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Study on Electrochemical Treatment of Chromium-containing Wastewater

Yidan Fan[1, a, *], Xin Deng[1, b] and Qingyun Zhang[1, c]

[1]Department of Environmental Engineering, Xi'an University of Science and Technology, Shaanxi, China

[a]2050415570@qq.com, [b]1076325219@qq.com, [c]zzzhang1229@qq.com

Abstract

The electrolysis method was used to treat chromium-containing wastewater. The effects of five factors including initial pH, electrolyte dosage, plate spacing, electrolysis voltage, and initial concentration on the degradation rate of chromium were investigated. The value range of each influencing factor is as follows: initial pH value is 3 ~ 11, electrolyte dosing amount is 0.5 ~ 3g, plate spacing is 1 ~ 3cm, and electrolytic voltage is 2 ~ 12V. Under the conditions of electrolysis for 2h, the degradation rate of chromium can reach 97.41%.

Keywords

Electrolytic method; chromium-containing wastewater; influencing factors; Cr (VI).

1. INTRODUCTION

With the development of China's economy, water pollution has become increasingly serious. Traditional methods of chemical precipitation and oxidation have failed to meet people's requirements for the quality of the water environment. In this context, it is imperative to explore new technologies for efficient and clean wastewater advanced treatment. . Among them, the rapid development of electrochemical wastewater treatment technology has made people see the hope of solving serious water environmental problems, and it is favored by more and more people.

The so-called electrochemistry is the treatment of sewage by electrolysis without the addition of chemicals. The application of traditional electrochemical methods in water treatment began in 1889. The original electrochemical water treatment technology was only applied in the purification of daily water. Due to the problems of large power consumption and lack of power, it has not been used in wastewater treatment. It has been applied and popularized. Around the 1960s, the rapid development of the power industry made electric energy no longer a bottleneck restricting the development of electrochemical technology. Electrochemical technology has been widely used in wastewater treatment, separation, organic synthesis, electroplating and other industries. Application [1]; In recent years, the electrochemical method is considered to be one of the cleanest and most environmentally friendly water treatment technologies due to its simple degradation process, small equipment footprint, convenient management and maintenance, and no incomparable advantages such as secondary pollution. It has received great attention from scholars, and more and more researches have been done in the field of sewage treatment. Among them, electrochemical degradation of heavy metal pollutants and organic pollutants in water have successively appeared [2]. The feasibility of this technology has been widely confirmed, and its unique high efficiency and clean advantages have attracted people to continuously try to apply it to various sewage treatment.

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As an important chemical raw material, chromium is widely used in industries such as metallurgy, beneficiation, electroplating, printing, circuit boards, coking, corrosion inhibitors and chemical catalysts, etc. will produce chromium-containing wastewater. Drained directly into the water body, through the enrichment and transfer of the food chain, it is seriously harmful to the ecological environment and human health. Chromium in nature exists mainly as a compound of trivalent and hexavalent chromium [3, 4, 5]. Studies have found that trivalent chromium can accumulate in human lungs; hexavalent chromium has higher toxicity, carcinogenicity, and teratogenicity, and its toxicity is 100 times higher than trivalent chromium [6,7], which requires deepening Process to achieve compliance emissions. Up to now, the chromium removal technology mainly includes chemical precipitation method [7], ion exchange method [8], biosorption method [9], solvent extraction method [10], membrane separation method [11] and electrolytic method [12]. Among them, the electrolytic method has the advantages of strong adaptability, high efficiency, no secondary pollution, simple operation, and high degree of integration [13]. In this paper, the electrolytic method is used to treat chromium-containing wastewater, and the parameters of the electrolytic process are optimized. The influence of factors such as the pH value of the wastewater, the initial concentration, the electrolysis time, and the current intensity on the treatment effect is investigated, and the operating conditions are optimized to explore the best treatment. effect.

2. EXPERIMENTAL PART

2.1. Experimental Reagents

Potassium dichromate (analytical grade), concentrated sulfuric acid (analytic grade), phosphoric acid (analytic grade), hydrochloric acid (analytic grade), acetone (analytic grade), sodium hydroxide (analytic grade), sodium sulfate (analytic grade), two Phenylcarbazide (analytical grade).

2.2. Experimental Instruments

VIS-7220 UV-visible spectrophotometer, AB104-N analytical balance, DZ-2BC vacuum drying oven, KQ-300GVDV ultrasonic cleaner, DF-101S constant temperature magnetic stirrer, MS305D DC stabilized power supply.

2.3. Experimental Methods

Constant current electrolysis experiments were performed using different electrode materials as anodes, graphite sheet electrodes as cathodes, and Na2SO4 as electrolyte solutions. The effects of parameters such as initial pH value, electrolyte dosage, plate spacing, electrolytic voltage, and initial concentration were studied, the best experimental conditions were determined, and the electrosorption performance was analyzed.

Then, the removal rate of hexavalent chromium was calculated according to formula (1).

$$E=\frac{(C_i-C_t)}{C_i}\times 100\% \tag{1}$$

In the formula: Ci—the initial concentration of hexavalent chromium (mg / L);

Ct—t concentration of hexavalent chromium (mg / L);

E—Removal rate of hexavalent chromium.

(1) Use potassium dichromate to prepare chromium-containing wastewater with different concentrations for future use.

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(2) Add chromium-containing wastewater to the electrolytic reactor, adjust the current and voltage, time the electrolysis and take samples for testing.

(3) Use different electrode plate materials to treat chromium-containing wastewater, and select the best electrode plate material.

(4) Investigate the influence of five factors, including initial pH value, electrolyte dosing amount, plate spacing, electrolytic voltage, and initial concentration on the treatment effect of chromium-containing wastewater.

①Effect of pH on the effect of electrolysis

To 200mL of 100mg / L hexavalent chromium ion simulation solution, add a certain amount of electrolyte, using the best electrode material as the anode, graphite sheet as the cathode, at different pH values, room temperature, electrolysis experiments, Take a certain amount of filtrate and centrifuge at high speed. After dilution, measure the absorbance of hexavalent chromium with a UV spectrophotometer and calculate the removal rate to get the optimal pH value.

②Effect of Dosage of Electrolyte on Electrolysis Effect

A certain amount of electrolyte was added to 200 mL of a hexavalent chromium ion simulation solution with a concentration of 100 mg / L. The optimal electrode material was selected as the anode, and the graphite sheet was used as the cathode. Electrolysis was performed at different temperatures and at normal temperatures. In the experiment, a certain amount of filtrate was removed by high-speed centrifugation. After dilution, the absorbance of hexavalent chromium was measured with a UV spectrophotometer, and the removal rate was calculated to obtain the optimal electrolyte dosage.

③Effect of plate spacing on electrolysis effect

Add a certain amount of electrolyte to 200mL of 100mg / L hexavalent chromium ion simulation solution, and use the best electrode material selected as the anode, graphite sheet as the cathode, and perform electrolysis experiments at different electrode spacings at normal temperature. Take a certain amount of filtrate and centrifuge at high speed. After dilution, measure the absorbance of hexavalent chromium with a UV spectrophotometer and calculate the removal rate to get the optimal plate spacing.

④Effect of voltage on electrolytic effect

Add a certain amount of electrolyte to 200mL of 100mg / L hexavalent chromium ion simulation solution, and choose the best electrode material as the anode and graphite sheet as the cathode. At different voltages and room temperature, perform an electrolysis experiment. A certain amount of filtrate was centrifuged at high speed, and the absorbance of hexavalent chromium was measured with a UV spectrophotometer after dilution, and the removal rate was calculated to obtain the optimal voltage.

⑤Effect of initial concentration on electrolysis effect

Add a certain amount of electrolyte to 200mL of 100mg / L hexavalent chromium ion simulation solution, and choose the best electrode material as the anode and graphite sheet as the cathode. At different initial concentrations and room temperature, perform the electrolysis experiment. A certain amount of filtrate was removed by high-speed centrifugation, and the absorbance of hexavalent chromium was measured with a UV spectrophotometer after dilution, and the removal rate was calculated to obtain the optimal initial concentration.

2.4. Analysis Method

According to the "Determination of hexavalent chromium in water quality diphenylcarbazide spectrophotometric method" (GB / T7467-1987), the mass concentration of Cr (VI) in wastewater was determined.

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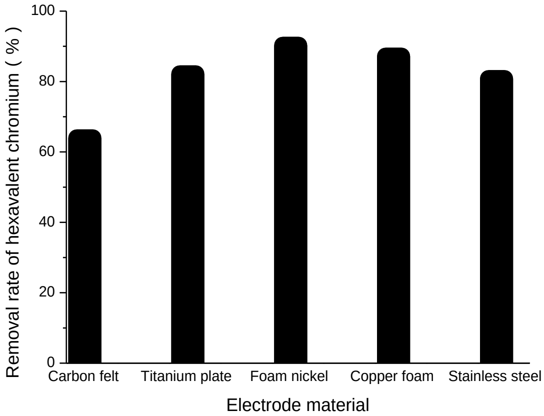
3. RESULTS AND DISCUSSION

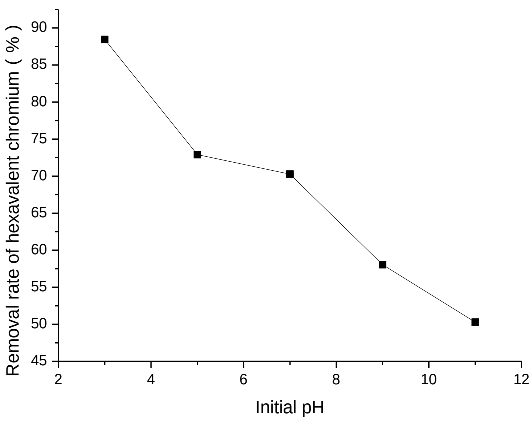
3.1. Plate Material Selection

Figure 1 shows the relationship between the anode material and the degradation rate of chromium. Carbon felt, titanium plate, foamed copper, foamed nickel, and stainless steel mesh were used as anode materials, and graphite plates were used as cathodes to electrolyze chromium-containing wastewater. It can be seen from the figure that the foamed nickel electrode is obviously better than other electrodes, so the subsequent experiments all use the foamed nickel electrode.



3.2. Influence of Initial Ph Value

Figure 2 shows the relationship between the initial pH value and the degradation rate of chromium. Under the conditions of pH = 3, pH = 5, pH = 7, pH = 9, pH = 11, and other influencing factors, the hexavalent chromium was subjected to electrolytic experiments and the graphs were drawn. It can be seen from the figure that the removal rate of hexavalent chromium decreases significantly with the increase of pH value. When the initial pH value is 3, the removal rate of hexavalent chromium can reach 88.45% at maximum. Precipitation, co-precipitation, specific adsorption removal. Therefore, the optimal pH value of electrolytic chromium-containing wastewater is 3.



3.3. Effect of Electrolyte Dosage

Figure 3 shows the relationship between the amount of electrolyte added and the degradation rate of chromium. Set the electrolyte dosing amounts to 0.5g, 1g, 1.5g, 2g, and 2.5g, respectively, and perform other electrolysis experiments on hexavalent chromium under the

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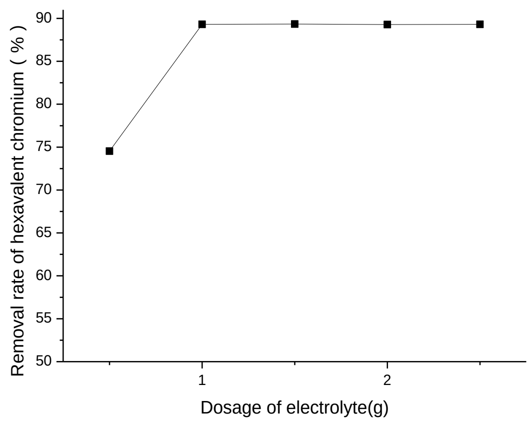
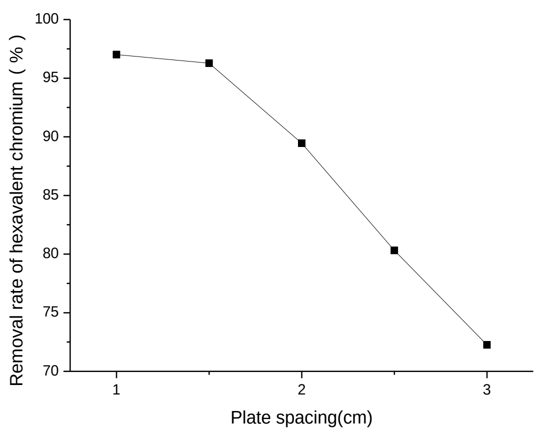
same conditions as other influencing factors, and draw a graph. It can be seen from the figure that the removal rate of hexavalent chromium increases significantly with the increase of the electrolyte dosage, and tends to be gentle when the electrolyte dosage reaches 1g. This shows that with the increase of the electrolyte, the conductive ions in the solution are also increasing, which promotes the electrode electrolysis. Therefore, the optimal electrolyte dosage for electrolytic chromium-containing wastewater is 1g.



3.4. Influence of Plate Spacing

Figure 4 shows the relationship between the plate spacing and the degradation rate of chromium. The electrode plate spacing was set to 1cm, 1.5cm, 2cm, 2.5cm, 3cm, and other conditions were unchanged. Electrolytic experiments were performed on hexavalent chromium, and the graph was drawn. It can be seen from the figure that under different conditions of electrode spacing, as time increases, the removal rate of hexavalent chromium after electrolysis decreases significantly with the increase of electrode plate spacing. However, the distance between the plates is too close, which is prone to short circuit and affect the degradation effect. The electrode spacing is one of the important parameters to be considered in the design of electrochemical reactors. The electrode spacing in the project is generally 0.5 to 5 cm, and a good treatment effect is generally obtained near the intermediate value. It should not be too small. From the perspective of treating heavy metal simulated wastewater, the pole spacing can be selected to be 1.5 cm.



3.5. Effect of Electrolytic Voltage

Figure 5 shows the relationship between the electrolytic voltage and the degradation rate of chromium. Figure 4 shows the relationship between the plate spacing and the degradation rate

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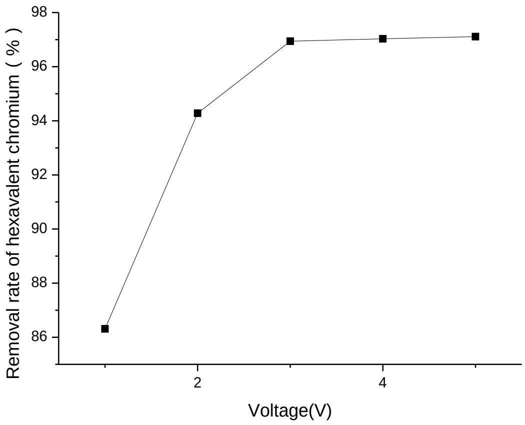
of chromium. Set the electrolysis voltage to 1V, 2V, 3V, 4V, 5V, and other conditions, and perform the electrolysis experiment on hexavalent chromium, and draw a graph. It can be seen from the figure that when the applied voltage rises from 1V to 5V, the electrolytic effect is also continuously enhanced. When the voltage is 5V, the removal rate of hexavalent chromium also reaches the maximum, the removal rate is 96.22%, but in actual operation, when the voltage is too large, it will cause the electrode to break up and collapse during the reaction. When it is increased, a huge volume expansion will occur inside the electrode material. The expanded electrode will apply a huge compressive load to the adjacent incompletely reacted area, destroying the crystal structure inside the material, causing it to undergo amorphous transformation, resulting in The electrode breaking effect is not conducive to the progress of the reaction. At the same time, it can be clearly seen that when the applied voltage is 3V, the removal rate of hexavalent chromium is 96.11%, and the difference from the maximum value of 99.22% is not large. Therefore, in order to maintain the stability of the electrode pad, 3V is used as the experimental optimal voltage value.



3.6. Effect of Initial Concentration

Figure 6 shows the relationship between the initial concentration and the degradation rate of chromium. Figure 4 shows the relationship between the plate spacing and the degradation rate of chromium. Set the initial concentrations of hexavalent chromium to 50mg / l, 100mg / l, 150mg / l, 200mg / l, 250mg / l, and other conditions, the electrolytic experiment of hexavalent chromium was performed, and a graph was drawn. It can be seen from the figure that when the initial concentration is 50 mg / l and 100 mg / l, the removal rate of hexavalent chromium is the same. After the initial concentration is greater than 100 mg / l, the removal rate of hexavalent chromium gradually decreases. The removal rate was only 48.67% when the initial concentration was 250 mg / l. The concentration of hexavalent chromium is 50mg / l, and the removal rate is the highest at 100mg / l, which can reach 96.34%. After treatment, it can reach the sewage discharge standard. Therefore, electrochemical technology is suitable to treat chromium ion wastewater with a concentration of less than 100mg / l.

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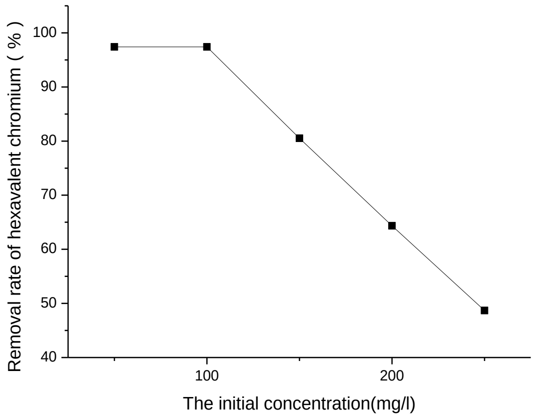

4. CONCLUSIONS

(1) The anode material has a great influence on the removal rate of hexavalent chromium. When the electrode material is selected from nickel foam, copper foam, carbon felt, titanium plate and stainless steel mesh, the removal effect of foam nickel is the best.

(2) When the chromium-containing wastewater is treated by electrolytic method, the initial pH value has a greater impact on the treatment effect. The removal rate of hexavalent chromium decreases with the increase of pH value. When the solution is acidic, the degradation rate of chromium is the highest and the treatment effect is the best.

(3) With the increase of the electrolyte, the conductive ions in the solution are also increasing, which promotes the occurrence of the electrolytic effect of the electrode.

(4) The smaller the distance between the plates, the smaller the resistance, the larger the current in the solution, and the better the treatment effect of chromium in a certain range.

(5) In a certain range, the larger the electrolytic voltage, the higher the removal rate of hexavalent chromium, but when the voltage is too large, the electrode will be broken and disintegrated during the reaction.

(6) The initial concentration has a great influence on the removal rate of hexavalent chromium. The larger the initial concentration, the lower the removal rate of hexavalent chromium.

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