

1. Introduction

Among various industrial wastewaters, dye color wastes have a prominent position. Since many dye pigments contain toxic organic pollutants, the presence of dye colors in wastewater may indicate the presence of toxicants. If an effort is not made to remove pigments, the public assumes that little effort will be expended in removing the other contaminations. The color in the wastewater has to be expelled before it is discharged into a water body or intended for land disposal [1]. Currently, the adsorption process is considered as a useful technology to minimize the extent of water contamination by various sorts of dyes. The major advantages of an adsorption system for controlling water pollution are a low capital investment in terms of initial cost and land required; easy design, easy operation and high removal efficiency of color related to waste constituents as compared to other methods. The adsorption process also achieves a high level of dye removal over a high range of solution conditions and reduces sludge or solid residuals requiring elimination. Although the bentonite industry is slightly over 70 years old; the name bentonite was applied as early as 1848 by Knight to a highly plastic clay material happening near Fort Benton [2]. The first commercial bentonite was shipped in 1888 under the name "Taylorite", from this modest beginning, in which production amounted to just a few tons per year, bentonite production now.

Angela et al. [3] investigated the matter that the waters were treated with laser radiation of different wavelengths (193 nm-ArF, 248 nm-KrF) frequently under addition of hydrogen peroxide or ozone as oxidizers. They found that the wastewaters from textile industries and appropriate model solutions was demonstrated that the shorter wavelength of the ArF excimer laser (193 nm) is more effective in the photochemical decomposition than the 248 nm Krf laser radiation because there are lower demands of the energy dose and the addition of oxidizers. Song et al. [4] found that the dye of acid brown 348 was removed from aquatic solution by using ultrasound devise-assisted adsorption on peel graphite. The relevant parameter's effect, they study namely, the contact time, sorbent potion, temperature, initial dye concentration and pH have been investigated. They concluded that ultrasound radiation significantly improves removal of acid brown 348 from aquatic solutions in presence of peel graphite. The ultrasound peel graphite process yielded the results 90% removal rate within 120 min using 2g L-1 peel graphite at 40◦C. Jasem [5] studied how the oil was removed from wastewater by organoclay. The organoclay was destined by combination of

DOI: https://doi.org/10.30684/etj.2018.136754
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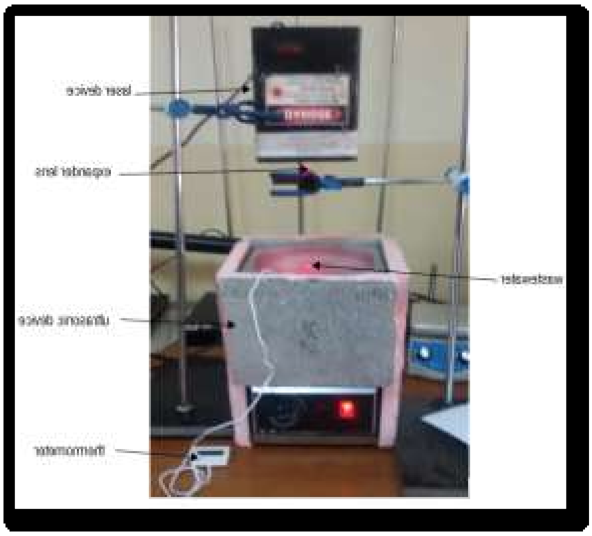
Iraqi bentonite with quadruple amine (hexadecyltrimethyl ammonium chloride), the concentration of wastewater used within the maximum range 230-1512 mg/L, and the oil concentration in the wastewater decreased less than 10 mg/L after treatment with organically. Tai-Li et al. [6] studied the efficient and convenient removal of dye C.I. Direct blue 78 from aquatic solution by the combination of ultrasound and peel graphite; they study the effects of different factors such as temperature, dosage of peel graphite and initial concentration of dye. The results exhibit that ultrasound radiation significantly improves removal of C.I. Direct blue 78 from aquatic solution in presence of peel graphite. A 98% of removal rate was achieved within 20 min using 1 g/L peel graphite at 25C for 50 mg/L Direct blue 78-dye aquatic solution. Tai Li et al. [7] found that an efficient and effected method for degradation of acid orange 3(AO_3) dye from aquatic solution by combination of ultrasound radiation and fly ash/H2O2. 96% of removal rate was obtained under the optimum conditions (concentration of dye, 100 mg/L; H_2O_2, 5.4 mM; fly ash, 2.5 g/L; pH3, ultrasonic radiation frequency of 25 KHz, room temperature 25°C). Pare et al. [8] investigated that photocatalytic degradation of neutral red was resulted from hydroxyl radicals (OH) in a batch slurry reactor, in the existence of visible light illuminated ZnO. In the existence of visible light, ZnO/Fenton process was found to be more efficient for the decolourization of dye. Both artificial visible irradiation and solar light degraded dye efficiently in the existence of ZnO. The demolition of aromatic Skelton and chromophoric part of dye were ascertained by the disappearance of absorption bands in UV/Vis spectra of dye with respect to time radiation. Al-Sa'adie and Badrie [9] studied the removal of Chromium Cr (VI) from aqueous solutions. In this research they used bentonite clay as adsorbent for the Cr (VI) concentration range (10-100) ppm at different temperatures (298, 303, 308 and 313) K for different periods of time. The adsorption isotherms were obtained by obeying Langmuir and Freundlich adsorption isotherm. The aim of this study is to activate bentonite and wastewater by using new method laser technology depending on the optimum parameter.

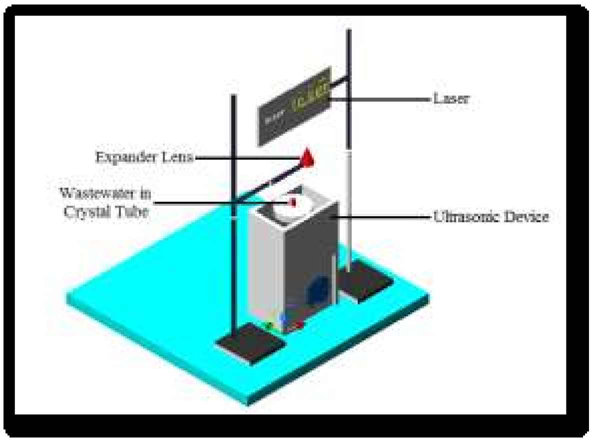
2. Experiment Work

I. The setup of experiment

The setup is containing {diode laser -ultrasonic device-thermometer-lens and crystal tube} as shown in Figure 1.



(a)



(b)

Figure 1: The setup of the work (a) laser and ultrasonic bath device system. (b) three-dimension view for laser and ultrasonic bath device system.

II. The procedure of the work

In the beginning, the bentonite was tested to remove the dye by adsorption without laser. The dyeing with certain weight (1.1×10^{-3} mg) was lighted by different volume of distilled water (100 ml to 900 ml) and then calculated the concentration of samples from the relation (concentration= weight/volume) then each sample was tested by using UV spectrum device to determine the absorption wavelength. The concentration of pigments diluted were put in several tubes with different amount of bentonite that was heated at a temperature 85°C

1- by using a laser thermometer. Then, they were placed in ultrasonic machine to mix them for several minutes (40,60,80) ˚C, each degree for 30 minutes, and the removal percentage of dyeing in degree 80 ˚C was found.

2- The samples of Bentonite and wastewater were prepared of (4, 6, 10, 13, 16) g of bentonite and 1.5 mg/liter of wastewater, and then mixing each amount of bentonite with certain amount of water box (1.5 mg/ lit) was reserved for experiments.
3- Hydrogen peroxide (H2O2) which is used as catalyst to remove the dye was prepared with different concentrations (3.1%, 12%, 18.5%, 25%and 33.9%) and put in the Flask opaque to prevent them from oxidation. The wavelength for dye and bentonite was determined by using ultraviolet –visible spectrophotometer, it is (380.66 nm for bentonite and 782.12nm for the dye). Then the wavelength of wastewater was taken, it is 628.52 nm.

III. Testing procedures

There are 31 experiments that were performed by using laser diode with 50mw power and 650nm wavelength, this wavelength is the closest to the wavelength of dye (782.12nm), so it was used to facilitate the process of removing the dye from wastewater.

In each experiment, the different samples of bentonite and wastewater were put in the crystal tube with 5.5 cm^3 of size and intervention in the ultrasonic device with distill water and adjust them at different temperature according to the conditions of experiment. then the samples were hit by diode laser with lens to divergence the laser radiation so as to distribute radiation on each sample. At the moment of shedding laser, five drops of H2O2 were added to the mixing, the time to experience was counted in minutes.

After the completion of experience, the samples were put in the UV/VIS spectrophotometer device to examine the wavelength for it, the proportion of discoloring of the dye after Laser beating by calculating the output concentration for wastewater was determined.

3. Results and Discussion

It has been observed from the experiments results that the laser diode was able to remove the color with the help of H2O2, when laser has influence on the stability of dye, because the strong laser radiation will damage the chain molecule junction and make the solution oxidize from heating, causing the dye to decompose and bleached.

H_2O_2 is used to decolorize the dye. The initial concentration of H_2O_2 plays significant role in the oxidation process. The decolorization efficiency of the dye increases at high concentration of H_2O_2. The decolorization efficiency also increases with increasing the temperature.

I. Measurement value by using Laser Diode:

Table 1 shows the parameters of experiments by using laser diode, the concentration of bentonite takes the range (4-16) g/lit, the temperature of wastewater takes the range (45-60) °C, the time has the range (7.5-29.25) min and H2O2 (3.1-33.9) %. In this table there are four independent variables, concentrations of bentonite (X1), temperature (X2) time (X3) and H2O2 (X4). There are 31 experiments for four variables covering the full design and building up models of the second order, the experimental points are given in this table done by using Minitab Release 16 (Minitab Inc., USA) software [10].

II. The best conditions

Figure 2 illustrates the optimum condition of experiment. It took the high and low point for each parameter and selected the best reading of/and between them. It was taken the high and low points for concentration of bentonite (16,4) g/l respectively and found that the best input concentration of bentonite was 4 g/l, it shows that the curve of output concentration was reduced with increasing input concentration to 4 g/l.

Then it was taken the high and low points for temperature (60,40) ◦C respectively and the best temperature was found to be 42°C, in this degree the output concentration of wastewater had little increase at first, and then reduced.

The high and low points for time were (29.250 ,0.250) min respectively. the best time to achieve the experiments was 27 min, the output concentration was decreasing in this point. and then the high and low points for H2O2 concentration were taken, there were (33.90, 3.10) % respectively. The best concentration of H2O2 was 10%, and the output concentration was reducing with increasing the concentration of H2O2.

This optimization of results was made by composite desirability method. This method explains that when d (composite desirability) =1 that mean the solution was optimal. Y axis takes the value 0.1 as a limit of drawing.

Figure 3 shows the relation of each parameter with Y (output concentration). The relation between x and y was limited by the program, the maximum value in (y- axis) was 0.32 and maximum value in (x- axis) was 60 the first diagram shows that with increasing of bentonite concentration, Y was decreasing. The second diagram shows that Y decreased with increasing temperature. In the third diagram, the increasing of time causes a decreasing in Y, and The last diagram shows that the increasing in H2O2 causes a decreasing in Y.

Table 1 Measurement value by using LD

Input					**Output**
Run	Conc. (g/lit)	Temp. (C)	Time (min)	H2O2%	Output conc. (g/lit.)
1	4	50	14.75	18.5	0.319
2	6	45	7.5	25	0.286
3	6	45	22	12	0.352
4	6	55	22	25	0.251
5	6	55	7.5	12	0.214
6	6	45	22	25	0.223
7	6	55	22	12	0.282
8	6	55	7.5	25	0.322
9	6	45	7.5	12	0.204
10	10	50	14.75	33.9	0.2
11	10	50	14.75	18.5	0.267
12	10	50	29.25	18.5	0.266
13	10	50	14.75	18.5	0.261
14	10	60	14.75	18.5	0.184
15	10	50	14.75	18.5	0.269
16	10	50	14.75	18.5	0.268
17	10	40	14.75	18.5	0.08
18	10	50	14.75	18.5	0.264
19	10	50	0.25	18.5	0.221
20	10	50	14.75	3.1	0.251
21	10	50	14.75	18.5	0.261
22	10	50	14.75	18.5	0.266
23	13	45	22	12	0.25
24	13	55	7.5	12	0.156
25	13	45	7.5	12	0.088
26	13	45	22	25	0.069
27	13	55	22	12	0.259
28	13	55	7.5	25	0.251
29	13	55	22	25	0.103
30	13	45	7.5	25	0.092
31	16	50	14.75	18.5	0.165

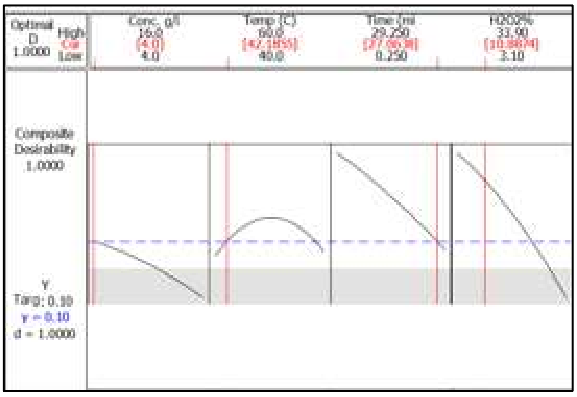


Figure 2: Best conditions for (concentration, temperature, time and H_2O_2)

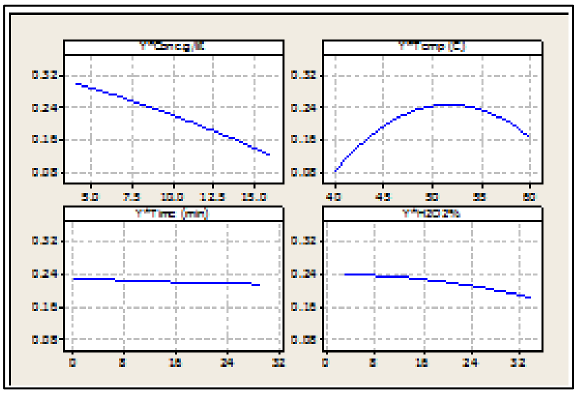


Figure 3: The effect of each factor (concentration, temperature, time and H_2O_2) on output concentration (Y).

4. Conclusions

The main conclusions from the present project are:

1) There is possibility of using a laser to remove pigment from wastewater with bentonite with presence of H2O2, but not in all circumstances, because sometimes the quenching leads to attenuation in laser technique.

2) Hydrogen peroxide is considered a highly effective catalyst to stimulate the laser.
3) The results of output concentrations of wastewater after hitting by laser was on the most exact, it was reduced significantly as compared to the first condition. Optimal conditions for the results have been chosen, where the best concentration of bentonite is 4 g/l, the best temperature of wastewater is 42 ◦C, best time of work is 27 min and best concentration of H2O2 is 10%.
4) The Iraqi bentonite can enter in the industrial field with laser with high efficiency especially in water purification.
5) Minitab is a good program, which is one statistical and graphical analysis software package for Windows.
6) Minitab is the study of the parameters' effect temperature, time, concentration and H2O2 and chooses the optimum condition of each them.

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