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Research and Analysis of Typical Pollutants Treated by Electroflocculation Technology in Water

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Abstract

Electrocoagulation is an electrochemical technology that realizes the removal of pollutants by generating flocculants in situ, which has the advantages of simple operation, easy control, small sludge generation and good treatment effect, and has received widespread attention in the field of drinking water and wastewater treatment. Combined with the mechanism of electrocoagulation reaction, this paper discusses the research progress of electroflocculation technology from the aspects of removing arsenic, phosphate and fluoride ions, and analyzes its combination process, which lays a foundation for the engineering application of electrocoagulation technology in the field of water treatment.

Keywords

Electrocoagulation; Water Treatment; Reaction Mechanism; Electrode.

1. Introduction

Electroflocculation technology has the characteristics of simple structure, good pollutant removal effect, small sludge generation and easy operation, and has attracted widespread attention in the field of drinking water and wastewater treatment. This technology mostly uses aluminum, iron and other metals as anodes, and generates flocculants in situ under the action of electric field, and realizes the removal of pollutants in the form of flocculation precipitation and air flotation, and electrochemical redox is one of the effective ways to remove pollutants. The flocculation size produced by electroflocculation is much smaller than that of traditional chemical flocculation, and the dispersion degree is more uniform, which is conducive to the collision and contact between flocculation and pollutants, and its pollutant removal effect is better than that of traditional coagulation technology. Electrocoagulation technology has certain application potential in the field of water treatment. In this paper, combined with the mechanism of electrocoagulation reaction, the research progress of electrocoagulation technology to remove arsenic, phosphate and fluoride ions is reviewed, and the different processes are discussed, in order to better apply electrocoagulation technology in the field of water treatment.

2. Background of Electrocoagulation Technology

The advantages of electrochemical processes include environmental compatibility, low cost, high efficiency, sludge minimization, ease of automation, and have been used to remove other contaminants from water[1.2]. Electrocoagulation removes different contaminants through specific pathways, releasing a large number of metal ions through electrolytic oxidation of the anode. These flocculant ions eventually combine in water with the hydroxide produced by the cathode to form flocs, which then adsorb contaminants and form polymer precipitates or float to the surface with the hydrogen produced by the cathode[3].

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Fe^{2+} and Al^{3+} produced by electrocoagulation can effectively remove phosphate and sulfur ion contaminants. However, the effectiveness of electroflocculation techniques may be limited by the conductivity of the feed water [4]. In addition, electrocoagulation does not increase the dissolved oxygen concentration of anaerobic water, nor can it promote the activity of microorganisms. Therefore, improving the electroflocculation process may lead to better processing efficiency. Possible modifications include adjusting the number of electrodes or their combination and spacing to adjust the power supply [5]. Depending on the number of electrodes and their interconnection, this operation is known as unipolar electrode (MPE) or bipolar electrode (BPE) flocculation [5]. In MPE, the power supply is connected directly to an inert cathode, which is either iron or aluminum. When the anode loses electrons, it releases iron or aluminum ions to flocculate contaminants. BPE was developed to overcome the problem of poor conductivity, which tends to limit MPE. It undergoes an electrochemical reaction on an iron or aluminum plate inserted between the cathode and anode as a bipolar electrode. The side near the anode of the bipolar electrode produces hydrogen by electrolysis, while the oxidation reaction takes place on the side close to the cathode. Iron or aluminum ions are released. Note that the hydrolysis process also produces oxygen. Since the introduction of bipolar electrocoagulation in the 90s of the 20th century [6], many scholars have found it to be excellent in dealing with heavy metals, chemical oxygen demand and arsenic [7.8]. The effect of the angle and shape of the sacrificial electrode on flocculation has been studied, and it is now recommended to place the sacrificial electrode perpendicular to the drive electrode in an H-type configuration for optimal efficiency[9]. Bipolar electrodes can also play a role in electron conduction to increase the reaction rate [10].

3. Research Progress of Electroflocculation Treatment of Wastewater

3.1. Electrocoagulation Removes Arsenic

Titanium electrocoagulation was used to treat simulated arsenic-containing drinking water, and the single-factor experimental results showed that titanium electrocoagulation had a good removal effect on arsenic. For the four plate spacings selected in the experiment, the total arsenic removal rate of more than 95% can be achieved. The higher the current density, the faster the removal rate of total arsenic, but the final removal effect is almost different; The initial pH had a great influence on the rate of arsenic removal by titanium flocculation, but the total arsenic removal rate after 30 min of reaction was close. Different anions had a great influence on total arsenic removal, and the order of total arsenic removal rate was Cl−>NO3−>SO42−. Cl− concentration has little effect on total arsenic removal, but the higher Cl− concentration, the lower the energy consumption[11].

3.2. Electrocoagulation Removes Phosphorus

Phosphorus is a typical pollutant causing eutrophication of water, and electroflocculation technology has a good effect in removing phosphorus. Yang Yahong [12] took secondary biochemical effluent as the research object, when the initial concentration of phosphate was 1.307mg/L, the current density was $2.5mA/cm^2$, and the reaction time was 10min, the phosphate removal rate exceeded 98%. Chen Peng [13] compared and analyzed the influence of anode type on phosphorus removal effect, under the optimal conditions, the phosphorus removal rate exceeded 99%, the phosphorus removal process met the requirements of the first-level reaction kinetics, and the aluminum electrode was better than the iron electrode. The results of Yang Haiyan [14] showed that current density and electrolysis time had significant effects on the removal effect of pollutants, and the removal rates of chemical oxygen demand (COD) and total phosphorus (TP) were 85.46% and 99.70%, respectively, under the optimal reaction conditions. Xiao Shuying [15] confirmed by orthogonal tests that the influence of plate spacing on phosphate removal is greater than that of initial pH and current density.

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3.3. Electrocoagulation to Remove Fluoride

The results of Xu Yuequn [16] using electrocoagulation technology to remove fluoride showed that when the fluoride ion (F^-) concentration was 6mg/L, the electrolytic voltage was 18V, the flow rate was 36mL/min, the pH was not adjusted, and the reaction time was 2h, the F- concentration of the treated effluent could meet the requirements of the sanitary standard of drinking water. Chen Congcong [17] used aluminum electrode to construct an electrocoagulation device to treat high fluoride groundwater, the fluoride removal process met the requirements of the first-level reaction kinetics, when the current density is 300A/m3, the pH is 6.0~7.0, and the plate spacing is 1cm, the removal rate of F- is 89.56%, and the energy consumption is 0.1578kW·h/g. The high content of inorganic salts such as sulfate and carbonate will reduce the effect of electrocoagulation and fluorine removal, and calcium and magnesium ions will promote the fluoride removal effect. In order to improve the treatment effect and reduce the treatment cost, the appropriate pretreatment method should be selected according to the water quality characteristics [18]. Compared with the traditional flocculation and precipitation method, electrocoagulation fluorine removal has the advantages of less sludge generation and no need to add chemical agents.

4. Conclusion

Electrocoagulation technology can achieve efficient removal of pollutants while producing less sludge, which is an electrochemical technology with broad application prospects. How to effectively control the reaction conditions, achieve efficient removal of pollutants, and reduce the negative impact of Al3+ contained in effluent on the water environment is one of the contents that needs to be considered in the engineering application of electroflocculation technology. The research on the mechanism of electrocoagulation needs to be further strengthened, and the contribution of metal ion hydrates to the removal of pollutants needs to be further clarified. The mechanism of anodic passivation is not clear, and how to effectively crack the anode passivation mechanism is an important prerequisite for the engineering application of electroflocculation technology.

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