Procedia on Economic Scientific Research
Procedia on Digital Economics and Financial Research
ISSN: 2795-5648 Available: https://procedia.online/index.php/economic

The Process of Sorption of Chromium (III) Ions Contained in Industrial Wastewater Onto Modified Bentonite Clays

E. Egamberdiev, S. Abdurazakova, U. Alamov, N. Bakhramova
Tashkent State Technical University named after Islam Karimov

Abstract: In this study, the chemical-mineralogical composition, physico-chemical properties of bentonite clay of Shafirkon mine were studied. Methods of modification of bentonite clay of Shafirkon mine were developed. The sorption isotherm of the sorption of chromium (III) ions contained in industrial wastewater to modified bentonite clays was determined based on physical and chemical laws. The thermodynamics of the regeneration process of adsorbents of modified Shofirkon mine bentonite clay was scientifically substantiated. Based on the obtained experimental data, the modified Shofirkon mine bentonite clay was used to solve environmental problems, i.e., the scientific basis for the rational use of limited water resources was created by cleaning the waste water of enterprises.

Introduction. Today, the rapid development of industry in the world causes an increase in the demand for sorbents with high sorption properties for wastewater treatment, water treatment and demineralization in enterprises. In particular, the use of sorbents based on cheap and convenient raw materials for the purification of wastewater from heavy metal ions in industrial enterprises is largely supported by modern advances in science and technology. Earth's water resources play a very important role at the current stage of development of society and production as the main natural energy carrier, raw material, cleaning agent, etc. It is important to introduce modern water supply systems that save water to production and technological processes, to create new high-efficiency tools and to improve existing technologies of industrial wastewater treatment, to introduce significant new approaches to solving current technical problems.

Today, in the world, there is a need to study the processes of cleaning industrial wastewater generated during the technological processes of raw materials processing and product production, to develop optimal technological developments based on the results of comprehensive research on the search for new available sorbents and natural resources. Special attention is paid to scientific research on effective treatment of wastewater from pollutants and related components and elimination of existing problems in the field.

Experiment and its analysis. In the study, three series of experiments were conducted in order to study the sorption process of Cr (III) in bentonite clay and the order of exchange of reagents in all experiments with other conditions being constant.

1) to study co-precipitation, a potassium hydroxide solution is added to the supporting electrolyte containing initial chromium (weak acidic solution) with a carrier precipitate to the desired pH value (co-precipitation);

2) to study the sorption on the surface, background electrolyte and Cr^{3+} with bentonite sediment are added to the solution a g ;

3) precipitation of $Cr(OH)_3$ is carried out under the same conditions, except without bentonite carrier.

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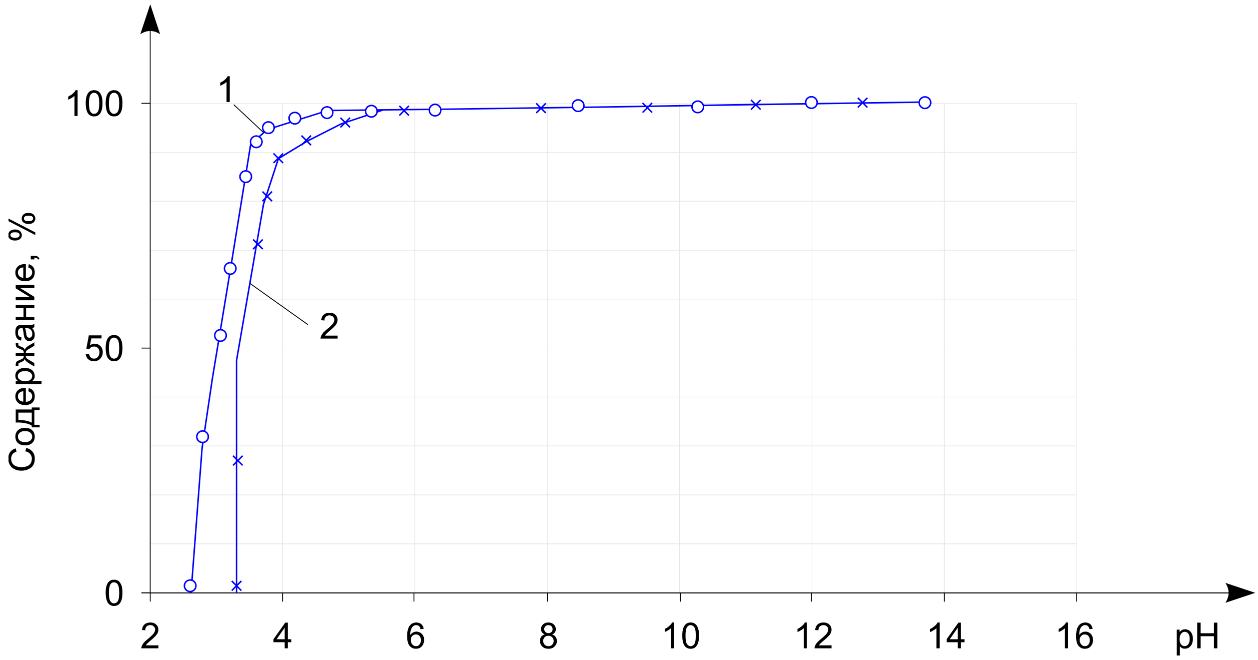
Carrying out the experiments in the above sequence helps to study the co-deposition and co-precipitation processes of the carrier surface in the complex.

During the experiments, the number of bentonite carriers corresponded to 1g/25 mg, and the volume of the solution was 50 ml. The sediment is separated using a centrifuge with an acceleration of 4500 - 5000. In this case, KNO_3 and NH_4KCO_3 solutions were used as electrolytes, and the temperature was t = 20 - 25 ℃. The contact time between solution and precipitation is 30 minutes. Co-precipitation of chromium (III) in bentonite in 1 mol of hydrochloric acid begins at rN = 4.5-12, which corresponds to the beginning of the hydrolysis of chromium (III) (Fig. 1).

Figure 1 shows the graph of sorption and mass deposition reaction of $4{,}5\bullet10^{-5}$ chromium (III) mol/l in bentonite clays in the presence of 1 mol of KNO_3.



Picture 1. The graph of the co-precipitation process is 4,5 10 $^{-5}$ mol/l chromium (III) in a 1 molar solution of potassium chloride in bentonite, 1 — drowning; 2 - sorption

The results of the experiment help clarify the course of the following sequential physico-chemical processes. At pH>3, the hydrolysis of chromium (III) begins mainly with the formation of three types of ions $CrOH^{2+}$ and $Cr(OH)_2^+$,, $Cr(OH)_3$ with increasing pH of this environment, the hydrolytic chromium shows the formation of forms.

Sorption of ions allows to compare the state of Cr^{4+} anionic forms with its sorption nature. During laboratory experiments, depending on the concentration of chromium anions and the acidity of the solution, it was also possible to accept the resulting variant. CrO_2^+, CrO_4^{2-}, $HCrO_4^-$Ba$Cr_2O_7^{2-}$ is possible due to the existence of a reciprocal equilibrium.

$$2CrO_4^{2-} \xleftrightarrow{2H^+} 2HCrO_4^- \leftrightarrow 4Cr_2O_7^{2-} + 2H_2O$$

Thus, the sorption processes of Cr^{4+}ions state were studied depending on the concentration of Cr, the effect of the chemical composition, structure and porosity of the natural adsorbent material (bentonite clay), as well as the conditions existing in a wide range of pH. 5.5 to 9.0. An attempt was made to determine the shape of anions from their ultraviolet spectra. Cr^{4-} It was determined that monochromate is characterized by two absorption maxima (260 and 365 nm), and bichromate is

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characterized by only one maximum (298 nm). The absorption spectra of the studied samples were studied in a UVVIS spectrophotometer with an absorption layer thickness of L=10 mm.

The concentration of Cr^{4+} changed in the range of $4.5 \times 10^{-5} \div 2.5 \times 10^{-4}$ mol / l; of the original chromate solution at pH =7.8.

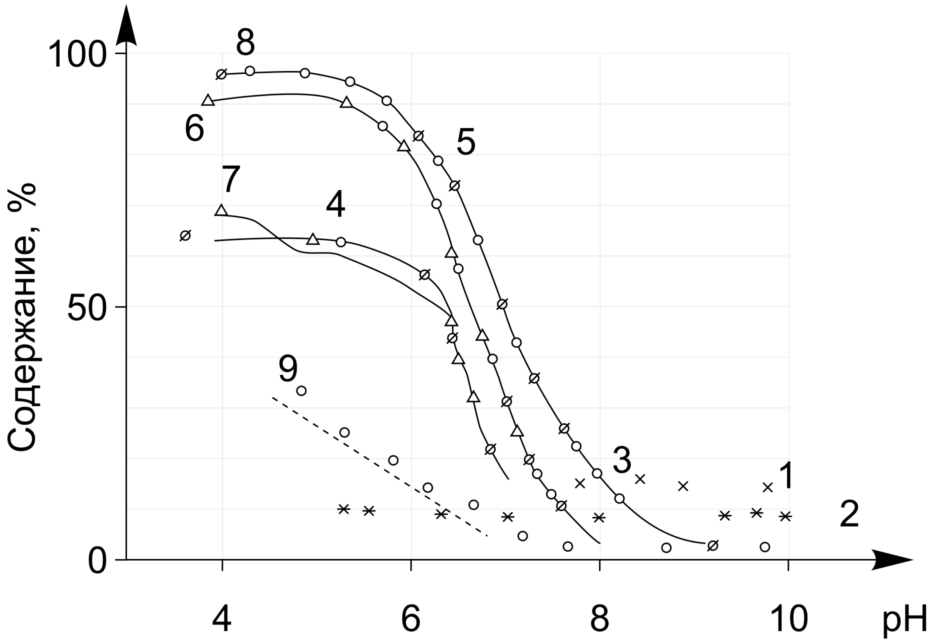

Figure 2. Graph of the dependence of Cr^{4+} sorption on bentonite on its concentration and composition under saline conditions at pH = 7.5÷8.

in which: 1,2 – pH=8 IM KNO_3, $C_{Cr} = 4.5\times10^{-5}$ M; 3,4 – pH=9 – 3,5 1M KNO_3; 5,6,7 - 1M $NaNO_3$, $C_{Cr} = 4.5\times10^{-5}$ M; 8,9 - 1M NH_4NO_3.

As can be seen from Figure 2, at the concentration of CrO_4^{2-} in bentonite CrO_4^{2-} in potassium nitrate $4,5 \times 10^{-5} \div 2,5 \times 10^{-4}$ mol / l, the sorption of the ion is almost no. The absorption spectrum of the initial solution was found to be identical to the ion spectrum and to be consistent with data obtained from previous studies by other researchers. CrO_4^{2-} For example, when this solution stood for 10 days, the pH did not change, which was confirmed by the data of other researchers.

At a concentration of 10^{-5}mol/l KNO_3. The sorption process of chromium is observed in the range rN = 8÷4, where in the range pH = 4÷6.5 the reaction of complete extraction of chromium from the solution takes place. It should be noted that the change in the composition of background electrolytes does not affect the amount of sorption of chromium, but sorption occurs less in potassium and sodium chloride solutions than in nitrates; it should be noted that the equilibrium between the ions. CrO_4^{2-}, $HCrO_{4,}^{-}$ Ba$Cr_2O_7^{2-}$ primarily depends on the pH of the environment, so sodium, potassium, ammonium cations and chlorine effect of anions. does not affect the shift of the reaction equilibrium and the performance of the sorption process.

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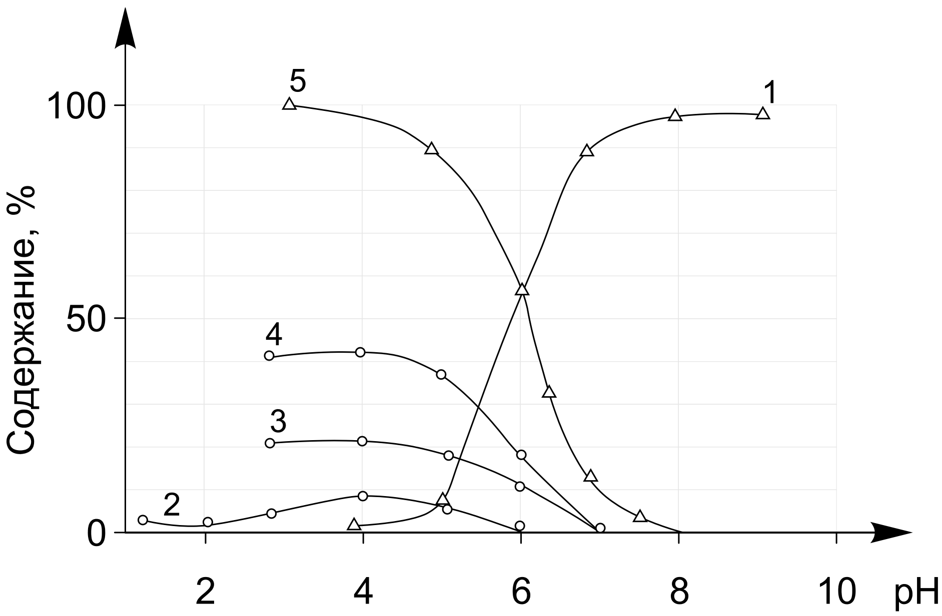

Figure 3. Distribution of anionic forms of (Cr (VI)) depending on pH

1- CrO_4^{2-} ;2 -$Cr_2O_7^{2-}$; 3- CrO_4^{2-}= 4,5×10^{-5}; 4 - 2,5×10^{-4} *mol/ l*, 5 - $HCrO_4^-$;
$C_{Cк}$ = 4,5×10^{-5}; 2,5×10^{-4} *m*.

Conclusion. Comparison of the data obtained from the study of the sorption process with the state of ions Cr^{4+} dissociation and formation using the balance equation $Cr_2O_7^{2-}$ constants H_2CrO_4 calculated from pH and distribution of anions depending on concentration Cr (3.3 - picture). As can be seen from Figure 3.3, as the chromium concentration increases from 4,5 • 10 $^{-5}$ mol/l to 2,5 • 10 $^{-4}$ mol/l, the ratio $Cr_2O_7^{2-}$ increases, and the ratio H_2CrO_4 will decrease. As a result of a comparative study of the calculation results based on the measurement results of the state in the solution and the sorption process, the $Cr_2O_7^{2-}$ sorption decreases with the increase in the proportion of Cr^{4+}, which is confirmed by research data.

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