

## SORPTION OF COBALT (II) AND NICKEL (II) IONS FROM INDUSTRIAL WASTEWATER ONTO MODIFIED BENTONITE CLAYS

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***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 cobalt (II) and nickel (II) 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.** Based on the criteria for determining the sorption reactions of cobalt (II) and their direct influence on the degree of sorption to bentonite, for example, the composition and concentration of the saline environment, the influence of pH of the environment, etc., a comprehensive study. . not done before. When interacting with  $NH_3$  and  $Co^{2+}$  in amounts up to 1.08 mol/l, complex compounds are formed in the form of hydrocomplexes:

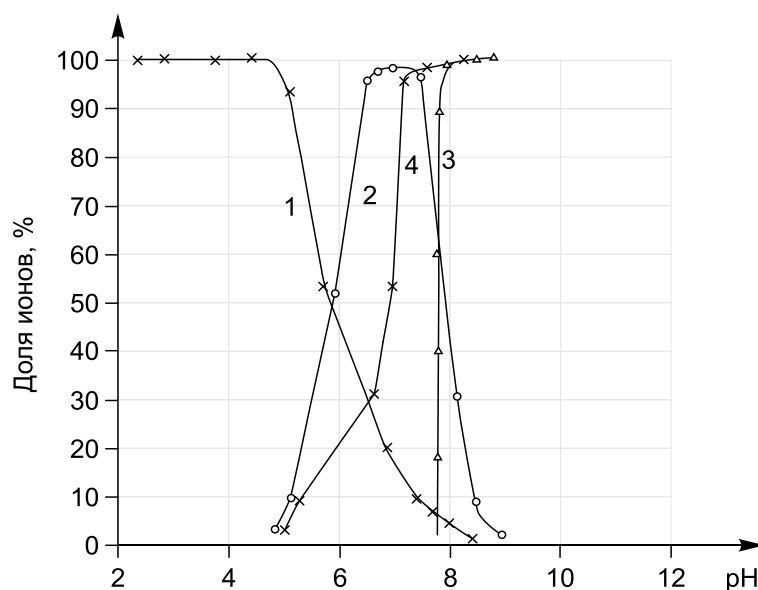


Based on the results of Cotton's research, active  $Co^{2+}$  ions in the form of  $Co(H_2O)_6^{2+}$  can have an octahedral shape and  $Co(H_2O)_4^{2+}$  can have a partial tetrahedral shape. They maintain a state of mutual balance. Presumably, this situation is observed when  $Co^{2+}$  ammonia is formed. Taking this situation into account, we studied the effect of pH in the presence of  $NH_3$  and  $NO_3^-$  anions for the co-precipitation of  $Co^{2+}$  with concentrations up to  $4.5 \times 10^{-4}$  mol / l.

During co-precipitation,  $Co^{2+}$  is a solution of potassium nitrate, ammonium, sodium carbonate, ammonium chloride, and nitric acid ( $NHO_2$ ) in the background of the salt, and different methods were used to mix the reagents:

- 1) co-precipitation: as a carrier — 1.25 g bentonite  $Co^{2+}$  extracted from an acidic medium;
- 2) sorption: cobalt salt was added to bentonite;
- 3) precipitation: under similar conditions, the loss of  $Co^{2+}$  is the precipitation of its solid phase.

The amount of sorption was determined by the radioactivity indicator using cobalt isotopes  $^{57}Co$  and  $^{58}Co$ , in which the contact time of the sediment with the solution was 30 minutes; other parameters of the experiment and their methodology literature.

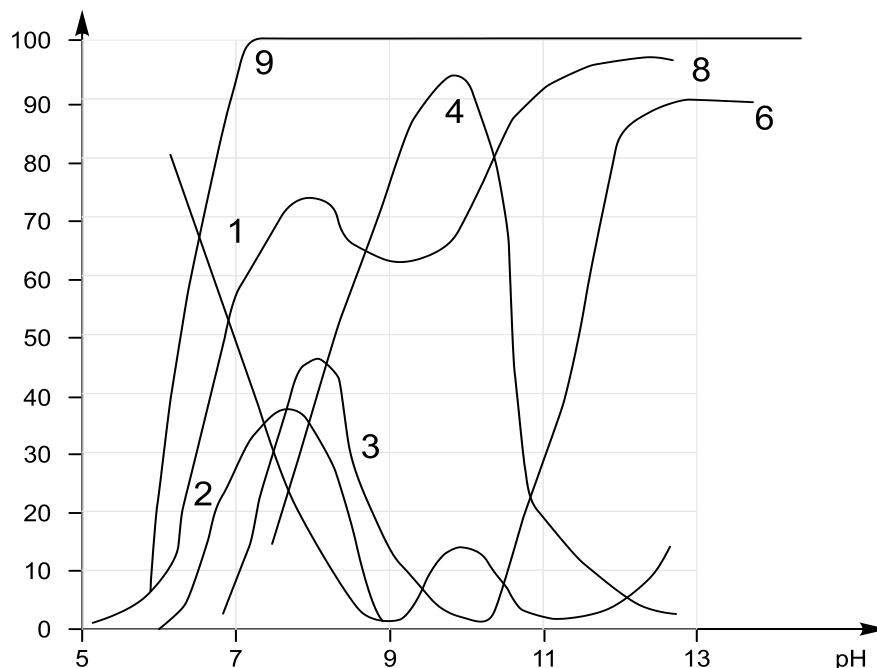


**Figure 1. Graph of state and sorption of  $Co^{2+}$  in 1M potassium nitrate**  
**1 and 2 — fractions of  $Co^{2+}$  and  $Co_4(OH)_4^{4+}$  ions, respectively;**  
**3 and 4 — deposition of  $Co(II)$  hydroxide, respectively**

As can be seen from Figure 1. Sorption of  $\text{Co}^{2+}$  in bentonite clays in 1 M  $\text{KNO}_3$  begins at  $\text{pH} = 5$ , which corresponds to the beginning of  $\text{Co}^{2+}$  hydrolysis ( $\text{pH} 8.3 \div 9$ ). The concentration of  $\text{Co}^{2+}$  in the specified sorption parameters is allowed, then it is separated from the carrier, as well as the precipitation of the carrier at  $\text{pH} = 5$  or the injection of the solution obtained by dissolving the microcomponent in a minimum amount of acid. high concentration  $\text{NH}_3$  solution. During sorption, two maxima of precipitation in the presence of  $\text{Co}^{2+} \text{NH}_4\text{NO}_3$  are observed:  $\text{pH} = 7.0 \div 7.5$  and  $\text{pH} = 10.0$ . As the concentration of ammonium nitrate increases from 1 to 3 mol, deposition decreases in the range  $\text{pH} = 7 \div 10$ , and therefore sorption.  $\text{Co}^{2+}$  decreases to  $b > 3$  mol ammonium nitrate at  $\text{pH} = 8.0$ .

At the same time, it can be seen from Figure 2 that with increasing salt concentration, age-dependent sorption is observed at  $\text{pH} = 7.0$ , that is, in the region of cobalt (II) hydrolysis, which is confirmed by the data presented.

In order to establish the process and the mechanism of separation of Ni from other elements, the concentration of  $\text{Ni}^{2+}$  during its separation in wastewater with precipitation by metal hydroxides was studied.



**Figure 2. Graph of state and sorption of  $\text{Co}^{2+}$  in 1M ammonium nitrate.**

**1-7 – ion fractions  $\text{Co}(\text{NH}_3)_2^{2+}$ ,  $\text{Co}(\text{NH}_3)_3^{2+}$ ,  $\text{Co}(\text{NH}_3)_4^{2+}$ ,  $\text{Co}(\text{NH}_3)_6^{2+}$ ,  $\text{Co}(\text{NH}_3)_2(\text{OH})_2$  and  $\text{Co}(\text{OH})_3$ ; 8 - sorption  $2,5 \cdot 10^{-4}$  g-ion/l  $\text{Co}^{2+}$  in 1 M  $\text{NH}_4\text{NO}_3$ , 9 - the same, in 1 M  $\text{KNO}_3$**

$\text{Ni}^{2+}$  ions are considered to cause hydrolysis reactions with the formation of the following hydroxy cations:

a)  $\text{NiOH}^+$  ( $\lg K_1=5,0$ ;  $K_1$ – hydrolysis constant);

b)  $\text{Ni}_2(\text{OH})^{3+}$  ( $\lg \beta_{1,2}=9,0$ );

c)  $\text{Ni}_4(\text{OH})_4^{4+}$  ( $\lg \beta_{4,4}=27,82$ )

The first hydroxy compound precipitates at  $\text{Ni}_2(\text{OH})_2$  pH=8.0, where, according to the authors, it is: 13.81; 14.5; 15.21; 18.06 and 17.19.

In the presence of ammonia with a concentration higher than 1.08 mol/l, nickel (II) forms amino acids ( $\lg$  formation constants are shown in parentheses).

$\text{Ni}(\text{NH}_3)^{2+}(2,80)$ ;  $\text{Ni}(\text{NH}_3)_2^{2+}(5,04)$ ;  $\text{Ni}(\text{NH}_3)_3^{2+}(6,77)$ ;  $\text{Ni}(\text{NH}_3)_4^{2+}(7,96)$ ;  $\text{Ni}(\text{NH}_3)_5^{2+}(8,71)$  and  $\text{Ni}(\text{NH}_3)_6^{2+}(8,74)$ .

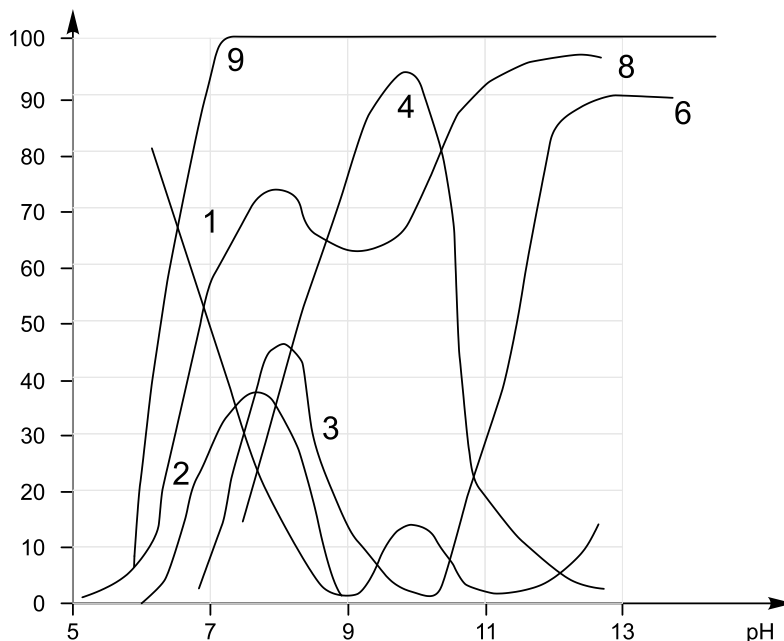
In the continuation of the experiments, the sorption of nickel ( II ) was studied in the presence of ammonia,  $\text{Cl}^-$ ,  $\text{CO}_3^{2-}$ ,  $\text{ClO}_4^-$  and  $\text{NO}_3^-$  depending on the change of pH of the medium. ions in solution, at different concentrations of sorbed component and ambient electrolyte, in bentonite clays. In this case, solutions of  $\text{KNO}_3$ ,  $\text{NaClO}_4$ ,  $\text{NH}_4\text{NO}_3$  and  $\text{KNO}_3$ ,  $\text{K}_2\text{CO}_3$  were used as saline medium. Under these experimental conditions, the order of substitution of reagents was modified as follows:

- 1) co-precipitation: 1.25 g of sample bentonite as a carrier was separated from the acidic medium together with the sorbed component;
- 2) sorption: the sorbed component was added to bentonite sediment;
- 3) sedimentation: under similar conditions, loss of nickel due to sedimentation of its solid phase, absorption by vessel walls, etc.

Based on the amount of nickel in the centrifuge, the sedimentation index was determined using the photometric method using dimethylglyoxime, the contact time of the sediment with the solution was 20 minutes, other parameters remained unchanged.

The amount of precipitation was determined photometrically using dimethylglyoxime from the amount of nickel in the centrifuge; contact time of the precipitate with the solution is 20 minutes. Other conditions were as described above.

Sorption of  $4,5 \cdot 10^{-5}$  g-ion/l nickel in 1 m  $\text{KNO}_3$  starts at pH =5 and is completed in the range of pH =7.5-10. In such conditions, it is possible to concentrate nickel, which is then separated from the carrier by precipitation, the latter at pH = 5, or by injecting a concentrated ammonia solution into bentonite clay sediment, followed by desorption on the nickel surface. sediment.



**Figure 3. Curves of nickel(II) precipitation in bentonite clay  
1 mol NaClO<sub>4</sub> and 1 mol, 2.5 mol, 4 mol NH<sub>4</sub>NO<sub>3</sub>  
Co-precipitation, sorption and precipitation in 1mol NaClO<sub>4</sub>;  
4-6 — the same, 1 mol NH<sub>4</sub>NO<sub>3</sub>, 7-9 — the same, 2.5 mol NH<sub>4</sub>NO<sub>3</sub>,  
10-12 — the same, in 1 mol of NH<sub>4</sub>NO<sub>3</sub>.**

Sorption of nickel in 1 mol KNO<sub>3</sub>, 1 mol NaClO<sub>4</sub> and 1 mol KNO<sub>3</sub> +0.5 mol K<sub>2</sub>CO<sub>3</sub> is almost the same. At 1 mol of NH<sub>4</sub>NO<sub>3</sub>, the maximum co-precipitation is observed at pH > 7.9 (Fig. 3). When the concentration of NH<sub>4</sub>NO<sub>3</sub> increases to 5 M, co-precipitation and sorption decrease in the regions. pH = 8.9-10, as well as its magnitude and the position of the first maximum on the rN axis. As the alkalinity of the solution increases, the sorption of nickel drops to zero in the range of pH = 8.9-10 in a 2.5 NH<sub>4</sub>NO<sub>3</sub> solution (Fig. 3).

Conclusion. The research results can also be explained by the sequential occurrence of the following reactions: in a weakly acidic environment with pH =5, the reaction of hydrolysis of Ni<sup>2+</sup> ions mainly begins with the formation of Ni<sub>4</sub>(OH)<sub>4</sub><sup>4+</sup> ions, which changes the ratio of hydrolyzed forms with increasing rN of the environment corresponds to the data calculated on At the same time, the fractional fractions of NiOH<sup>+</sup> and Ni<sub>2</sub>OH<sup>3+</sup> are insignificant compared to the fraction of tetramer Ni(OH)<sub>4</sub><sup>4+</sup> (Fig. 3.6).

Thus, the nickel sorption process in bentonite starts with the appearance of Ni(OH)<sub>4</sub><sup>2+</sup> in the solution and does not occur if only aquilones are present in the solution.

## REFERENCES

1. E.Egamberdiev, S. Turabdjano, D. Mirzaeva, Kh. Khaydullaev, U. Sharipova, A. Shokhakimova, and O. Bakhtiyorov.: Effect of chitosan substance on the mechanical properties of paper obtained on the basis of flax cellulose. E3S Web of Conferences 371, 01045 (2023) <https://doi.org/10.1051/e3sconf/202337101045>
2. Igamqulova N.; Mengliev, Sh.; Egamberdiev E.: Reduction of waste disposed to the environment through recycling of unused methyldiethanolamine. E3S Web of Conferences 371, 01049 (2023) <https://doi.org/10.1051/e3sconf/202337101049>
3. Ergashev Y.; Egamberdiev E.; Mirkhodjaeva D.; Akmalova G.; Umarova M.; Kholdarov R.: Obtaining a filter material used in gas and air purification. E3S Web of Conferences 371, 01012 (2023) <https://doi.org/10.1051/e3sconf/202337101012>
4. Egamberdiev E.; Ergashev Y.; Turabdjano S.; Abdumavlyanova M.; Makhkamov A.; Rashidov, Sh.; Karimov, Sh.: Effect of chitosan on the surface properties of cellulose-based paper obtained from the flax plant. E3S Web of Conferences 371, 01010 (2023) <https://doi.org/10.1051/e3sconf/202337101010>
5. Arslanov, Sh.; Turabdjano S.; Azimova, Sh.; Azimov D.; Sultankhojaeva N.; Egamberdiev E.: Physico-chemical properties and research of acids contained in oils of Uzbekistan. E3S Web of Conferences, 2023, 371, 01021
6. Ergashev Y.; Egamberdiev E.; Turabdzhanov S.; Akmalova G.; Isanova R.; Rashidov R.; Sobitov O.: Obtaining filter material from natural fiber composition and areas of its use. E3S Web of Conferences, 2023, 371, 01047
7. Egamberdiev E.; Turabdjano S.; Akmalova G.; Mukhtarova N.; Ayubova I.; Mirzakhmedova M.; Rakhmonberdiev G.: Obtaining paper from composition of different fibers and its analysis. E3S Web of Conferences, 2023, 371, 01004
8. Egamberdiev, E.; Ergashev, Y.; Khaydullayev, K.; Husanov, D.; Rahmonberdiev, G. Obtaining paper samples using basalt fibers and studying the effect of natural glue obtained from chitosan on paper quality. Universum: technical science 2022, 4, 14-18, <https://7universum.com/ru/tech/archive/item/13348>.
9. Egamberdiev E.; Akmalova G.; Rahmonberdiev G. Obtaining paper products from cellulose-containing plants and researching its field of application. 3rd International Conference on Energetics, Civil and Agricultural Engineering, ICECAE 2022Virtual, Online13 October 2022до 16 October 2022Код 187394, DOI 10.1088/1755-1315/1142/1/012054

10. Egamberdiev E.; Makhkamov A.; Rakhimjonov B.; Khusanov D.; Akmalova G.; Mirzakhmedova M.; Rahmonberdiev G. Effectiveness of cleaning of sunflower oil with filter material made from composition of organic and inorganic fibers. 3rd International Conference on Energetics, Civil and Agricultural Engineering, ICECAE 2022Virtual, Online13 October 2022до 16 October 2022Код 187394, DOI 10.1088/1755-1315/1142/1/012050
11. M. Mirzakhmedova., D. Tukhtaboeva., E. Egamberdiev., G. Akmalova. Study of paper technology on the basis of reed cellulose. “Harvard educational and scientific review”, 2022. 149.
12. E.A. Egamberdiev., Y.T. Ergashev., Kh.Kh. Khaydullaev., G.Y. Akmalova., G.R. Rakhmonberdiev. The effect of chitosan on the surface properties of cellulose-based paper obtained from the stem of flaxseed. “Technical science and innovation”, 2022. 27.
13. Egamberdiev E.A., Makhkamov A.R., Rakhmonberdiev G.R. Obtaining wrapping paper used in furniture wrapping and quality delivery and determining its quality indicators // Tashkent state technical university named after Islam Karimov Technical science and innovation – Tashkent, – No. 2(12). 2022.– P. 33–39.
14. Egamberdiev E.A., Norboyev S.K. Extraction of cellulose nanocrystals from secondary paper waste and their use in paper production // Tashkent state technical university named after Islam Karimov Technical science and innovation –Tashkent, – No. 3(13). 2022.– P. 215–222.
15. Soatboev, K., Daddahodjaev, A., & Egamberdiev, E. (2023). Creation of mixed polyfunctional catalysts for hydration of acetylene in vapor phase. Educational Research in Universal Sciences, 2(5), 430–433. Retrieved from <http://erus.uz/index.php/er/article/view/3167>
16. Zokirbekov, J. K., Aliev, B. A., & Egamberdiev, E. A. (2023). Modified mineral sorbents for waste water treatment. Innovative Development in Educational Activities, 2(10), 155–157. Retrieved from <https://openidea.uz/index.php/idea/article/view/1345>
17. Zokirbekov, J. K., Aliev, B., & Egamberdiev, E. (2023). Effect of temperature on sorbents. Innovative Development in Educational Activities, 2(10), 158–161. Retrieved from <https://openidea.uz/index.php/idea/article/view/1346>
18. Zokirova, Z. Q., Egamberdiyev, E. A., & Sattarkulov, L. A. (2023). Installation of new types of basalt fiber filters in industry. SCHOLAR, 1(11), 122–125. Retrieved from <https://researchedu.org/index.php/openscholar/article/view/3281>
19. Zokirova Zilola Qaxramon qizi, Egamberdiyev Elmurod Abduqodirovich, & Sattarkulov Lazizbek Abror o‘g‘li. (2023). Use of cellulose-based filters in the oil

- and gas industry. Ta'limni rivojlantirishda innovatsion texnologiyalarning o'rni va ahamiyati, 1(1), 261–264. Retrieved from <https://researchedu.org/index.php/konferensiya/article/view/3388>
20. S.S. Aliev, E.A. Egamberdiev, G.Yu. Akmalova, G.U. Ilkhamov. Analysis of physical-mechanical properties of new type of wood-polymer composite materials. [Vol. 3 No. 1 \(2023\): Harvard Educational and Scientific Review](#), 48-53
  21. Turabdjano, S., Egamberdiev, E., Iskandarov, A., & Zokirova, Z. (2023). Installation of new types of basalt fiber filters in industry. SCHOLAR, 1(10), 106–110. Retrieved from <https://researchedu.org/index.php/openscholar/article/view/3109>
  22. Rashidov Sh.A., Egamberdiev E.A., Turabdjano S.M. Obtaining cellulose nanocrystals and their use in paper production. Austrian Journal of Technical and Natural Sciences 1.2 2023, 3-8. <https://doi.org/10.29013/AJT-23-1.2-3-8>
  23. E Egamberdiev, R Kholdarov, R Masharipov, O Muratkulov, G Akmalova, Ergashev Yo, M Mirzakhmedova. [Effect of flocculants on stability of paper materials](#) Austrian Journal of Technical and Natural Sciences 1.2 2023, 9-12. <https://doi.org/10.29013/AJT-23-1.2-9-12>
  24. Egamberdiev Elmurod, Ergashev Yorqinjon, Mahkamov Adham, Umarova Muattar, Akmalova Guzal. [Obtaining oil filters from local fiber raw and its advantages](#). Universum: технические науки 8-3 (101) 2022 – P. 49-54.
  25. Egamberdiev Elmurod, Ergashev Yorqinjon, Khaydullayev Khurshid, Husanov Dilshod, Rahmonberdiev Gappor. [Obtaining paper samples using basalt fibers and studying the effect of natural glue obtained from chitosan on paper quality](#). Universum: технические науки 4-13 (97) 2022 – P. 14-18.
  26. Gulnoza Iskhakova Elmurod Egamberdiev, Jamshid Ziyadullaev. Obtaining thermal insulation materials containing basalt fiber and cellulose. International scientific and practical conference modern views and research 2021/6, 10-11
  27. G'R.Rakhmonberdiev E.A.Egamberdiev, G.Yu.Akmalova, Yo.T.Ergashev, M.M.Shakirova. The influence of different natural fibers applied on the quality index of the paper. American journal of research 2021/4, 48-57
  28. G.Akmalov S.Arslanov, E. Egamberdiev. Physiologically active polymers with anti-tuberculosis activity. International scientific and practical conference modern views and research 2021/2, 48-50.
  29. G.Rakhmanberdiev E. Egamberdiev, Yo.Ergashev. Obtaining a filter material based on basalt fiber used for the oil industry. International scientific practical conference modern views and research 2021/2, 63-65



30. Toyir Safarov, Elmurod Egamberdiev, Yorqin Ergashev. Study of the effect of binders on paper materials made based on mineral fibers. Internationales Deutsches Akademika Aachener, Germany 2021, 40-43
31. S.Arslanov, E. Egamberdiev, G.Akmalova. Physiologically active polymers with antituberculosis activity. Modern views and research - 2021, January-February, 2021: Egham. 48-50
32. E. Egamberdiev, Yo.Ergashev, G.Rakhmanberdiev. Obtaining a filter material based on basalt fiber used for the oil industry. Modern views and research - 2021, January-February, 2021: Egham. 63-65
33. Aliev S.S., Rakhmanberdiev G.R., Sharafatdinov B. Study physical and mechanical properties of wood-polymer composition materials made on the basis of local wood flours and polyvinylchloride // “Technical science and innovation”, Tashkent State Technical University named after I.A. Karimov, Tashkent 2022, pp. 211-214.
34. Aliev S.S., Egamberdiev E.A., Akmalova G.Yu., Ilkhamov G.U. Analysis of physical-mechanical properties of new type of wood-polymer composite materials // Harvard Educational and Scientific Review. International Agency for Development of Culture, Education and Science. 0362-8027 47 Vol.3. Issue 3 Pages 48-53
35. Aliev S.S., Egamberdiev E.A., Juraev A.B., Ismatov M.N., Zokirova Z.Q. The Effect of Wood Fillers in Individual Conditions on Wood-Polymer Composites // “Technical science and innovation”, Tashkent State Technical University named after I.A. Karimov, Tashkent 2023, pp. 208-213.
36. Aliev S.S., Egamberdiev E.A., Akmalova G.Yu. Obtaining environmentally friendly polymer composite material from local wood flour // Al-Farabi Kazakh National University NJSC Faculty of Biology and Biotechnology Department of Biodiversity and Bioresources Research Institute for Problems of Biology and Biotechnology Research Institute for Ecological Problems. Almaty, 2023, pp.168-171