

Laser- Induced Removal of Azo Dye Acid Red14 Using Tungsten Oxide

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ABSTRACT

Tungsten oxide nanoparticles were applied for removal of adyeacid red 14 using a 355 nm laser radiation generated from Nd:YAG for the first time. Andthe degradation of dye was studied by varying different parameters such as laser energy, reaction pH, catalyst concentration. The aim of the present work is to investigate the potential of nanocrystalline WO₃ as a photocatalyst under unique source (laser) of UV radiation for the oxidation of textile dyes in aqueous solutions. This study clearly demonstrates that the laser-induced photocatalytic process could be able to degrade organic pollutants present in waste water in shorter time durations as compared to conventional setups.

KEY WORDS: Tungsten oxide, Acid red 14, Laser irradiation.

INTRODUCTION

Azo dyes constitute the largest class of dyes used in industry. In the textile industry, it is estimated that 10–15% of the dye is lost during the dyeing process and released as effluent. [1]Azo dyes are resistant to aerobic degradation; however, under anaerobic conditions, the azo linkage is reduced to generate aromatic amines that are colorless but can also be toxic and potentially Carcinogenic[2].Certain azo dyes, which are known toform carcinogenic amines on reductive cleavage of theazo bonds, have already been banned (Reife et al. 1998).While anaerobic decolourization of azo dyes is welldocumented, less information is available on the aerobic degradation of azo dyes (Michaels & Lewis 1986).[3] In photocatalysis systems a combination of semiconductors (such as TiO₂, ZnO, WO₃,F2O₃, CdS and ZnS) and(laser) of UV radiation or visible lights can be used. Upon irradiation, valence band electrons are promoted to the conduction band leaving a hole behind.[4-5] Band electron interact with surface adsorbed molecular oxygen to yield superoxide radical anions ,while band holes interact with water to produce hydroxyl radical. Advanced oxidation processes are the methods in which OH⁻ radicals are produced.[6]OH⁻ is a powerful oxidizing agent and completely degrades the most of organic Pollutant.[7]

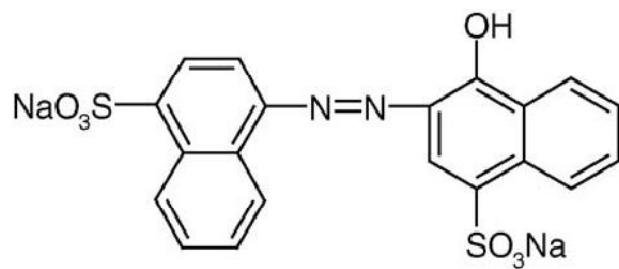


Figure 1.Structure of the dye acid red 14

EXPERIMENTAL

All experiments in this work were done in a batch photoreactor system consists of a woodenchamber with aluminum foil cover and magnetic stirrer and a 500 ml beaker as reaction chamber.

Irradiations were carried out using a 355 nm wavelength high power laser beam generated from the third harmonic of the Spectra Physics Nd:YAG laser (Model GCR 250), with a pulse width of 8 ns. A 100 ml volume of dye solution, previously adjusted to a fixed pH value with diluted NaOH and HCl, HNO₃ or H₂SO₄, respectively, was added to a 500 ml beaker containing different amount of WO₃. The temperature of the bath was kept at 22 °C.A

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stock solution containing 200 mg L⁻¹ of the dye was prepared to investigate the photocatalytic degradation of dye acid. 100–400 mg of nanocrystalline WO₃ was added to 100 mL of the dye solution and allowed to equilibrate for 10 min without laser irradiation. Then the sample was irradiated using the third harmonic at $\lambda = 355$ nm generated from Nd:YAG laser. The photochemical reaction was carried out in batches. The photocatalytic removal of the dye from water was monitored by recording the changes in the absorption spectra of dye acid at different laser irradiation times with a UV-vis spectrophotometer in the wavelength range from 200 to 700 nm. The data obtained was used to estimate the rate of the photodegradation of acid red. Dye concentration of the samples was calculated using a calibration plot of absorbance vs. concentration. The conversion fraction of dye was calculated using the equation 1:

$$X = \frac{C_0 - C}{C_0} = 1 - \frac{C}{C_0}$$

In which X was conversion fraction, C₀ and C are the initial and equilibrium concentrations (ppm) of dye.

RESULTS AND DISCUSSION

1. Effect of pH

The photocatalytic degradation was found to decrease with the increase in reaction pH and the best result for photocatalytic degradation for dye was obtained at pH 3.2.

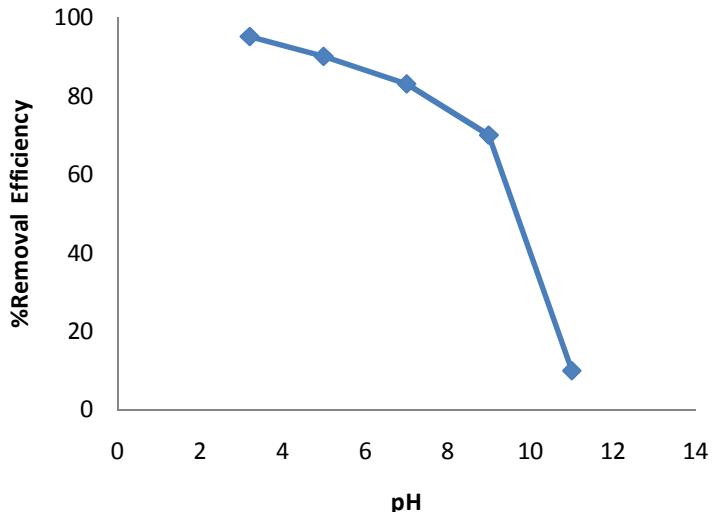


Figure 2. Effect of pH

2. Effect of laser UV irradiation and photocatalysis

Since some dyes are photo-degraded by direct laser UV irradiation. Therefore, prior to study the photocatalytical removal, it was observed to what extent the dye acid red 14 is degraded under UV laser irradiation without the presence of catalyst. For this purpose, blank experiments were carried out for the dye solution without catalyst. No significant degradation was observed without the catalyst. The removal efficiency of the dye under different amount of catalyst was investigated. The results obtained and photocatalytic degradation is depicted Fig 3.

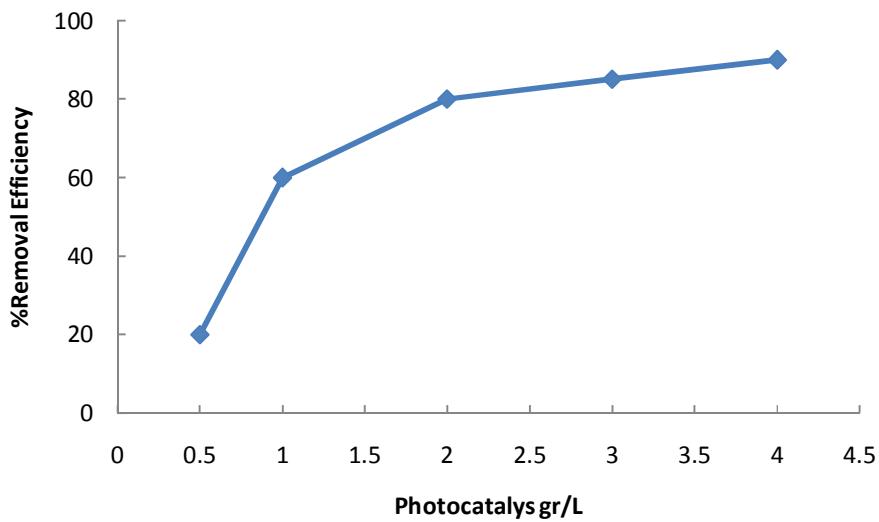


Figure3. Effect of photocatalysts

Conclusion

Advanced oxidation process of UV/WO₃ system were efficient method to remove acid red 14 from aqueous solutions. A linear increase in dye degradation was observed with the increase in catalyst concentration. The maximum removal of dye was achieved using laser energy = 150 mJ and catalyst concentration = 4 g L⁻¹. This study clearly demonstrates that the laser-induced photocatalytic degradation method could be applied as an effective method to remove the organic pollutants present in waste water in shorter time durations as compared to conventional setups.

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