

Applicability of Fenton Process for Treatment of Industrial Effluents: A Review

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ABSTRACT

Wastewater and effluent treatment has undergone innovative changes over the years. Traditional wastewater treatment has yielded to modern and path-breaking procedures which are more efficient and effective. The world of difficulties and unknown has opened new avenues and paths to highly feasible effluent treatment procedures, so the vigorous importance of advanced oxidation procedures. This review paper will delineate the increasing importance of various advanced oxidation processes including Fenton treatment for wastewater. Advanced oxidation processes (AOP's), which involve and includes the in-situ generation of highly potent chemical oxidants such as the hydroxyl radical, have emerged as an important avenue of technologies to accelerate the non-selective oxidation and thus the destruction of a wide range of non-degradable organic contaminants in wastewater which cannot be eliminated biologically. Advanced oxidation processes (AOP) are technologies based on the generation of highly reactive species, the hydroxyl radicals, used in oxidative degradation procedures for organic compounds dissolved or dispersed in aquatic media. These processes are promising alternatives for decontamination of media containing dissolved recalcitrant organic substances, which would not be efficiently removed by conventional methods.

Keywords - Advance Oxidation Process, Fenton process, Hydrogen peroxide (H₂O₂), Ferrous sulphate, COD removal, Color removal.

I. INTRODUCTION

A wide range of organic compounds is detected in industrial and municipal wastewater. Some of these compounds (both synthetic organic chemicals and naturally occurring substances) pose severe problems in biological treatment systems due to their resistance to biodegradation or/and toxic effects on microbial processes.

As A Result, The Use Of Alternative Treatment Technologies, Aiming To Mineralize Or Transform Refractory Molecules Into Others Which Could Be Further Biodegraded, Is A Matter Of Great Concern. Among Them, Advanced Oxidation Processes (Aops) Have Already Been Used For The Treatment Of Wastewater Containing Recalcitrant Organic Compounds Such As Pesticides, Surfactants, Colouring Matters, Pharmaceuticals And Endocrine Disrupting Chemicals. Moreover, They Have Been Successfully Used As Pre-Treatment Methods In Order To Reduce The Concentrations Of Toxic Organic Compounds That Inhibit Biological Wastewater Treatment Processes. [3]

More than 10,000 dyes are used in the textile industry and 280,000 tonnes of textile dyes are discharged every year worldwide (Hsueh et al., 2005), Textile dyeing and finishing processes produce large quantities of wastewater that is highly coloured and contains large concentration of organic matter(

Mass et al.,2005),which is difficult to treat via classical methods.^[7] Apart from the aesthetic problems created when coloured effluents reach the naturalwater currents, dyes strongly absorb sunlight, thus impeding the photosynthetic activity of aquatic plants and seriously threatening the whole ecosystem (Slokar et al.,1998).

The problem of colored effluent has been a major challenge and an integral part of textile effluent treatment as a result of stricter environmental regulations. The presence of dyes in receiving media is easily detectable even when released in small concentrations (Little et al., 1974; Nigam et al., 2000).^[7] This is not only unsightly but dyes in the effluent may have a serious inhibitory effect on aquatic ecosystems as mentioned above. Commonly applied treatment methods for color removal from dye contaminated effluents consist of integrated processes involving various combinations of biological, physical and chemical decolourization methods (Galindo et al., 2001; Robinson et al., 2001). These integrated treatment methods are efficient but not cost effective.^[7] Traditional physical-chemical techniques such as ultra-filtration, reverse osmosis, ion exchange and adsorption on various adsorbents (activated carbon, peat, fly ash and coal, wood. chips, silica gel, corncob, barley etc.) have efficiently been used for the purpose of color removal from textile

effluents. Activated carbon is the most commonly applied method for color removal.^[11]

II. MATERIALS AND METHODS

Fenton's reagent experiments were carried out at room temperature in a 1 litre reactor using varying hydrogen peroxide and FeSO₄ dosages at varying pH values in order to determine the optimum conditions for best COD and color removal. Optimum PH determination was carried out for chemical dosages of H₂O₂ = 900 mg/lit and FeSO₄ = 1000 mg/lit. In order to find optimum chemical dosages at a predetermined optimum pH, H₂O₂ and FeSO₄ dosages varied between 100 and 1000 mg/lit. The solutions were mixed by means of magnetic stirrer.

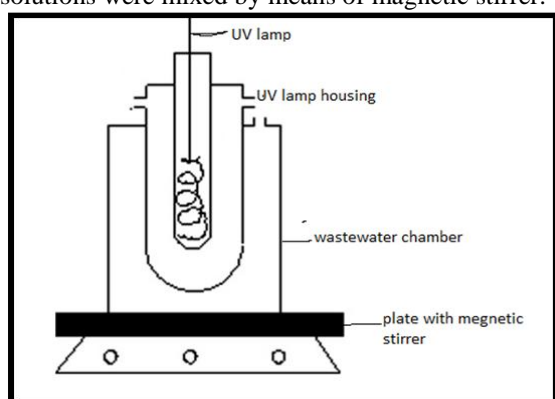


Fig 1: Experimental set up for photofenton treatment^[5]

A photo-reactor was set up for the experiments with UV in batch mode operation. A Phillips 250 W mercury lamp (wavelength of 420 nm) was used. After addition of predetermined amount of Hydrogen peroxide and Ferrous sulphate in to the dye sample, the solution within the UV irradiated reactor was mixed by the help of a magnetic stirrer to ensure homogeneous mixture. In addition, both sodium hydroxide and sulphuric acid were used to adjust the PH. Sonolysis experiments were performed in a Sono reactor (DU-MINI-120), at an ultrasound frequency of 34 KHz in a continuous wave mode. The power output was 120 W. The volume of solutions sonicated was 500 ml. Experiments were carried out under atmospheric conditions and at room temperature.^[26]

III. FENTON REACTION

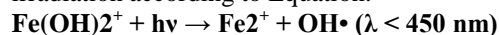
Among many AOPs, Fenton (H₂O₂/Fe (II)) and solar photo-Fenton treatment processes (combination of H₂O₂, Fe (II) and solar irradiation) have been proven to be effective in degradation and mineralisation of single organic toxicants and the mixtures of various organic wastes (Xu et al., 2007).^[14]

The photo-Fenton process can be divided into the following stages (Pignatello, 1992; Bossmann et al., 1998): the firststep is the so-called Fenton

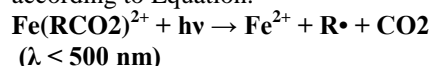
reaction, in which ferrous ions are oxidised to ferric ions in acidic aqueous solution, as shown in Equation, giving rise to hydroxyl radicals:



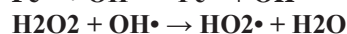
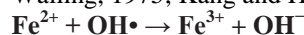
The ferric ions, represented by the complex Fe(OH)₂⁺, is reduced back to Fe²⁺ by UV-visible irradiation according to Equation:



The ferric species can also form complexes with the initial organic compounds and/or degradation products, leading to photo-reduction back to Fe²⁺, according to Equation:



The OH[•] species formed will then attack the organic substrates present in the wastewater. Nevertheless, numerous competitive reactions can also occur, namely, the following, which negatively affect the oxidation process (Harber and Weiss, 1934; Walling, 1975; Kang and Hwang, 2000):



This network of consecutive and parallel reactions results in complex reaction kinetics. To overcome these difficulties, most of the kinetic studies focused on single component degradation or, in the case of complex effluents, the overall kinetics was analyzed instead.

IV. FACTORS AFFECTING THE PERFORMANCE OF FENTON PROCESS

A. Effect of H₂O₂ Dosage

Fig. 1 shows the removal of color and COD at different H₂O₂ dosages. The pH was controlled at 4 and the ferrous dosage was 50 mg/l. In the presence of H₂O₂ only, the color removal increased from 10% to 57% and the COD removal decreased from _2% to _15% as the H₂O₂ dosage increased from 10 to 100 mg/l, respectively.^[23]

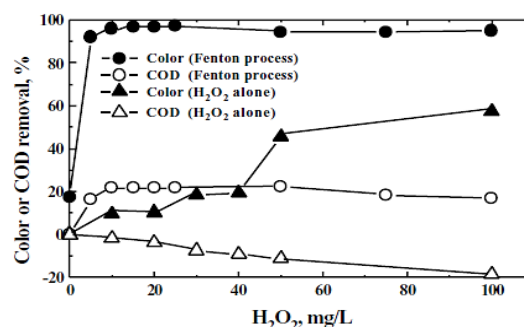


Fig. 1. Effect of hydrogen peroxide dosage on color and COD removal by Fenton process and H₂O₂ oxidation (Fe²⁺ / 50 mg/l).

The COD removal is due to residual H₂O₂, which consumes K₂Cr₂O₇, according to reaction (Talinli and Anderson, 1992). It appears that H₂O₂ alone is not effective in the removal of both COD and color reached 92–96%, but only 16–22% for COD removal. When increasing the H₂O₂ dosage from 10 to 100 mg/l, the color removal remained in the range 94–96%, while the COD removal decreased slightly from 22% to 17%. According to reaction, the concentration of HO is expected to increase with increasing H₂O₂ dosage, leading to increased oxidation rates of color and other organic compounds (COD). However, as mentioned above, excess H₂O₂ interferes with the measurement of COD. The residual H₂O₂ in the Fenton process can consume K₂Cr₂O₇, leading to the increase of inorganic COD (Talinli and Anderson, 1992). In this study, 1 mg/l of H₂O₂ was found to be equivalent to 0.43 mg/l of COD.

B. Effect of Ferrous Dosage

Fig. 2 shows the removal of color and COD under different ferrous dosages at a constant H₂O₂ dosage of 10 mg/l. At Fe(II) dosage of 5 and 20 mg/l, the color removal was 70% and 96% and COD removal was only 4% and 18%, respectively.[12] It is obvious that the ferrous dosage significantly affects the color removal and only slightly increases the COD removal.

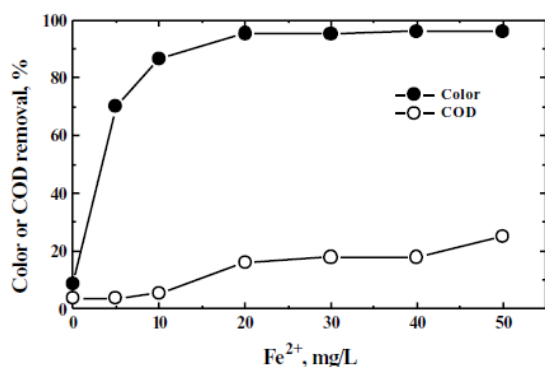


Fig. 2. Effect of ferrous dosage on color and COD removal by Fenton process (H₂O₂ ¼ 10 mg/l).

V. CONCLUSION

From literature review it can be revealed that;

- I. Photo-Fenton like advance oxidation is an effective treatment method for complete decolourization accompanied with appreciable COD and TOC removal from dye production wastewater.
- II. The Fenton process can work at ambient pH but the water matrix and mainly the concentration of alkalinity play a prominent role in oxidation process.

- III. Photo-Fenton give effective result for pharmaceutical and other trace organic contaminants.

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