

Removal of Rhodamine Dye from Water Using Erbium Oxide Nanoparticles

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Abstract Environmental pollution remains a considerable health risk source all over the world; however, hazards are usually higher in developing countries. Iraq has long been suffering from the problem of pollution and how to treat pollution. Photo-catalytic degradation has turned out to be most productive process for dye degradation. In this investigation, Rhodamine B (RhB), dye has been selected for degradation under visible light illumination. To address this issue, we fabricate erbium trioxide nanoparticles ($\text{Er}_2\text{O}_3/\text{NPs}$). Erbium trioxide nanoparticles are prepared and utilized for photo-catalytic degradation. The characterization of $\text{Er}_2\text{O}_3/\text{NPs}$ is described and confirmed by utilizing of XRD (X-ray diffraction) and SEM (Scanning Electron Microscopy). The average size of Er_2O_3 nanoparticles is observed to be 16.00 nm. $\text{Er}_2\text{O}_3/\text{NPs}$ is investigated for its ability of photo-catalytic degradation through certain selected parameters such as concentration and time. The methodological results show that the synthesized $\text{Er}_2\text{O}_3/\text{NPs}$ is a good photo-catalytic for Rhodamine degradation.

Key words erbium trioxide, photocatalytic, rhodamine B.

1. Introduction

Rhodamine B is an organic dye that was used extensively in biotechnology employment, for instance, fluorescence microscopy, stream cytometry, fluorescence relationship spectroscopy and ELISA.¹⁾ Rhodamine B is being tried for use as a biomarker in oral rabies immunizations for natural life, for example, raccoons, to recognize creatures that have eaten an antibody trap. The Rhodamine is consolidated into the creature's stubbles and teeth.²⁾ The profluent delivered by dyeing manufactures is harmful to the living creatures. The unwanted substances located in liquid effluents present serious risk to the prompt beneficiaries. Wastewaters from dyeing industries have made a major issue the earth. The discharged wastes having dyes are dangerous to microorganisms,

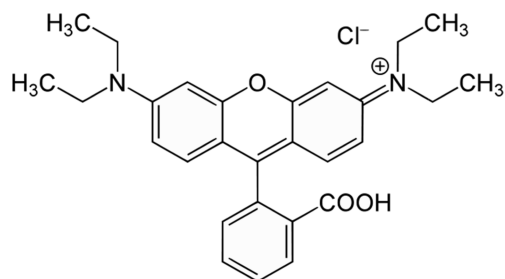
aquatic life and individuals.³⁾ The appearance of colored wastewater in environment causes contamination and eutrophication and could start perilous side effects through oxidation, hydrolysis, or through other concoction responses.⁴⁾ It was published that dyes establish one of the biggest gatherings of natural organic molecules that represent an expanding ecological threat.^{5,6)} Various chemical compound and natural changes for dyes could happen which expend the dissolved oxygen in the water bodies. In addition, dyes have high poisonous quality that endangers aquatic life.^{7,8)} The distinctive conventional techniques utilized for the treatment of toxins dyes in water include different physical, natural, and chemical procedures. Photo-catalytic degradation was demonstrated as a hopeful planning for processing of wastewater, polluted, with natural and synthetic toxins. The procedure, as methods

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Scheme 1. The chemical structure of Rhodamine B.

for expulsion of constant water contaminants, such as dyes and pesticides has pulled in the consideration of numerous specialists as of late.⁹⁻¹¹⁾ A large number of these examinations have used fluid suspension of semiconductors lit up by UV light to photodegrade the poisons.¹²⁾ The execution of a semiconductor photocatalyst is emphatically connected with the electronic structure of it.^{12,13)} It has been built up that the photocatalytic degradation of a natural atom/particle in arrangement is started by photo generated gaps (h^+) in the valence band (VB) and electrons (e^-) in the conduction band (CB) of the semiconductor photocatalyst. The created h^+ has a high oxidative potential, which allows an immediate oxidation of the natural particle/particle to receptive intermediates. Furthermore, hydroxyl and imine radicals are receptive species that could support in degradation of the natural molecules. In this investigation Rhodamine B (RhB), an organic dye as in Scheme 1 was chosen with the intension of degrading it by utilizing the synthesized $\text{Er}_2\text{O}_3/\text{NPs}$.

2. Experimental

2.1 Materials

All materials used in this work were supplied from Fluka Company, and were used without further purification.

2.2 Synthesis of Er_2O_3 NPs:

Erbium oxide nanoparticles (Er_2O_3 NPs) had been synthesized by dissolving of ascorbic acid (1 g) and of sodium fluoride (0.063 g) in distilled water (10 mL). Adjusted the pH solution to four by adding drops of ammonium hydroxide solution. The resulting mixture have been heated to 70 °C for 20 min. An alcoholic solution of Erbium nitrate (2.5 g in 4 mL) had been added to the above solution and continuous stirring 2 h. At room temperature. Centrifuged and washed the precipitate several times with de-ionized water dried in air for 24 h under vacuum. The precipitate, then calculated at 800 °C for 3 h.

2.3 Sample Preparation

Er_2O_3 nanoparticles were prepared as the catalyst of 0.1 g diluted in 100 mL methanol. Erbium oxide Er_2O_3

and Rhodamine B were weighed by using sensitive balance. Rhodamine Bas a dye often used for catalytic tests (0.05 g diluted with 500 mL methanol).

2.4 Photocatalytic Set Up

The photocatalytic set-up consists of UV- source as a lamp (6 watt) of cylindrical shape 22 cm body length and 16cm arc length of cylindrical shape, which was used as a photo source. This was used as a photo source. This lamp was positioned in a container of the sample(mixture of Er_2O_3 NPs and Rhodamine B) and then placed on magnetic stirrer(to mix and disperse solutions result of high speeds and long time to prepare it solutions).

2.5 Methods

2.5.1 Irradiation Time Effect

The Mixture of $\text{Er}_2\text{O}_3/\text{NPs}$ and Rhodamine B was placed on magnetic stirrer and the temperature was fixed at 25 °C. The UV-lamp was switched on inside the sample container. Different irradiation time (1, 2, 3, 4 and 5 h) were employed. The photo degradation measured after each hour. The samples were examined by UV-spectrometer to measure the absorbance of all sample.

2.5.2 Dye Concentration Effect

Different concentrations of the Rhodamine B were used in the range of 0.1, 0.2, 0.5, 1, 1.5, 2 wt% and 0.1 wt% from $\text{Er}_2\text{O}_3/\text{NPs}$. The samples withdrawn from the mixture without photo catalysts and after 15 min for each concentration of Rhodamine B. The samples were examined by UV-visible spectrophotometer to measure the optical absorbance.

2.5.3 SEM “Scanning Electron Microscopy”

The morphology of Erbium oxide nanoparticles have been investigated through SEM technique. It was recorded on the “JEOL JSM-6390LV SEM” fitted with secondary electron detector.

2.5.4 XRD “X-ray diffraction”

$\text{Er}_2\text{O}_3/\text{NPs}$ powder crystallinity was studied by XRD technique.

3. Result and Discussion

3.1 Absences of Sunlight

The results had been discussed with/without sunlight as shown in Figs. 1 and 2. Fig. 1 demonstrates the relation between absorbance and time of photocatalytic without sunlight radiation. The increasing of time of photo-degradation up to 3.0 h, leads to that the absorbance values will raise, due to the degradation process organic dye. This attitude harmonize with Lazar et al..¹⁴⁾ Fig. 2

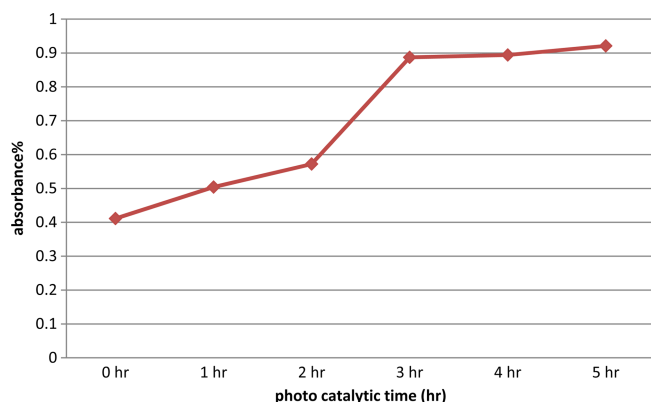


Fig. 1. The photocatalytic time vs absorbance without SL.

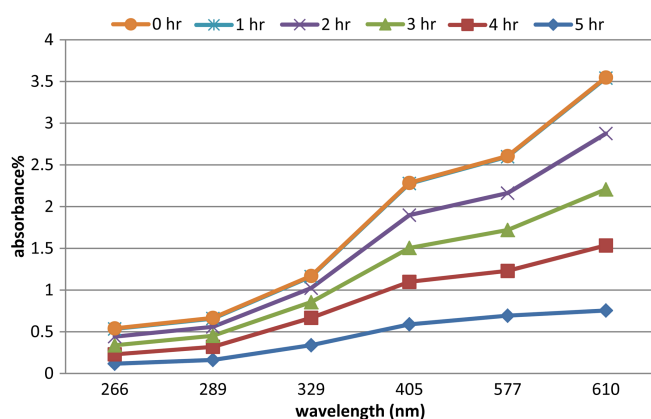


Fig. 2. UV-visible spectra of Er_2O_3 nanoparticles without SL.

elucidate the absorption of Er_2O_3 spectrum in absence of sun light (SL), that could be shown that the minimum absorption occurs at wavelength range of (324–489 nm) for various irradiative time.

Fig. 2 shows the absorption spectrum of Er_2O_3 nanoparticles without SL. One can be shown that the minimum absorption take place at the range of wavelength (450 ~ 650 nm) for different irradiative time.

Transmission spectra have greatest powers at wavelengths that the absorptions are weakest on the grounds that all the more lights are transmitted sample. Absorption spectra have greatest powers at wavelengths where the ingestion is most grounded. At the point when test particles are exposed to light having an energy that coordinates a conceivable electronic progress inside the atom, a portion of the light vitality will be ingested as the electron is elevated to a higher vitality orbital. An optical spectrometer records the wavelengths at which retention happens, together with the level of ingestion at every wavelength.

3.2 In presence of SL

Fig. 3 shows the photo catalytic Rhodamine B

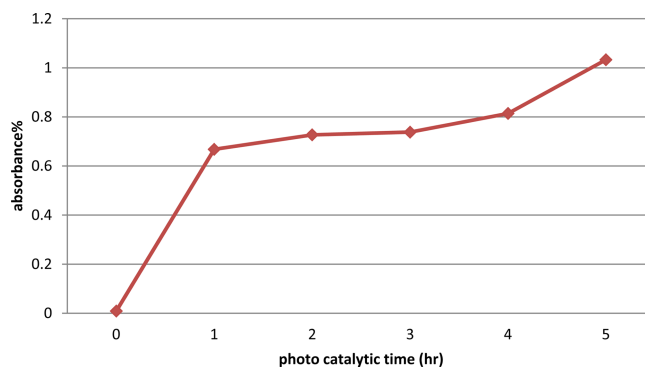


Fig. 3. Photocatalytic degradation of Rhodamine B dye over Er_2O_3 samples as a function of irradiation time with SL.

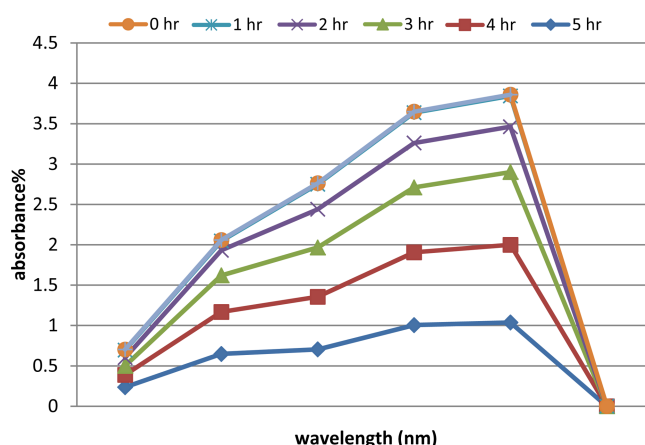


Fig. 4. UV-visible spectra of Er_2O_3 with SL.

degradation that irradiated under sunlight in the presence of Er_2O_3 nanoparticles. The presence of Er_2O_3 nanoparticles was investigated as a very important factor for improvement the degradation process. Higher efficiency of degradation was found within 4.0 h, of irradiation time and considering the optimum loading of catalyst. After 4.0 h, of irradiation time with Er_2O_3 nanoparticles, can be shown other peak at irradiation time of 5.0 h, when we carried out a comparison between the absorbance values at 5 h with Fig. 1 and without sunlight can be conclude the improvement in benzoic acids compound degradation when taken into account the role of sunlight.

Reaction rate have increased and greatest rates were getting after four hour as shown in Fig. 4. It may be explained on the basis that the operation time of UV source was increased, the photons number per unit area incident on the sample also increased, resulting in high rate of degradation in the mixture of Erbium oxide and Rhodamine B Leads to increase the absorption value.

3.3 Impact of Rhodamine B Concentration

3.3.1 Concentration of Rhodamine B effects without

irradiation

The increasing in the dye concentration leads to increases of absorbance. The maximum change of absorbance increasing was noticed when the concentration changed from 0.5 wt% to 1 wt% as in Fig. 5, shown. Rhodamine B degradation efficiency was analyzed using UV-Vis spectrometer. Peaks were observed to be present between 450 and 650 nm, which was indicative of the degradation of Rhodamine B. Regarding to Beer-Lambert Law, Rhodamine B concentration is proportion directly to its absorbance.¹⁵⁾

3.3.2 Concentration of MO Effects with Irradiation

When Rhodamine B concentration increased leads to

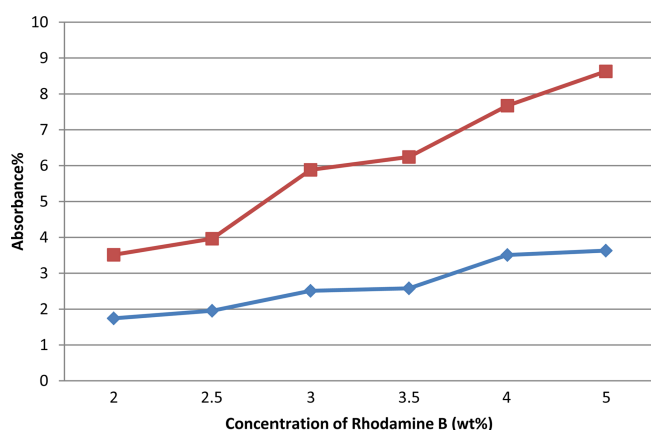


Fig. 5. The concentration of Rhodamine B dye versus with absorbance, with and without irradiation.

the value of absorbance was increased after 15 min from irradiation. Maximum increasing in absorbance notice when changed the concentration at the period 0.5 ~ 1.0 wt% as shown in Fig. 5. This might be elucidated base on the increasing of dye concentrations that leads to the reaction average increases as additional, molecules. When increased the dye 3.0 ~ 5.0 wt% the value of absorbance remains constant at 5.0 % cause reaction retardation because of the increasing in number of collisions between dye particles whereas, collisions between dye decrease. As a conclusion, proportion of reaction was decrease.^{16,17)} The main rate of degradation exists in the region near irradiated side where the intensity of irradiation was much higher than in the other sides. Thus, dye with greater concentration, the degradation decreases at sufficiently high distance from the source of light or the reaction zone because of retardation in the penetration of light.

3.4 SEM Results

The images of SEM for prepared Er_2O_3 nanoparticles are shown in Fig. 6, this Figure show the distribution and the morphology of Er_2O_3 nanoparticles. Average size of the Er_2O_3 NPs were found to be (~16 nm) and appeared to be uniform.

3.5 XRD Results

XRD have been utilized to demonstrate the Er_2O_3 nanoparticles formation phase.¹⁸⁻²³⁾ All the reflections were well indexed to cubic phase of Er_2O_3 nanoparticles and can be seen from Fig. 7, XRD parameter of Er_2O_3

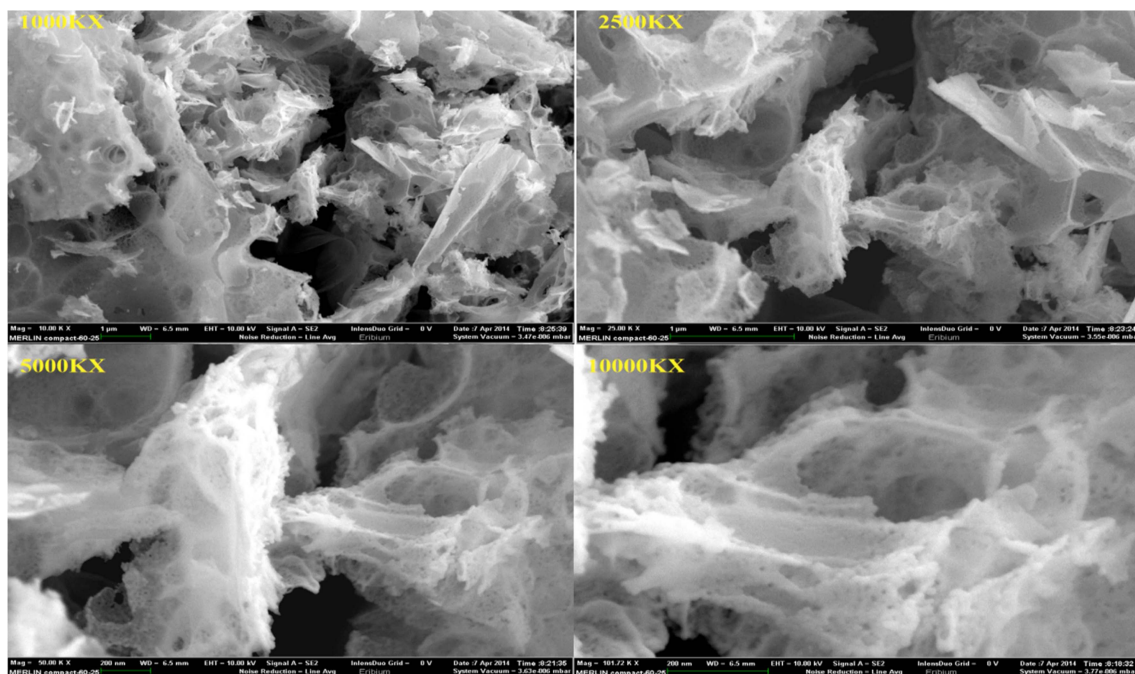


Fig. 6. SEM image of nano-sized Er_2O_3

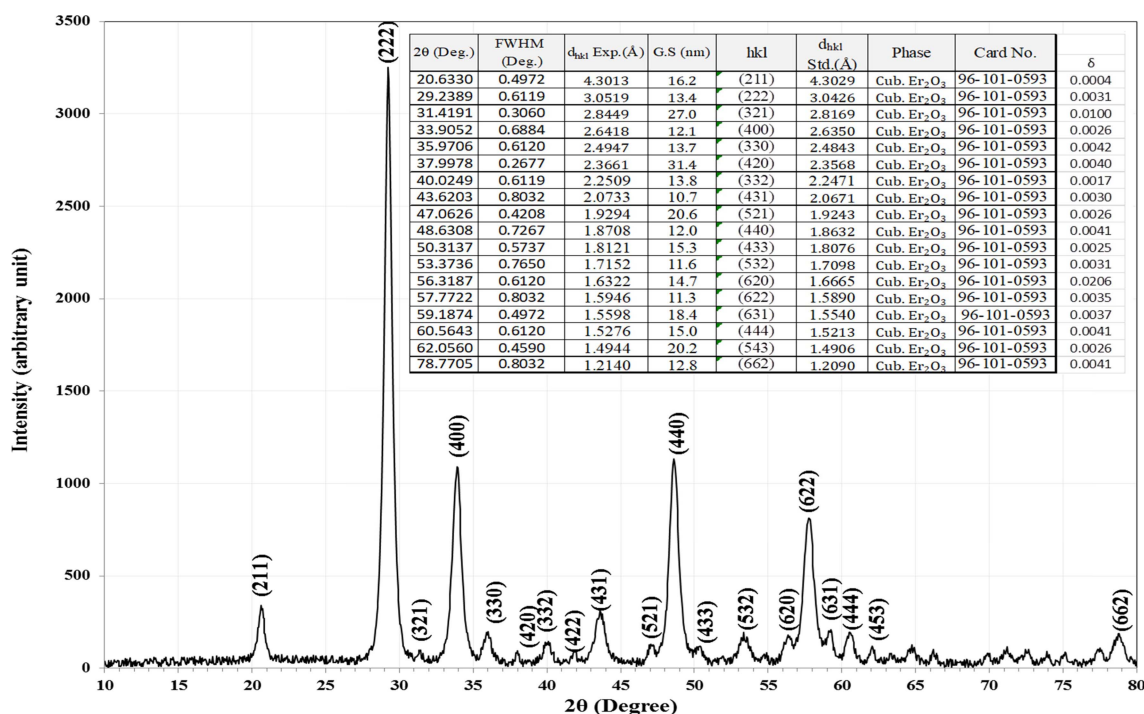


Fig. 7. XRD of Er₂O₃ nanoparticles with parameters.

nanoparticles show in Fig. 7, with a space group of I 21 3 (199) and cell parameters of $a = 10.5400$ Å. The perfect crystalline and no impurities may infer as a sharpness result of exact number of peaks in the XRD pattern. Moreover, it referred that the product is a single phase. XRD was used to clarify the Er₂O₃ nanoparticles phase formation. All the reflections were well indexed to cubic phase of Er₂O₃NPs, the average crystallite size of Er₂O₃ NPs is found to be 16 nm.

4. Conclusion

Nanoparticles of Er₂O₃ under SL improvement the effectiveness degradation diazomium compounds for Rhodamine B or in other words removal of mixture polluted by Rhodamine B. The photo catalytic activity under UV and light illumination, components for the enhanced photo synergist reactivity of the Er₂O₃. The Er₂O₃ nanoparticles have stage and it is ready to ingest a high measure of photo catalytic in the obvious light area, driving adequately photochemical degradation responses. Maximum increasing of absorbance was noticed when the concentration of Rhodamine B increased from 0.5 w-t% to 1 wt% and this behavior leads to increasing degradation of Rhodamine B up to 11% for Er₂O₃ catalyst. XRD measurements show that the structure of Er₂O₃ nanoparticles was Cubic, the average crystallite size of Er₂O₃ nanoparticles is found to be 16 nm.

Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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