International Journal of Eco-Innovation in Science and Engineering (IJEISE) Vol 3 (1), 2022 (41-44)
https://ijeise.upnjatim.ac.id/ E-ISSN: 2721-8775

Article

Catalytic Decomposition of Azo Dye Using ZnO in Sunlight

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Received: 12th April 2022; Revised: 27th April 2022; Accepted: 17th may 2022;
Available online: 19th May 2022; Published regularly: May and November

Abstract

The degradation of azo is a challenge for environmentalists. Catalytic decomposition of azo dyes by ZnO heterogeneous photocatalysis and the influence of operating parameters such as light intensity, temperature, amount of ZnO catalyst, solution pH and amount of pollutants. It has been observed that ZnO catalysts is quite capable of removing azo dyes in the presence of sunlight. We can use the same catalyst over and over, and it works well every time. We recovered 99% clear water within a few hours of exposure to sunlight.

Keywords: catalyst, zinc oxide, photocatalysis, non-degradable, water pollutants, azo dye

1. Introduction

The decomposition of azo dyes is a major problem and a difficult task for ecologists. Azo dyes are an important class of organic compounds used in various industries like textiles. Sunlight induced by the advanced oxidation process (AOP) is a promising technology for ZnO wastewater treatment. This catalyst has proven to be effective and can destroy all types of organic pollutants. AOP-ZnO heterogeneous photocatalysis can be used to treat wastewater from the textile industry, Paper industry, chemical industry etc. The waste of these industries contains residual dyes, pesticides, herbicides, dyestuffs etc. which cannot be decomposed easily. Adsorption, sedimentation, flocculation, and coagulation are common conventional methods used to treat this wastewater. These traditional methods also require a large amount of energy and a continuous supply of basic chemicals. This technology is based on solar energy-based catalytic technology that can entirely destroy all water soluble organic pollutants, including azo dyes. This technology is better used by renewable energy sources as this technology is based on solar energy. We can use the same catalyst over and over again. We don't need electricity as a power source.

Since 1977, when Frank and Bard (1977) first discovered the possibilities of using zinc oxide in the decomposition of cyanide in water, there has been a growing interest in environmental applications[1]. The degradation of Acid Green 16 was investigated using sun-irradiated ZnO[2]. Here, the image degradation efficiency decreased with increasing initial dye concentration. It was

DOI: https://doi.org/10.33005/ijeise.v3i01.63

found that the optimal catalyst load is 250 mg in 100 ml. Akyol et al. (2004) work with the photolysis of dyes from various industries[3]. Poulios and Tsachpinis (1999) investigated catalytic decomposition using different semiconductor oxides, ZnO, UV-100 ZnO, and ZnO/WO_3[4]. Xu et al. (1999) worked on "Improved photocatalytic activity of a supported ZnO compound: the effect of SiO_2 dispersion" Many researchers agree that transition metal oxides such as ZnO, CdS, WO_3, etc. are excellent for decomposing organic pollutants[5]. Some of the research published in recent years on the decomposition of azo dyes from textile and photocatalyst wastewater [5],[6],[7],[8],[9]. Legerini et al. (1993) suggested that purification using ZnO photocatalyst in the presence of UV rays is known to have several benefits; Effective and cheap removal of dissolved or dispersed organic compounds in water[9]. Stylidi et al. (2003) suggested a mechanism for ZnO-mediated photodegradation of acid orange 7. It resulted in complete mineralization of the organic molecule to naphthalene and benzene rings, carbon to CO_2, nitrogen to NH^{4+} and NO^{3-}, and sulfur to SO_2^{2-} ions[10]. Wang, et al. (2004) reported the improvement of the photocatalytic activity for the decomposition of methyl orange using SO_4^{2-}/ZnO/ZnO and ZnO, respectively, as photocatalysts[11].

The work aims to draw the researchers' attention to the use of solar energy in the decomposition of water pollutants such as azo dyes, pesticides, and herbicides, by AOP technology. We use this solar-based technology to process various samples of industrial waste (especially textile waste) and samples from heavily polluting industries. We have observed various parameter changes in the decomposition/removal of organic pollutants, Impact control. These parameters are (1) change in the size of the catalyst, (2) change in pH (3) variation in light intensity; All sets were displayed in sunlight for 3 hours.

2. Material and Method

2.1. Dye Sample

Dye sample was using Azo dye.

2.2. Photocatalyst

ZnO is used as a photocatalyst.

2.3. Analysis Methods

Changes in dye concentration can be easily observed with a Shimatsu-160 UV/Spectrophotometer. Pretreatment, intermediate and posttreatment observation of sample-10 ml of contaminated water samples were pipette out at 30 min time intervals and a change in the transparency ratio of the solution was observed.

2.4. Test settings

The photoreaction takes place in a glass furnace containing samples of water and ZnO photocatalyst which is an azo dye contaminated with azo dye. The reactor solution is continuously circulated by a water pump during the test. We have recovered more than 97% transparency clear water from highly polluted azo dye polluted wastewater.

3. Results and Discussion

3.1. Possible chemical reaction of this decomposition

When sunlight is irradiated at the surface of ZnO, it begins the electronic transition from the equilibrium (VB) to the conduction band (CB) through (ISC), the electron reaches the triplet mode, after the start of the intermolecular electronic transition between the solar catalyst, water and Dye pollutants, water molecules and dissolved oxygen produced hydroxyl radicals and Supra (o^-) oxidation, holes, by the sequential process, By the action of holes, hydroxyl radicals and Supra (o^-) oxidation on Azo dyes, are converted into simple organic compounds such as CO_2, H_2O, SO_2, N_2 etc.

3.2. Effect of Different Factors on Rate of Degradation

The main factors affecting the photodegradation of Azo dyes are catalyst loading, the concentration of azo dye pollutant, solution pH, light intensity and dissolved oxygen.

3.3. Effect of Catalyst

We note the effect of variation in the amount of photocatalyst on the decomposition rate of water-soluble organic pollutants at a constant pH of 7.5.

DOI: https://doi.org/10.33005/ijeise.v3i01.63

We found that the decomposition rate is directly related to the amount of catalyst to some extent.

3.4. The Effect of pH

The results showed that the degradation rate is very low in the acidic pH range, i.e., less than pH 3.5, and with increasing pH, the degradation rate also increases. The decomposition rate increases rapidly, with a further increase in pH. Therefore, we conclude that the decomposition rate of dissolved dye pollutants in water is higher in the alkaline medium than in the acidic medium. The rate of increase in photolysis may be due to the availability of more -OH ions in the pH range of 8 to 9 pH.

3.5 Light Intensity Effect

We note that as the light intensity increases, the decomposition rate of water-soluble organic pollutants also decreases. This change in the decomposition rate of water-soluble organic pollutants by variation in light intensity may be due to the increase in the number of photons to be reached at the catalyst surface.

4. Conclusions

After a long observation, we conclude that this photocatalyst has very good capabilities to decompose water-soluble azo dye to simple molecules such as CO_2, H_2O and N_2 etc. The main objective of the research was to exploit renewable, environmentally friendly and non-polluting solar energy sources for this treatment, which was considered promising for the following reasons: (1)Do not leave any chemical sludge or toxic residues in the treated wastewater, (2)Sun/UV degradation can improve percentage transparency and reduce toxicity in one step, (3)Cost-effective because a renewable energy source (solar energy) is used and the same catalyst can also be recycled, (4)As the amount of catalyst increases, the rate of decomposition also increases, (5)We note that the decomposition rate is between pH range 7.5 to 10, the decomposition rate is reasonable, (6) We note that the decomposition rate of water-soluble organic pollutants is higher in the afternoon throughout the summer than in the afternoon with the rainy cycle and winter session.

Acknowledgement

The authors are thankful to the Principal of the College and Prof. A.L. Ramanathan, School of Environmental Sciences, Jawaharlal Nehru University Delhi, for providing the necessary facilities.

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