

Advanced Oxidation Process for Wastewater Treatment: A Review

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ABSTRACT: Treatment of textile wastewater is an important issue because there is limited source of drinking water. This review is the approach to all advanced oxidation processes (AOP) for the textile wastewater treatment. In the advanced oxidation process pollutant is oxidized by strong oxidizer and breakdown of the pollutant occur. Oxidation by O₃/UV, Electrochemical oxidation, Electro-Fenton, H₂O₂/O₃ and photo-catalyzed is reviewed. Mechanism and affecting parameters of the treatment are also described in this review. The advantage and disadvantages of the process are also discussed.

KEYWORDS: Advanced oxidation process, wastewater treatment.

I. INTRODUCTION

Treatment of the textile wastewater can be characterized by the organic and inorganic compound matter present in it. It is also depends on the nature and concentration of the waste. There is no universal technique, which can treat all type of wastewater. Figure 1 shows the schematic representation of the advanced oxidation processes. In advanced oxidation process basically there are two processes like homogeneous and heterogeneous processes. In homogeneous with the help of energy and without energy can be proceed. In heterogeneous catalytic Ozonation, photo catalytic Ozonation process is used.

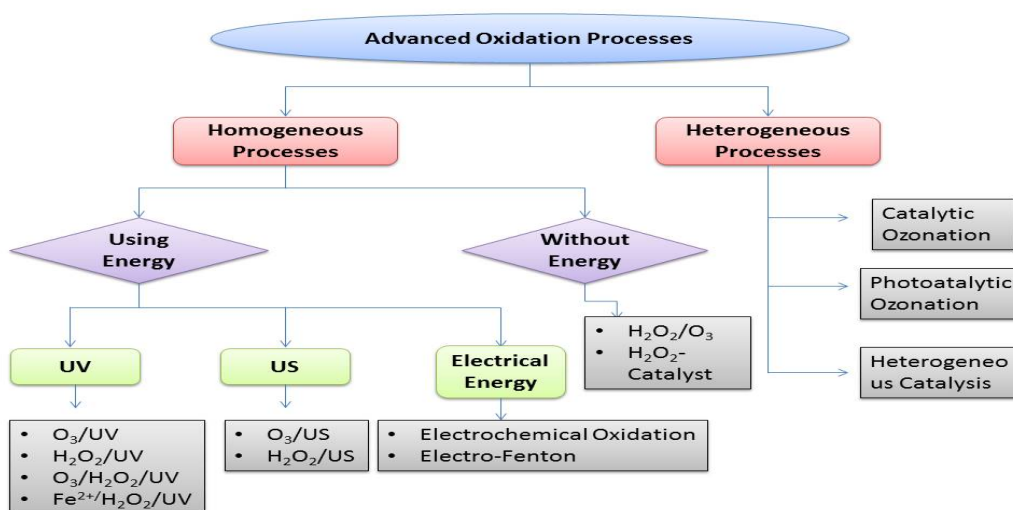


Figure 1. Schematic representation of the advanced oxidation process

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Figure 2(Fryda et al. 2003) shows the organic load for the different process used for the treatment. Biological treatment process is used when organic load is less. Electrochemical advanced oxidation processes and advanced oxidation processes are the most used process for the higher organic load.

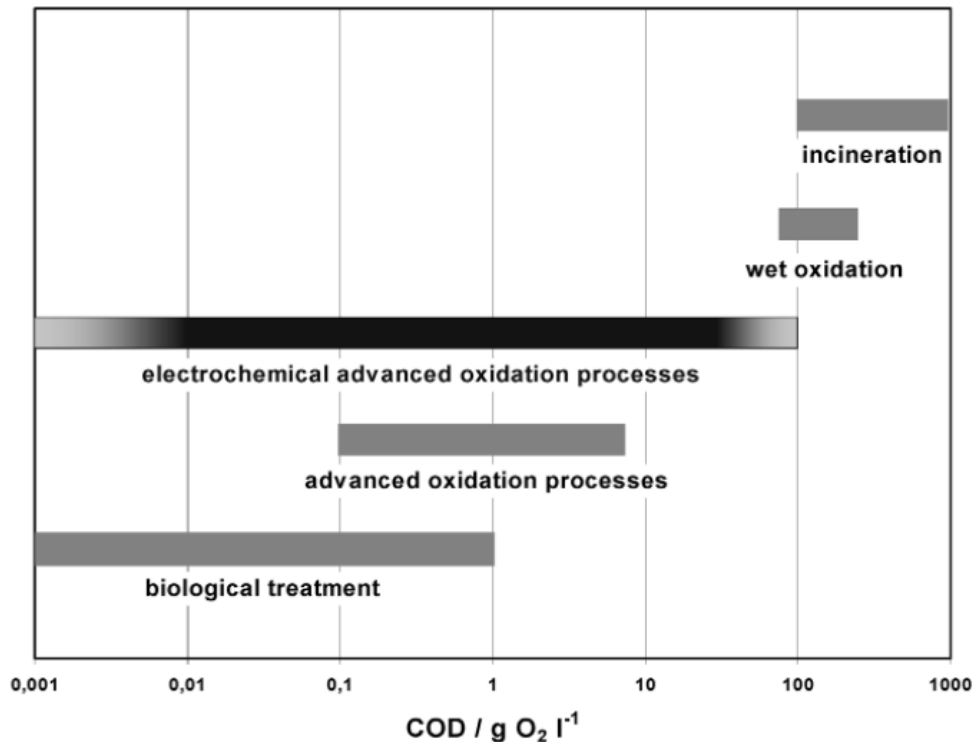


Figure 2. Application of wastewater treatment technique based on organic load (COD)

Different oxidizing species can be used for the oxidation. Highest oxidation potential is fluorine and positively charged hole on TiO₂. Table 1 shows different oxidation potential of the chemical species.

Table 1. Standard potential of some oxidizing species(Sirés et al. 2014).

S. No.	Oxidizing Agent	Standard Potential (V vs. SHE)
1.	Oxygen (molecular)	1.23
2.	Chlorine dioxide	1.27
3.	Chlorine	1.36
4.	Oxygen (atomic)	2.42
5.	Ozone	2.08
6.	Fluorine	3.06
7.	Positively charged hole on TiO ₂	3.20

II. RELATED WORK

K. Sivagami et.al. used Advanced oxidation processes for the treatment of tannery wastewater. Their results shows that the COD removal varies between 30 and 50% in Fenton treatment and 15–20% in ozonation. The effect of pH,

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hydrogen peroxide, ferrous ions concentration on removal of COD was studied The pH and ferrous ion(Fe²⁺) to hydrogen peroxide(H₂O₂) ratio was found to be 4 and 1:10 respectively.[11]

Advanced Oxidation Processes for Wastewater Treatment in the Pulp and Paper Industry was reviewed by Laura G. Covinich et.al. explaining that advanced oxidation processes are technically applicable for the removal of recalcitrant compounds from effluents of pulp and paper mills. They also revealed that due to the differences between the effluents from pulp and paper industries, some oxidative techniques must be combined to improve the efficiency.[12]

Muhammad Saqib Nawaz et.al. recommended the combination of techniques for the treatment of textile waste water.They reported that the combination of conventional activated sludge treatment followed by sand filtration and activated carbon adsorption gives highest organics (81.6%) and color (94.5%) removal with nominal cost.[13]

In the study of Textile Industries Wastewater Treatment by Electrochemical Oxidation Technique Using Metal Plate, Norazzizi et.al. investigated experimentally the optimization of electrochemical oxidation technique for textile wastewater treatment. They had taken C.I. Reactive Blue 109, platinum plate electrode (10 mm x 10 mm) as anode and stainless steel (10 mm x 10 mm) as cathode. Under the optimum operating conditions, sodium chloride concentration of 0.1 M, current density of 20.0 mA/cm², initial pH of 4 and electrolysis time of 75 minutes, the percentage of color and COD removals efficiency was reached 96%, while for BOD, TOC and surfactant removals, the percentage was less than COD removal percentage. Their study revealed that electrochemical oxidation technique can be used for COD removal as well as for color removal.[14]

Yang et.al. reviewed AOPs for treatment of landfill leachate and Effluent Organic Matters in Biologically Treated Secondary Effluent. They concluded that hydroxyl radical AOP is to remove recalcitrant organic matters, traceable emerging contaminants, in addition to certain inorganic pollutants. Sulfate radicals have a similar strong oxidative capacity and a short lifespan but different reaction patterns from hydroxyl radicals.[15]

III. ADVANCED OXIDATION PROCESS

Advanced oxidation is most promising technology for the treatment of wastewater containing organic matter. In advanced oxidation processes oxidant used for the oxidation of organic compound like chlorine hydrogen peroxide and ozone. It is also reported (Pera-titus et al. 2004) that all type of organic matter can be degraded by advanced oxidation process.

Homogeneous Process

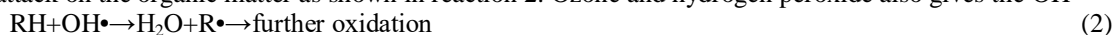
Energy Assisted Process

There are basically three ways with energy assisted treatment process. In first way energy is used by UV light. Energy from UV light is also promoted with O₃, H₂O₂, O₃/H₂O₂ and Fe⁺²/H₂O₂. In second way ultra-sonication irradiation (US) is used as energy source aided with O₃ and O₃/H₂O₂ and in third way electrochemical oxidation and electro Fenton process are used.



Without Energy

In this part of homogeneous process, O₃/H₂O₂ and O₃/catalyst is used.OH[•] is formed during the initiation of the process which attack on the organic matter as shown in reaction 2. Ozone and hydrogen peroxide also gives the OH[•]



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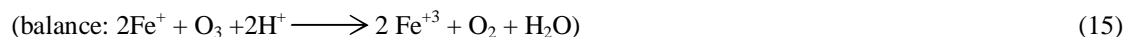
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Heterogeneous process

In the heterogeneous process catalytic oxidation is done by (Zhuang et al. 2014) in which performance of the Ozonation was increased of gasified wastewater from biologically preheated lurgi. Catalytic oxidation was also done by (Logemann & Annee 1997) on fixed bed under different pH condition. Catalytic oxidation can be done with metals like Fe, Mn, Ni, Co, Zn, Ag etc. to remove different organic matter from wastewater (Legube & Leitner 1999).



Catalytic Ozonation

The first ozonation study was done in the year of 1990, for the anionic surfactant. In this work ozonation was done as a polishing step of the effluent using USAB reactor for domestic wastewater treatment. It is also reported in (Brillas & Martı 2009) TOC removal can be increased from 21 to 43% by using catalytic ozonation instead of single ozonation.

Photo catalytic Ozonation

Photocatalytic oxidation of pollutant by transparent TiO₂ material was done by (Ishibashi et al. 2000) using low intensity UV light source. Photo catalytic oxidation is also useful for the gas purification from Acetone, 1-Butanol, Butyraldehyde, Formaldehyde, and m-Xylene (Engineering & Carolina 1992). Photo reactor also proposed in (Pera-titus et al. 2004) for the photocatalysis based on a continuous rotating disk photo-catalytic reactor (RDPR).

Heterogeneous Catalysts

Heterogeneous catalyst is used to enhance the removal capacity of the pollutant. Metallic ion or heterogeneous catalyst is combined with ozonation, hydrogen peroxide, UV radiation. In the process of heterogeneous catalytic ozonation organic matter is mineralized by the transformation of ozone into more active species. Reaction is undertaken on the surface of catalyst (Faria 2009).

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IV. ADVANTAGE AND DISADVANTAGE OF AOP'S

AOP remove organic compound without pollution transfer to another phase. AOP is very efficient technique for all type of organic waste treatment and cheaper than other process. AOP can be adapted to small scale development. Some specific catalysts are having higher cost which is drawback. In textile treatment some intermediate is also very toxic in nature.

V. CONCLUSION

It was found that advanced oxidation process is used for the textile wastewater treatment as well as domestic wastewater. Advanced oxidation process based on H_2O_2 (Fenton, photo-Fenton and H_2O_2 -UV) achieve the degradation of pollutant in a short period of time. In the process of catalytic ozonation the cost of catalyst generally high, this is drawback of process.

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