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EFFECT OF ETLENE GLYCOL IN ELECTROCHEMICAL PURIFICATION OF CHROMATE IONS IN INDUSTRIAL WATER

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Abstract
At many industrial enterprises, process water comes into contact with various substances during technological processes, as a result of which they become contaminated with various additives, and sometimes with heavy metal ions. Basically, they are cleaned by the reagent method, but a large amount of non-utilizable sludge is formed.
The purpose of this work is to study the effect of polyatomic alcohols on the efficiency of the process of electrochemical treatment of industrial wastewater contaminated with chromate ions.
Wastewater containing chromate ions formed in the electroplating plant, as well as model solutions containing chromates, were used as the object of study. The current efficiency of chromium during electrolysis during wastewater purification does not exceed 19 %, when the process is carried out in the presence of 0.21 % ethylene glycol, it rises to 24.6 %.

Keywords: industrial wastewater, heavy metals, chromate ions, electro coagulation, reduction, electrical density, electrical efficiency.

Introduction

Industrial wastewater contaminated with various organic and inorganic additives is formed as a result of enrichment of raw materials, processing of recycling and detail processing. In industrial plants, technical and process waters come into contact with products and equipment during technological processes, which leads to various levels of pollution with organic, inorganic additives and some heavy metal ions.

Such effluents, especially effluents contaminated with heavy metals, especially effluents containing chromate ions, are very harmful and improvements in their purification methods are still relevant. In such industries, mainly reagent methods are used to purify wastewater from heavy metal ions, especially chromates. This method is based on the formation of precipitated heavy metal hydroxides, which are recycled into relatively harmless, stable compounds and filtered to separate them. Reagent treatment of purification gives good results, but it produces a large amount of complex sludge that cannot be processed. One of the most effective methods for industrial wastewater treatment from heavy metal ions is the electrochemical method, which is effectively used in developed countries [1–6]. Electrochemical wastewater treatment is carried out by electrodialysis, electro flotation, electro coagulation, and galvano coagulation.

Each of these methods has its advantages and disadvantages, and the electro coagulation method is relatively effective with properly selected electrochemical parameters of coagulation of additives in wastewater under the action of hydroxides with highly active sorption properties. It consists of the following sequential processes: electrophoretic concentration, i.e., the transfer of charged charges to the corresponding electrode, melting of the anode, formation of metal hydroxides, and coagulation of additives in wastewater under the action of highly active, sorption hydroxides.

Electro coagulation is the main available method and is widely used in industrial wastewater treatment. The hydroxides formed in the process are quite active and have sorption properties, effectively precipitate highly dispersed additives in wastewater, and the resulting precipitate is separated by filtration or filtration [7].

In this method, the efficiency of the electrochemical coagulation process in the purification of industrial effluents is significantly affected by the type of electrode material, the current density at the anode, the composition of the purified effluents, and the flow rate. The magnitude of the current supplied to the process of melting the anode metal and the efficiency of the process depend on the distance between the electrodes; it is expedient to find the optimal values of these parameters in the course of experiments [8].

Generally, in wastewater purification, the current density is 1.5-2.5A/dm2, the distance between the electrodes is 10-12mm, and the flow velocity is about 0.4m/s. The theoretically calculated power consumption at voltages up to 12 V is 2.9 W • hour per 1 g of iron and 12.0 W • hour per 1 g of aluminum. At the same time, when dissolving 1 g of iron, 3.58 g of $FeSO_4$ is released into water, and when dissolving 1 g of aluminum, 6.33 g of $Al_2(SO_4)_3$ is released [9].

The main working element of the cell is the electrode chamber, which consists of several iron or aluminum electrodes connected in series, interchangeable. Depending on the degree of water pollution, waste water is passed between electrodes connected in series with the positive and negative poles of alternating electricity, at a speed of 0.3-0.5 m/s, depending on the total surface area of the electrodes. The electrical current is selected. The electrodes can be mounted horizontally or vertically, depending on the design of the equipment.

In the purification of industrial and domestic wastewater by electrochemical methods, the designs of wooden equipment, the modes of optimal parameters and optimal values have been restored to a greater extent, and patents have been obtained [10-17] Scientific research on electro coagulation of wastewater has been carried out in recent years, especially in Japan, the USA, France, Poland and other countries [18-20].

The experiments of the authors and the results of [21-23] for the first time showed the extraction (reduction) of hexavalent chromium ions in electrolyzers consisting of iron electrodes and the precipitation of iron hydroxides formed in the process.

The disadvantages of using electrochemical method wastewater purification in industry. In addition, electrochemical methods for industrial wastewater purification have a number of disadvantages, such as significant energy and metal consumption, anode passivity in the process, and the advantage of the method is compactness, ease of operation, and the chemical reagents that form additional sludge are not used.

The aim of this study is to improve the process of electrochemical purification of industrial wastewater contaminated with some chromates in the presence of ethylene glycol and to optimize the electrochemical parameters.

For the experiments, samples were taken from wastewater containing chromium (VI) ions formed in the galvanic shop of METFURSERVIS LLC and analyzed by photo colorimetric method. The concentration of chromium (VI) ions in the effluent in the sample averaged 12 mg / l, and experiments were performed to purify the effluent from these ions by electro coagulation. The volume of the laboratory device for electro coagulation was 1.5 l, the surface of the iron anode and cathode electrodes was 3.0 dm^2, the process was carried out at a constant current of 10 V, with a current density of 2 A / dm^2.

Experiments were carried out to study the effect of acidity condition on wastewater purification from chromate ions by electrochemical methods. When a current is applied to the electrolyzer, the iron electrode melts and oxidizes and goes into solution in the form of Fe^{2+} ions, which return chromium (VI) ions to chromium (III). The resulting iron (III) hydroxide ions have the properties of a sorbent and are

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precipitated due to the sorption of metal ions in solution. In this case, the efficiency of the process depends on the solution condition, and to study this dependency, we carried out the treatment of wastewater from the galvanic shop of METFURSERVICE LLC, containing 12 mg/l of Cr6+ ions at various pH values. On fig. 1 shows the dependence of the process efficiency on the pH of wastewater treatment from chromate ions.

It is known from the literature that the complex formation of chromate ions with polyatomic alcohols is accelerated, and the process of reduction of Cr6+ ions proceeds more efficiently in its complex compounds.

In subsequent experiments, dependency of the reduction of Cr^{6+} ions on time in the treatment of wastewater containing chromate ions by electrochemical method was studied.

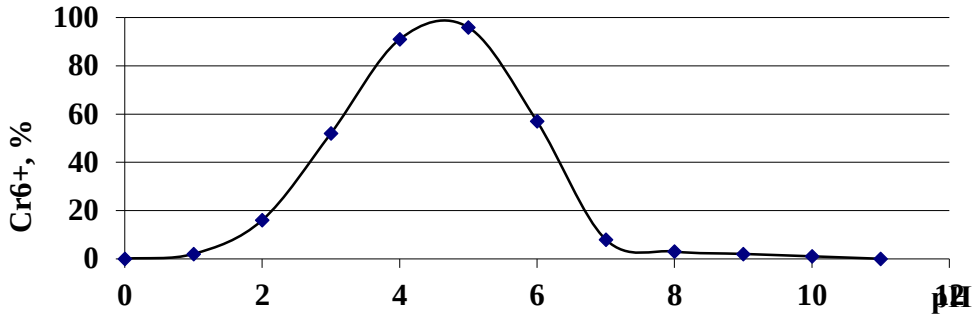

Figure 1. Reduction of Cr^{6+} ions during the process dependence of the level on the ambient pH

Figure 2 shows the time dependence of the process efficiency in the purification of wastewater from chromium (VI) ions, in which the increase in Cr^{3+} ions with the return of Cr^{6+} ions is studied over time. As can be seen from Figure 1, the reduction process of Cr^{6+} ions is most efficient in the medium pH = 4-5 range.

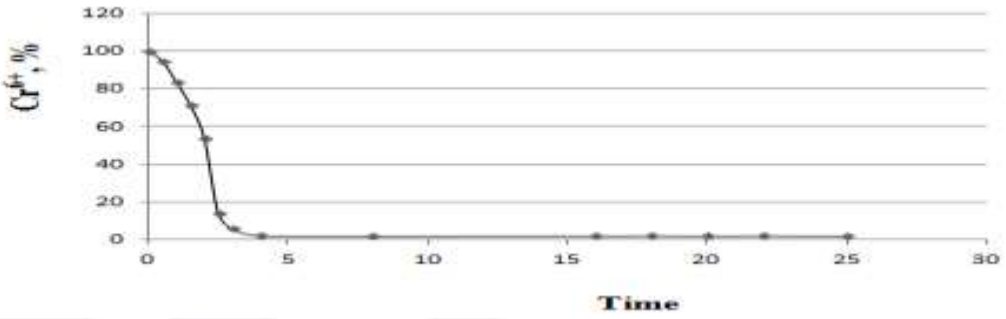

Figure 2. Decrease in time of Cr^{6+} ions in electrochemical wastewater treatment.

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Experimental results show that in electrochemical treatment of wastewater in 1.5 minutes almost half of the Cr^{6+} ions are returned to Cr^{3+}, in 2-3 minutes the process reaches its maximum value, the extension of time has almost no effect on the process. It is known that polyatomic alcohols, such as ethylene glycol, sorbitol, xylitol, have a positive effect on the reduction of hexavalent chromium ions. In our previous experiments, we chose ethylene glycol, which gave good results in polyatomic alcohols. In our subsequent experiments, we studied the process of electrolysis without ethylene glycol and the rate of reduction and current efficiency of chromium (VI) ions at different concentrations of ethylene glycol in the optimal environment defined above, the results obtained are given in Tables 1 and 2.

Table 1 Current efficiency in the reduction of chromate ions change over time

V = 1500 ml, C_{Cr} = 12m/l, H_2SO_4 =0,5 g, i = 2 A/dm²

№ s/n	Time (sec)	Current efficiency, %
1	0	0
2	5.0	2.5
3	10.0	5.3
4	15.0	8.5
5	20.0	9.7
6	25.0	12.1
7	30.0	14.9
8	40.0	15.8
9	50.0	15.7
10	60.0	16.5
11	70.0	17.2
12	80.0	18.0
13	90.0	19.6
14	100.0	20.2
15	110.0	20.1
16	120.0	20.1

Table 2 Variation of current efficiency in the return of chromate ions by the adding amount of ethylene glycol

V = 1,500 ml, S_{Cr} = 12m/l, H_2SO_4 =0,5 g, i =2 A/dm², τ = 1.5 min

№ s/n	Ethylene glycol,%	Current efficiency, %
1	0	0
2	0.01	2.7
3	0.02	6.3
4	0.04	7.5
5	0.06	9.7
6	0.08	13.2
7	0.10	15.8
8	0.12	16.7
9	0.14	17.6
10	0.16	18.4
11	0.18	20.2
12	0.19	22.0
13	**0.21**	**24.6**
14	0.23	21.3
15	0.27	20.4
16	0.30	20.1

According to the results obtained, the current efficiency in the process of electrolysis of wastewater containing chromate ions under normal conditions was 18.1%, while according to the results of experiments with ethylene glycol, the value of this process slightly increased The electrolysis process increased from 0.21% in the presence of ethylene glycol to 24.6%.

Conclusion

The reduction process of Cr^{6+} ions depends on the pH of the medium and gave an effective result when pH = 4.5. In this environment, the complex formation of chromate ions is accelerated, and the reduction of Cr^{6+} ions is more efficient in its complex compounds.

In the case of electrochemical wastewater treatment, the fact that the current flow of electricity for 1.0-1.5 minutes is sufficient for wastewater purification, and the increase in time has almost no effect on the process.

Electrolysis of wastewater from chromate ions in the presence of ethylene glycol, a polyhydric alcohol, increased the efficiency of the process, while in the presence of 0.21% ethylene glycol, the current efficiency increased to 24.6%.

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