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A Cretical Review on Advanced Oxidation Processes (Aops) for Wastewater Treatment

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Abstract: Advanced oxidation processes (AOPs) constitute important, promising, efficient and environmentally friendly methods developed to principally remove persistent organic pollutants(POPs) from waters and wastewaters. Generally, AOPs are based on the in-situ generation of apowerful oxidizing agent, such as hydroxyl radicals (•OH), obtained at a sufficient concentration to effectively decontaminate waters. The main types of AOPs, based on electrochemical reactions, are explained in detail and broadly in this critical summary of the present work. Based on indicates, these AOPs perform well for break down and reducing particulate matter in lakes and rivers and for purifying water and wastewaters.

Keywords: Advanced Oxidation Process, Persistent Organic Pollutants, AOPs, POPs, Hydroxyl Radicals, Particulate Matter.

1. INTRODUCTION

The field of wastewater treatment views Advanced Oxidation Processes (AOPs) as one of the strong decontamination processes due to their rapid rate of division and the creation of simpler products. This can in fact help to minimize the buildup of sludge. Glaze et al. (1987) defined advanced oxidation processes (AOPs) precisely as water treatment processes performed at room temperature and normal pressure and built on the in-situ generation of an effective oxidizing agent, such as hydroxyl radicals (•OH), at a concentration sufficient to effectively decontaminate waters. AOPs have attracted a lot of attention recently, as seen by the many basic and feasible studies on the area [1] to [8]. Persistent organic pollutants (POPs) can be efficiently removed from rivers and lakes by these methods. Based on the in-situ production of (•OH) radicals using a variety of chemical, photochemical, sono-chemical, or electrochemical reactions discussed in [9] many types of AOPs are being created. The Fenton technique, involving a soluble iron (II) salt and H_2O_2 as the Fenton's reagent to break down and clear

POPs, is the most conventional and widely used chemical AOP [1, 3, 5,].

1.1. Versatility:

AOPs are effective against a diverse array of contaminants, including organic dyes, pharmaceuticals, pesticides, and emerging pollutants. Their versatility makes them suitable for treating complex wastewater streams with multiple contaminants.

1.2. Minimization of Byproducts:

AOPs aim to minimize the formation of harmful byproducts during the oxidation process. The goal is to achieve complete mineralization or transformation of pollutants into less toxic substances.

1.3. Application in Water and Wastewater Treatment:

AOPs find applications in both water and wastewater treatment, ranging from the removal of micro-pollutants in drinking water to the treatment of industrial effluents containing recalcitrant compounds.

1.4. Challenges and Considerations:

Challenges associated with AOPs include energy consumption, the need for catalysts, and the potential formation of harmful intermediates. Researchers are continually exploring ways to optimize AOPs and mitigate these challenges.

2. CHEMICAL AOPs

2.1. Anodic Oxidation:

Anodic oxidation (AO), in which electrons act as a single reagent, is a simple, chemical-free method of electrochemically producing •OH radicals. Water oxidation at the anode surface directly forms OH radicals, with a strong O_2 evolution overvoltage anodes [10-15]. at first Pt, PbO_2, doped SnO_2, IrO_2, or DSA (Dimensionally Stable Anodes), which are mostly mixed metal oxide anodes, had been employed to create the AO process [16] to [19]. These anodes have been shown to have a catalytic mechanism that involves the production of heterogeneous hydroxyl radicals.

$M + H_2O \rightarrow M(\bullet OH) + H^+ + e^-$ (1)

$M(\bullet OH) + R \rightarrow M + mCO2 + nH_2O + pX$ (2)

Where, M is the anode material, R is the organic matter, X is the inorganic ions, and M(•OH) is the heterogeneous •OH radicals adsorbed on the anode material.

2.2. Fenton's Reagent:

The origins of Fenton's chemistry go to the late 1800's, when Fenton published a groundbreaking study on the oxidation and destruction of tartaric acid using a combination of H_2O_2 and Fe^{2+}, which came to be known as Fenton's reagent (Fenton, 1894). More recent mechanistic research has shown that, in accordance with the traditional Fenton's reaction (1), the hydroxyl radical production launched the Fenton process. This indicates that the Fenton process might be utilized to degrade or destroy an array of organic pollutants [20 to 22].

2.3. Reaction Mechanism

$Fe^{2+} + H2O2 \square Fe^{3+} + \bullet OH + OH^-$ (3)

$Fe^{2+} + H2O + H^+ \square Fe^{3+} + H2O + \bullet OH$ (4)

$Fe^{3+} + HO^\bullet \square Fe^{2+} + O2 + H^+$ (5)

$Fe^{3+} + R\bullet$ □ $Fe^{2+} + R^{+}$ (6)
$Fe^{3+} + O_2^{\bullet-}$ □ $Fe^{2+} + O2$

3. ADVANTAGES:

- ✓ Simple and flexible operation that makes it simple to integrate into already-existing facilities.
- ✓ Chemicals that are affordable and easy to handle.
- ✓ External energy for activation may not be required.

4. DISADVANTAGES:

- ✓ The storage and transportation of H_2O_2 entails significant risks and costs.
- ✓ Secondly, significant amounts of chemicals are needed to acidify effluents at pH 2 to 4 prior to decontamination and/or neutralize treated solutions before disposal. 3. Buildup of iron sludge that needs to be removed at the end of the treatment.
- ✓ The inability to mineralize the entire area because Fe (III)-carboxylic acid complexes form and are poorly removed by bulk •OH.

5. SUMMARY:

Advanced Oxidation Processes (AOPs) represent a group of powerful and versatile water treatment techniques designed to remove or degrade pollutants in water and wastewater. These processes involve the generation of highly reactive hydroxyl radicals (•OH) to break down organicand inorganic contaminants. AOPs are considered advanced due to their ability to address a widerange of persistent and toxic pollutants that may be challenging to treat with conventional methods.In summary, Advanced Oxidation Processes offer a promising approach for the efficient removalof a broad spectrum of pollutants from water and wastewater. Their adaptability to various contaminants and potential for minimizing environmental impact make them valuable tools in theongoing efforts to address water quality challenges and ensure sustainable water management.

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