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Research of Kinetic Sorption of Pb^{2+} Ions in $Pb(NO_3)_2$ Solution by Composite Polymeric Sorbents Under Various Conditions

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ABSTRACT. The article presents the kinetics of sorption of lead ions in a solution of lead nitrate with composite polymer sorbents. A composite polymer sorbent is obtained from electrolyte polymers, which polymers consist of polyaniline and polyacrylic acid, as well as polyaniline and polycaproamide.

The content of lead ions in a solution of lead nitrate is 45 mg·ekv/l. Sorption kinetics was carried out in a temperature range from 20 to 50°C. In addition, the kinetics of sorption of composite polymer sorbents using bentonite and kaolin fillers was studied.

KEYWORDS. Polyaniline, polyacrylic acid, polycaproamide, polymer, composition, sorbent, lead, kinetics, solution, modification, kaolin, bentonite, filler.

I.INTRODUCTION

Currently, research is under way in the countries of the world to develop non-deficit, relatively cheap composite polymer sorbents with high sorption capacity and physical and mechanical properties and, accordingly, durability, which is an important task. At the same time it is necessary to create composite polymer sorbents (CPS) of new generation on the basis of local raw materials and wastes of production, intended for extraction of non-ferrous and heavy metals and treatment of industrial waste water in production of metallurgical and chemical industries[1-2].

The composite polymer sorbent we created was based on the use of local raw materials and industrial wastes, which are based on the purification of ions of non-ferrous and precious metals in waste waters formed in the chemical and metallurgical industry[3-4].

Composite polymer sorbent based on polyaniline and polyacrylic acid (PANI-PAC) and polyaniline and polycaproamide (PANI-PCA).

II. SIGNIFICANCE OF THE SYSTEM

The article presents the kinetics of sorption of lead ions in a solution of lead nitrate with composite polymer sorbents. The study of literature survey is presented in section III, methodology is explained in section IV, section V covers the experimental results of the study, and section VI discusses the future study and conclusion.

III. METHODOLOGY

Lead ion sorption kinetics from composite polymer sorbents were studied by static method. For this purpose, the concentration of lead in the solutions was measured in the bulk of the composite polymer sorbent previously swollen in the solution $Pb(NO_3)_2$ at certain intervals. Concentration of lead was determined by a photo colorimetric method at λ=440 nanometers. In figure-1kinetic curves of lead ions in solution $Pb(NO_3)_2$ with sorbents are presented[5-8].

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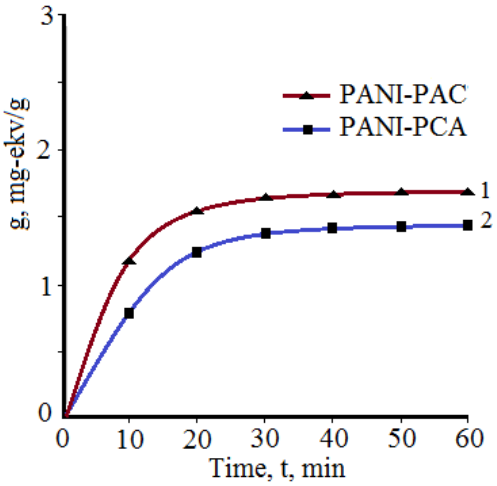


Static exchange capacity of sorbents for NaOH = 2,0mg·ekv/g; PANI-PAC (1); PANI-PCA (2).
Fig. 1. Kinetics of sorption of Pb^{2+} in a solution of $Pb(NO_3)_2$ =45 mg-ekv/l complexes at 30 °C

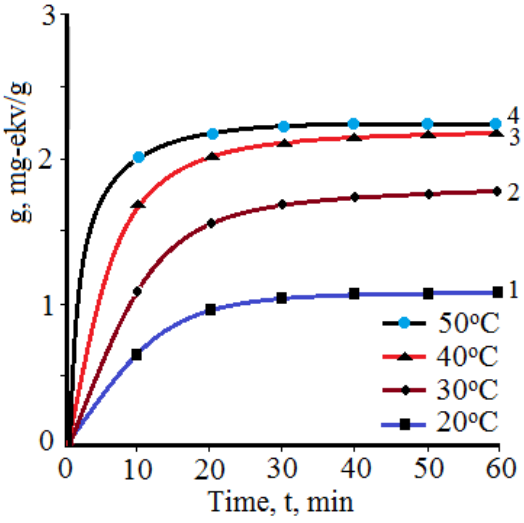
Figure-1 shows that in the initial stages this process proceeds very quickly, then it slows down and the effect of blocking is observed. The sorption rate depends on the structure of functional groups in the polymer.

The nature of the functional group of the used sorbents has a great influence on their complexing ability with lead ions. It can be seen that the modified Polyaniline and polyacrylic acid (PANI-PAC) adsorbs lead at a higher rate than the sorbents polyaniline and polycaproamide (PANI-PCA)[9].

The sorption rate of composite polymer sorbents is high in the first 30 minutes, i.e. PANI-PAC sorption kinetics is 1,2 mg-ekv/gin 10 minutes, in PANI-PCA 0,75 mg-ekv/g in 20 minutes PANI-PAC 1,55 mg-ekv/g, 1,25 mg-ekv/gin PANI-PCA, PANI-PAC 1,65 mg-ekv/g for 30 minutes, 1,45 mg-ekv/g in PANI-PCA, after 40 minutes PANI-PAC 1,75 mg-ekv/g, PANI-PCA 1,5 mg-ekv/g, PANI-PAC 1,78 mg-ekv/g in 50 minutes, PANI-PCA 1,58 mg-ekv/g PANI-PAC after 60 minutes was 1,78 mg-ekv/g, while PANI-PCA was 1,58 mg-ekv/g.

IV. EXPERIMENTAL RESULTS

The results of the research, that the sorption of lead ions with sorbents depends not only on the contact time, but also on temperature. Figures 2-3 show the effect of temperature on the complexation process of lead with modified PANI-PAC and PANI-PCA.



Static exchange capacity of sorbents in NaOH = 2,0 mg-ekv/g;
Fig.2. Sorption kinetics of lead ions in a solution of $Pb(NO_3)_2$ = 45 mg-ekv/l of the PANI-PAC complex at temperatures of 20°C (1), 30°C (2), 40°C (3) and 50°C (4)

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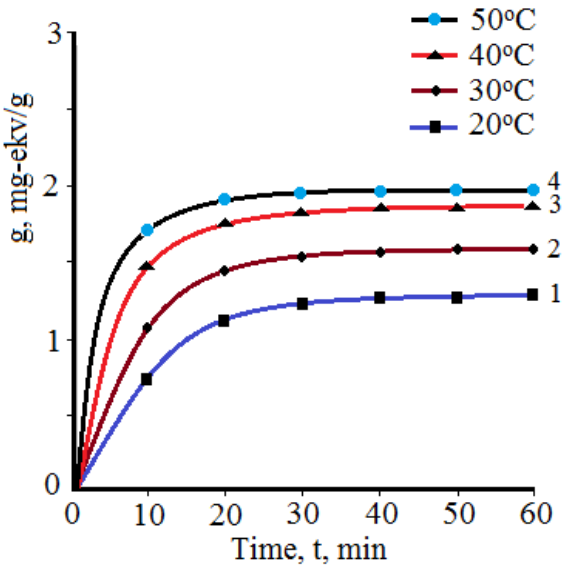
Figure 2 shows that, with increasing temperature, the composite polymer sorbent based on PANI-PAC increases the kinetics of sorption of lead ions. This process can be explained by chemical sorption.



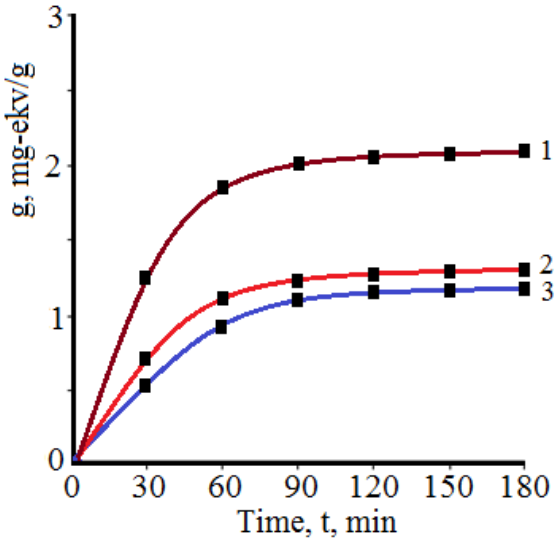
Static exchange capacity of sorbents in NaOH=2,0 mg-ekv/g;

Fig.3. Sorption kinetics of lead ions in a solution of $Pb(NO_3)_2$ = 45 mg-ekv/l of the PANI-PCA complex at temperatures of 20°C (1), 30°C (2), 40°C (3) and 50°C (4)

As can be seen from Figures 2-3, the best results were obtained at 50°C. After 50°C, the kinetics of sorption does not change.

We can also see in Figure 2-3 that the CPS sorption kinetics change rapidly during the first 20 minutes and the sorption kinetics changes slowly over the next minutes.

Next, we investigated the kinetic sorption of a composite polymer sorbent with fillers.



without filler (1); with kaolin (2) with bentonite (3).

Static exchange capacity of sorbents in NaOH = 2,0 mg-ekv/g;

Fig. 4. Sorption kinetics of lead ions in a solution$Pb(NO_3)_2$ = 45 mg-ekv/l of the PANI-PAC complex at a temperature of 30°C

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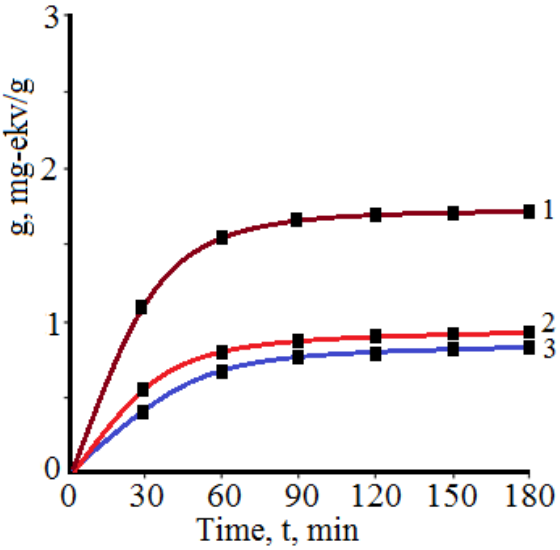
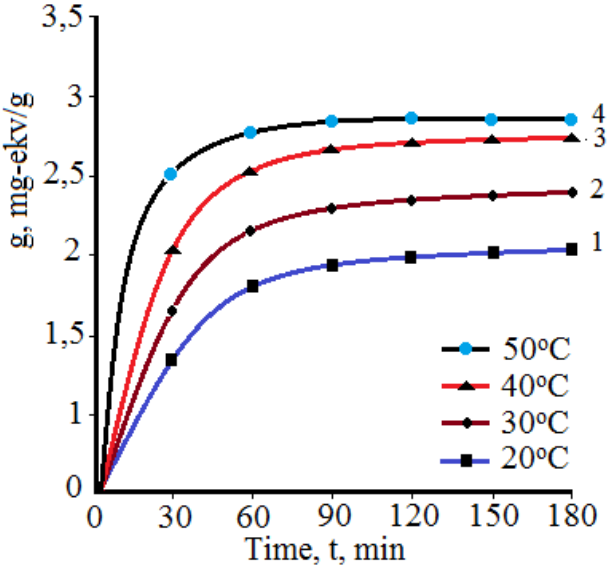


without filler (1); with kaolin (2) with bentonite (3).
Static exchange capacity of sorbents in NaOH = 2,0 mg-ekv/g;
Fig.5. Sorption kinetics of lead ions in a solution $Pb(NO_3)_2$ = 45 mg·ekv/l of the PANI-PCA complex at a temperature of 30 °C

From the results of the study in Figures 4-5, it can be seen that a composite polymer sorbent with bentonite filler sorb better ions of lead in a solution of lead nitrate than sorbents without filler and kaolin filler.

Next, we studied the kinetics of sorption of composite polymer sorbents from a kaolin filler in the temperature range from 20 to 50 °C.



Static exchange capacity of sorbents in NaOH = 2,0 mg-ekv/g;
Fig.6. Sorption kinetics of lead ions in a solution of $Pb(NO_3)_2$ = 45 mg-ekv/l of the PANI-PAC complex with kaolin at temperatures of 20°C (1), 30°C (2), 40°C (3) and 50°C (4)

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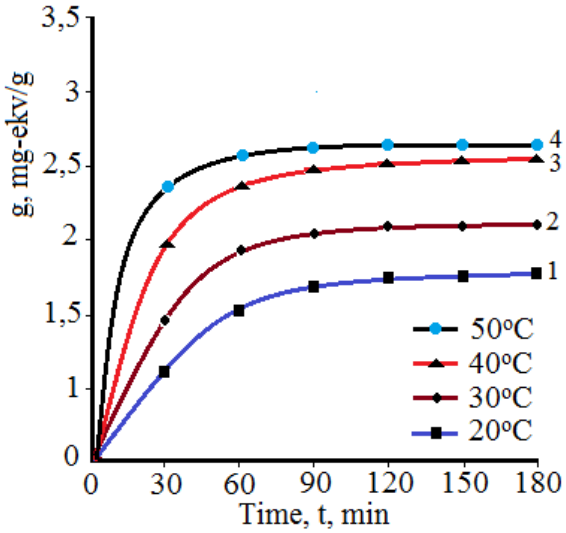
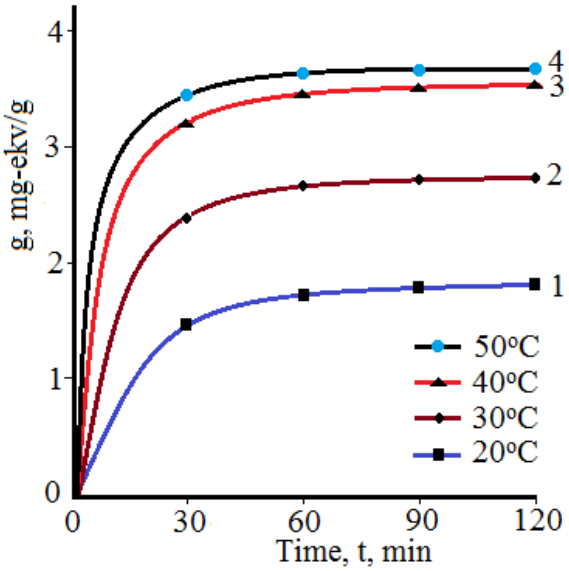


Static exchange capacity of sorbents in NaOH = 2,0 mg-ekv/g;

Fig.7. Sorption kinetics of lead ions in a solution of $Pb(NO_3)_2$ = 45 mg-ekv/l of the PANI-PCA complex with kaolin at temperatures of 20°C (1), 30°C (2), 40°C (3) and 50°C (4)

Figures 6-7 show that the rate of sorption of the composite polymer sorbent increases with hanging temperature.

Next, we studied the kinetics of sorption of composite polymer sorbents from a bentonite filler in the temperature range from 20 to 50°C.



Static exchange capacity of sorbents in NaOH=2,0 mg-ekv/g;

Fig.8. Sorption kinetics of lead ions in a solution of $Pb(NO_3)_2$=45 mg-ekv/l of the PANI-PAC complex with bentonite at temperatures of 20°C (1), 30°C (2), 40°C (3) and 50°C (4)

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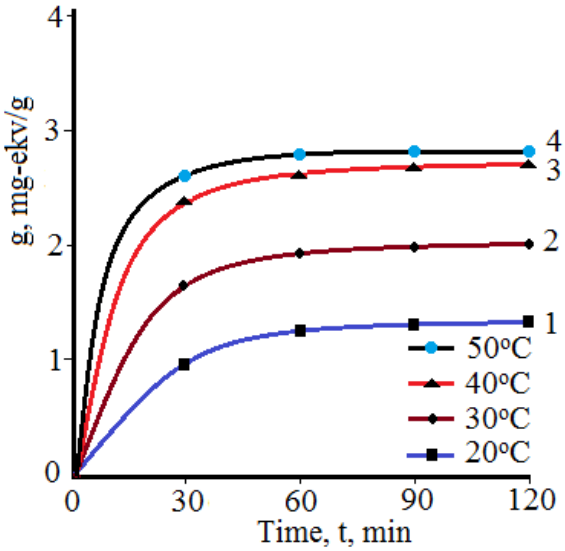

Static exchange capacity of sorbents in NaOH=2,0 mg-ekv/g;

Fig.9. Sorption kinetics of lead ions in a solution of $Pb(NO_3)_2$ = 45 mg-ekv/l of the PANI-PCA complex with bentonite at temperatures of 20°C (1), 30°C (2), 40°C (3) and 50°C (4)

As can be seen from Figures 8–9, with increasing temperature, the efficiency of sorption of lead ions in a solution of lead nitrate of a composite polymer sorbent with bentonite fillers increases compared to a filler and a kaolin filler of a composite polymer sorbent.

Next, we studied the sorption kinetics of various composite polymer sorbents in the temperature range of 20–50 °C.

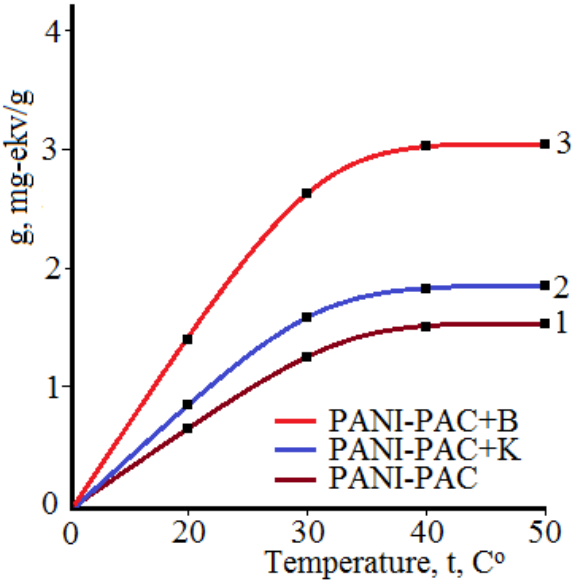

Fig.10. Sorption kinetics of lead ions in a solution of $Pb(NO_3)_2$ = 45 mg·ekv/l of the PANI-PAC (1) complex, PANI-PAC+K (2), PANI-PAC+B (3) at temperatures

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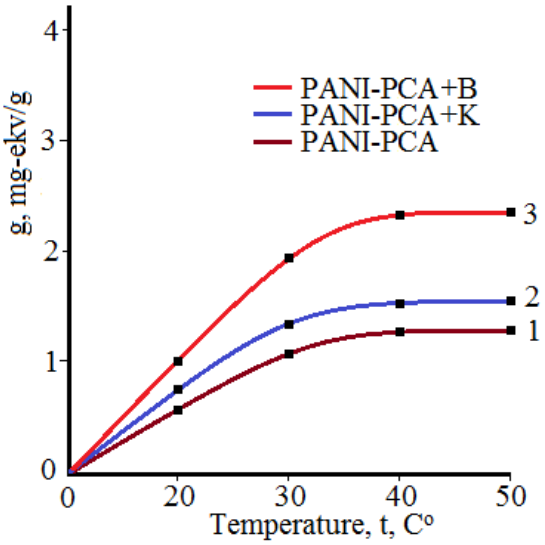

Fig. 11. Sorption kinetics of lead ions in a solution of $Pb(NO_3)_2$ = 45 mg·ekv/l of the PANI-PCA (1) complex, PANI-PCA + K (2), PANI-PCA + B (3) at temperatures

The figures show that with increasing temperature from 20ºC to 50ºC the sorption speed of the metal and its content in the sorbent increases. The process of metal sorption by sorbents depends not only on temperature, but also on the SEC of the sorbent. It can be seen from the figures that an increase in the SEC of sorbents by NaOH leads to an increase in the sorption rate and the amount of metal absorbed. From these figures, the rate constants of sorption of metal ions with the sorbents PANI-PAC+B and PANI-PCA+B were calculated. As can be seen from the figures, with increasing temperature, the sorption of metal ions increases and the complex formation process of non-ferrous, heavy and noble metals with sorbents is accelerated.

V. CONCLUSION AND FUTURE WORK

Thus, the high sorption of lead ions of composite polymer sorbents depends on the nature of the functional groups in the sorbent and the mineral fillers added to it. An improvement in the physicochemical and mechanical properties of composites filled with various mineral fillers is shown[10-11].

According to the results of experimental studies, it is revealed that when a composite polymer sorbent is immersed in an aqueous solution of $Pb(NO_3)_2$, effective sorption of lead ions proceeds with the formation of a triple (polymer-metal-polymer) complex. As a result of sorption of lead ions, a more significant increase in PANI-PAC+B is observed compared to PANI-PCA+B by a factor of 2–3.

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