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Application of Electrocatalysis and Particle Swarm Electrodes in Organic Industrial Wastewater Treatment

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ABSTRACT. *With the development of society, a large amount of organic wastewater generated by industrial production has gradually become a key issue of concern in all sectors of society. This article will analyze the use of electrocatalysis and particle swarm electrodes in organic industrial wastewater treatment, and explain its main mechanism and application characteristics. And the effect, it can provide a reference for similar research, and also provide practical technical guidance value for organic industrial wastewater treatment produced in China's industrial production.*

KEYWORDS: *Electrocatalysis, Particle swarm electrode, Organic industrial wastewater treatment*

1. Principle of electrocatalytic water treatment

1.1 Electrochemical Oxidation

Electrochemical oxidation refers to the process of generating various free radicals under the action of an electric field, using the strong oxidizing characteristics of free radicals, to oxidize and decompose organic pollutants in water on the electrode surface. According to the mechanism of electrochemical oxidation of organic matter, electrochemical oxidation can be divided into direct electrochemical oxidation and indirect electrochemical oxidation[1]. Direct electrochemical oxidation is the process of oxidizing and decomposing organic substances through the direct transfer of strong oxidants and electrons generated on the electrode surface. Indirect electrochemical oxidation is a strongly oxidizing substance generated during the electrochemical reaction, diffuses into the body of the aqueous solution, and reacts with organic substances to cause it to be degraded. This process is divided into an irreversible process and a reversible process.

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1.2 Electrochemical Reduction

Electrochemical reduction is the partial or complete hydrogenation reduction of organic substances through cathodic reduction. It converts highly toxic organic substances into low-toxic substances. It can be used as pretreatment for oxidation and biological processes[2]. It is mostly used for halogenated hydrocarbons and dyes. Degradation. Electrochemical reduction includes direct electrochemical reduction and indirect electrochemical reduction. Direct electrochemical reduction is a process in which organic matter directly obtains electrons on the cathode surface and is reduced. The recovery of metals in solution belongs to the direct electrocatalytic reduction process. Indirect electrochemical reduction is the process of reducing organic matter by using redox substances generated during the electrochemical reaction, or active hydrogen atoms generated in aqueous solution.

2. Particle Swarm Motors Apply Water Treatment Principles

Electrochemical reaction is a heterogeneous reaction on the electrode surface. The reactants must reach the interface to participate in the reaction [3]. Therefore, increasing the electrode area to promote the migration of the reactants is an effective method to increase the reaction speed. The working mechanism of the particle group electrode reactor is not only different from the simple activated carbon adsorption method, but also different from the traditional electrolytic method. Although activated carbon has different degrees of adsorption and enrichment of dyeable molecules due to its huge specific surface area, this is the same as simple activated carbon adsorption; but it is also a good conductor. When activated carbon particles are directly or indirectly with the main electrode When electrically connected, it becomes the epitaxial part of the main electrode and becomes a unipolar particle group electrode, which effectively increases the surface area of the electrode; when insulating particles are added to the activated carbon particles to isolate the carbon particles from each other, they are not separated from the main electrode When it is directly or indirectly electrically connected[4], it will be electrostatically induced to cause positive and negative poles to appear on both sides of the carbon particles, which will become a bipolar particle group electrode. In this way, each bipolar particle becomes a miniature electrolytic cell, which effectively shortens the distance between the two poles, reduces the migration distance of the reactants, increases the potential gradient between the two poles, and accelerates the charged particles in the solution. The migration speed is conducive to the high-speed electrolysis in the solution with lower concentration and smaller conductivity.

3. Electrocatalytic Electrode Application Analysis

3.1 Select Electrode Material

It is first necessary to understand how the electrocatalytic reaction is affected by the properties of the electrode matrix material. Electrode reaction is an

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oxidation-reduction reaction involving electrons, so the progress of electrocatalytic reaction has an important relationship with electrode potential. The more negative the electrode potential, the easier it is to lose electrons; the more positive the electrode potential, the easier it is to get electrons. The metal with a negative electrode potential is a stronger reducing agent, and the metal with a positive electrode potential is a stronger oxidant. Important basis. The results of electrolytic decolorization of amaranth red dye wastewater show that the decolorization rate and COD removal rate have a clear corresponding relationship with the electrode potential of the anode material. The more positive the electrode potential, the higher the decolorization rate and COD removal rate [5].

3.2 Organic Oxidation Reactions and Products

The oxidation reaction mechanism and product selectivity of organics on the metal oxide anode are related to the valence of the anode metal oxide and the oxide species on the surface. The higher-valent metal oxide MO_{X+1} generated on the metal oxide MO_X anode is beneficial to the selective oxidation of organic matter to form oxygenates; the free radical MO_X (OH ·) generated on the MO_X anode is beneficial to the oxidation and combustion of organic matter to generate CO_2. The oxidation products of phenol on the IrO_2 anode were aromatic compounds, fatty acids and CO_2, while the CO_2 generated on the SnO_2 anode increased significantly. This is because the electrode potential of the SnO_2 electrode is greater than the electrode potential of the IrO_2 electrode. In the presence of anionic surfactant and supporting electrolyte $HClO_4$, β-PbO_2 electrode was electrodeposited on titanium. The surface of the electrode prepared by this method can absorb more hydroxyl radicals, which significantly improves the electrocatalytic activity of anodic oxidation reaction of DMSO and benzaldehyde.

3.3 Catalysts in Electrode Electrocatalytic Reactions

The electrode in the electrocatalytic reaction is like a catalyst in a chemical reaction, so the selection of electrode materials is similar to that of the catalyst used in general chemical reactions. In order to make chemical reactions have high selectivity and specificity [6], catalysts often require multi-components. In electrochemical reactions, multi-component electrodes are also an important research aspect. The preparation of Ti / SnO_2-Sb_2O_3-MnO_2 / PbO_2-MnO_2 anode can be used as an example of multi-component electrode design. The main reason for the failure of the titanium anode is that the new ecological oxygen generated by the oxygen evolution reaction diffuses to the electrode surface, thereby forming a non-conductive TiO_2 film on the titanium surface. In order to activate the anode, a PbO_2-MnO_2 active layer is added on the electrode surface; in order to reduce the diffusion of new ecological oxygen on the titanium surface, a SnO_2-Sb_2O_3-MnO_2 intermediate layer is added between the titanium electrode substrate and the active layer. This anode has high electrocatalytic activity and electrochemical stability in the treatment of phenol-containing wastewater.

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From the above, it can be found that the electrode's electrocatalytic effect can come from the electrode material itself, or it can be achieved by modifying the surface of the electrode with a “covering layer” with an electrocatalytic function. Therefore, the electrode is required to have a higher oxygen evolution potential.

4. Particle Swarm Electrode Application Analysis and Prospect

The activated carbon adsorption method can be used for the treatment of some organic sewage, but the adsorption capacity of activated carbon is limited and the regeneration process is complicated, so its application is limited. Activated carbon is used as a particle group electrode. Due to its adsorption, organic matter can be enriched on its surface. The adsorbed substance can be easily oxidized and degraded during the adsorption process under the action of an electric field, so it is not affected by the amount of adsorption saturation. After applying voltage to the activated carbon that is close to adsorption saturation, the removal rate and decolorization rate of COD in dye wastewater were significantly improved. The electrocatalytic material was placed between the anode and cathode. The effects of voltage and electrocatalytic material on the degradation of phenol, aniline and dimethyl phthalate in aqueous solution were investigated. Under the action of voltage and catalytic materials, the degradation reaction of organics can be significantly improved. H2O2 and · OH produced by electrocatalysis are active species for organic degradation.

The particle group electrode can be a porous material with a large specific surface area, so the specific surface area of the electrode is much larger than its geometric surface area. In addition, the electrolyte flows through the channels between the particles and inside the porous body, so the mass transfer process in the electrode is enhanced. When the anode or cathode chamber of the electrolytic cell is filled with conductive particles, they serve as the epitaxial part of the plate electrode, which can greatly speed up the electrochemical reaction rate. According to the mechanism of organic matter elimination reaction, a particle swarm expansion anode or a particle swarm expansion cathode can be selected respectively. When the particles with large contact resistance are filled between the main electrodes, each particle can form a pair of bipolar microelectrodes, so that it is like forming many tiny electrolytic cells between the main electrodes, which effectively use the electrolytic space. It plays the role of strengthening the electric field, and the oxidation reaction and the reduction reaction can be performed simultaneously on the positive electrode and the negative electrode of each particle. During the degradation of many organic substances, various bond breaking reactions are often accompanied. The anode of a bipolar microelectrode is used for the oxidation reaction, and the hydrogen evolution of the cathode is helpful for the bond breaking reaction. Very good application prospects.

5. Conclusion

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In summary, the use of electrocatalysis and particle swarm electrodes in the treatment of organic industrial wastewater can achieve better wastewater treatment results and contribute to the promising application of electrochemical conversion reactions of organic substances.

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References

[1] Mark H B, Atta N, Ma Y L, et al (2015). The electrochemistry of neurotransmitters at conducting organic polymer electrodes: electrocatalysis and analytical applications [J]. Bioelectrochemistry and Bioenergetics, vol. 38, no. 2, pp. 229-245.
[2] Fangke Y, Yi W, Hongrui M, et al (2018). Enhancement of H2O2 production and AYR degradation using a synergetic effect of photo-electrocatalysis for carbon nanotube/g-C3N4 electrodes [J]. New Journal of Chemistry, vol. 10, no. 1, pp. 391-394.
[3] Cristina Sáez, Pablo Cañizares, Llanos J, et al (2018). The Treatment of Actual Industrial Wastewaters Using Electrochemical Techniques [J]. Electrocatalysis, vol. 4, no. 4, pp. 252-258.
[4] I. C. Eleotério, Forti J C, Andrade A R D (2019). Electrochemical Treatment of Wastewater of Veterinary Industry Containing Antibiotics [J]. Electrocatalysis, vol. 4, no. 4, pp. 283-289.
[5] Martínez-Huitle, Carlos A, Andrade L S (2017). Electrocatalysis in wastewater treatment: recent mechanism advances [J]. Química Nova, vol. 34, no.5, pp. 850-858.
[6] Pei J, Li X Y (2011). Electrocatalysis and Flow-Injection Analysis of Hydrogen and Organic Peroxides at CuPtCl6 Chemically Modified Electrodes [J]. Electroanalysis, vol. 11, no. 16, pp. 1211-1217.