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Research of Organomineral Sorbents Based on Shungite of Kazakhstan

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Abstract. Kazakhstan ranks second in the world in terms of natural uranium reserves and dominates in its production. Hydrometallurgical processing of uranium-containing raw materials generate a large amount of liquid technogenic waste, which are waste solutions requiring disposal. Sorption methods fall under the group of the most effective methods for purifying liquids from contamination with radionuclides. Synthetic sorbents are expensive, and the natural ones have low sorption capacity, which represents a disadvantage in their usage. Obtaining modified ion-exchange materials based on their combination is an urgent problem faced by the nuclear industry.

The paper discusses a modifying method applicable to natural coal and mineral raw materials in Kazakhstan. The Koksu deposit shungite was selected for the research. Source raw materials were subjected to flotation. The paper introduces data obtained from physical and chemical studies of the source raw materials and the derived concentrate. A modified sorbent was derived based on the concentrate, and its sorption capacity was studied.

1. Purpose

The aim of the study is to research of organomineral based on shungite of Kazakhstan.

2. Method

The quantitative uranium content in solutions before and after sorption was determined on an Optima 8000DV inductively coupled plasma (ICP) atomic emission spectrometer.

The phase composition of schungite was studied by X-ray phase method as a part of X-ray phase analysis using a Bruker D8 Advance diffractometer (Cu–Kα radiation).

The elemental composition of the source raw materials and the obtained concentrate was determined by X-ray fluorescence analysis using instruments of a Venus 200 X-ray fluorescence dispersive spectrometer from PANalytical and a D8 Advance diffractometer produced by Bruker (Cu–Kα radiation). The results of X-ray phase and X-ray fluorescence methods are supplemented by data obtained using a scanning electron microscope. A JEOL JXA-8230 electron probe microanalyzer was used to perform the studies.

3. Results.

The research resulted in synthesizing a schungite-based organopolymer according to the procedure described above. The source raw material was preliminary floated shungite obtained at the Koksu deposit. The described procedure was also observed during flotation. The flotation circuit is shown in Figure 1.

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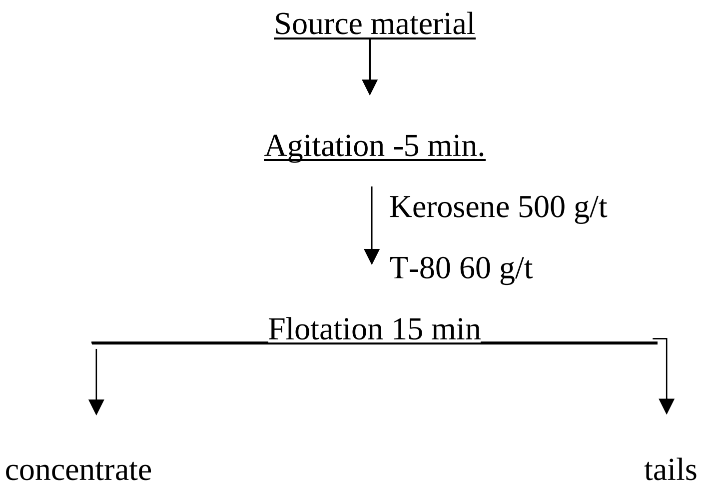

Figure 1 Shungite flotation circuit

Table 1 presents the elemental composition of the source shungite and the resulting concentrate according to the x-ray fluorescence analysis data.

Table 1 - Elemental composition of the source shungite and concentrate after flotation

Product name	Yield, %	Content, %							Extraction, %						
		C	O	Al	Si	S	K	Fe	C	O	Al	Si	S	K	Fe
concentrate	43.2	**21.03**	40.88	3.29	14.8	0.052	0.772	3.099	**60.50**	40.84	40.34	42.91	47.90	39.96	46.07
tails	56.8	10.44	45.036	3.7	14.97	0.043	0.882	2.759	39.49	59.15	59.65	57.08	52.09	60.03	53.92
ore	100	15.01	43.21	3.522	14.896	0.046	0.834	2.905	100	100	100	100	100	100	100

The table suggests that the obtained concentrate contained the increased carbon (up to 21%) resulting from flotation.

Table 2 shows the results drawn from the X-ray phase analysis of a schungite sample obtained at the Koksu deposit. As it follows from Table 2, the Koksu deposit shungite consists of quartz, siderite, muscovite, albite, and clinochlore.

Table 2 - The results drawn from the X-ray phase analysis of the source shungite.

Name	Formula	Semi-quantitative composition, %
		Koksu deposit shungite
Quartz	SiO_2	47.4
Siderite	$FeCO_3$	5.8
Muscovite	$KAl_2Si_3AlO10(OH)_2$	3.3
Albite	$Na(AlSi_3O_8)$	2.1
Clinochlore	$Mg2.5Fe1.65Al1.5Si2.2Al1.8O10(OH)_8$	3.9

Shungite was modified with orthophosphoric acid, as well as oxyethylidenediphosphonic acid (OEDP) in 1,4-dioxane.

An organomineral sample was studied by X-ray spectral microanalysis on a JEOL SUPERPROBE-733 electron probe microanalyzer. The surface of the synthesized organopolymer is shown in Figure 2.

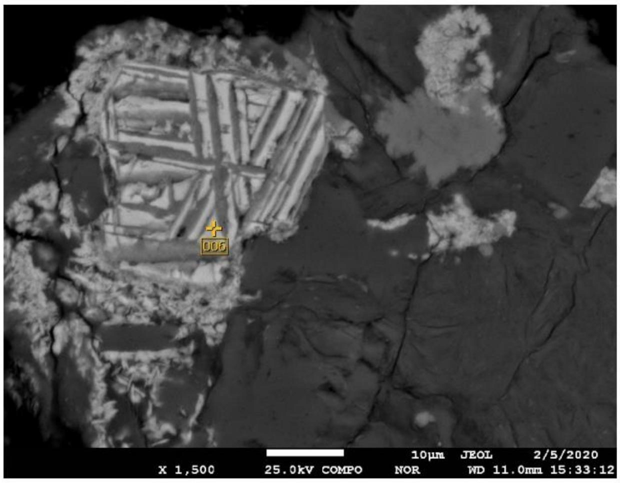

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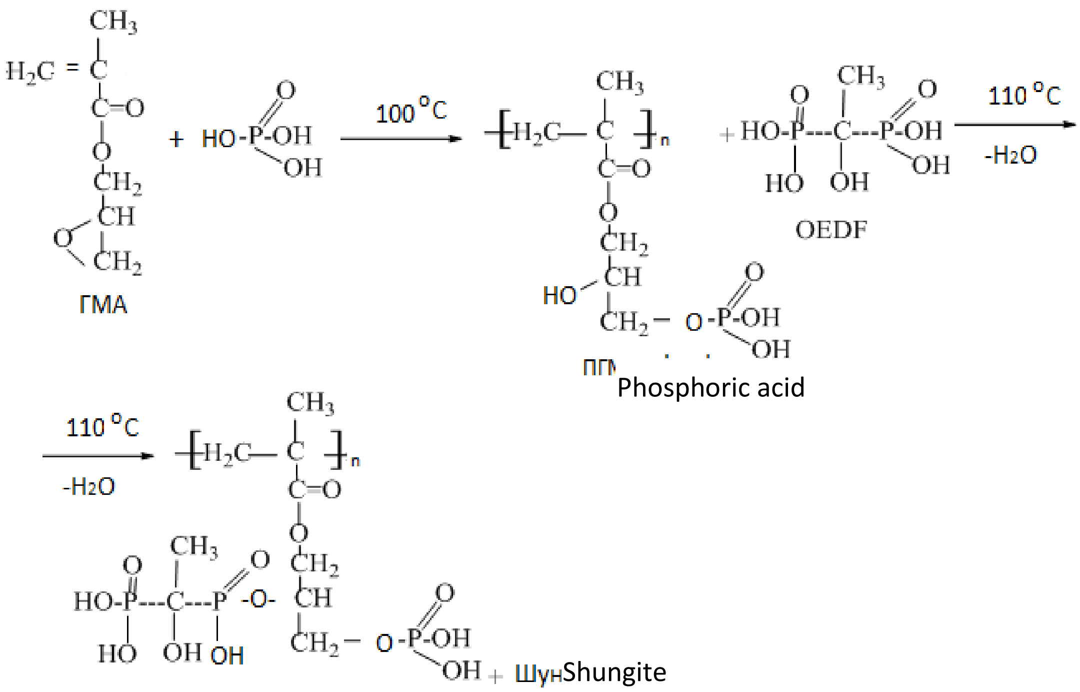
Figure 2 - The organomineral surface.

The expected structural formula of the phosphorus-containing copolymer for the schungite modification is as follows:



The formation mechanism for the organomineral phosphorus-containing cation exchanger includes the interaction of chemically active hydroxyl and acid groups and a shungite molecule. Chemically active chelating phosphorus-containing groups are formed on the shungite molecule surface. These functional phosphorus-containing groups effectively adsorb uranyl ions from aqueous solutions according to the donor-acceptor bond and the coordination mechanism.

Uranium was sorbed from the process solution under static conditions. The obtained results are presented in Table 3.

Table 2 - The results of uranium sorption by organopolymer

Sample	Extraction degree, %	
Shungite-based organopolymer	98.7	2.27

For comparison: the sorption capacity of unmodified shungite is 0.130.

Table 2 suggests that the shungite-based organopolymer almost completely extracts uranium from productive solutions in the described experimental conditions. The sorption capacity of the organopolymer is significantly higher compared to the original shungite.

4. Conclusion.

The paper proposes a method for producing an organopolymer based on coal and mineral raw material from Kazakhstan – the Koksu deposit schungite. The elemental and phase composition of the source raw material was studied. Testing of the schungite flotation method resulted in obtaining a concentrate. The carbon content in the concentrate is higher than that in the source raw material.

The paper suggests the structural formula of a phosphorus-containing copolymer for schungite modification and its formation mechanism.

Uranium was sorbed from process solutions. It has been shown that the shungite-based organopolymer almost completely extracts uranium from productive solutions in the described experimental conditions. The sorption capacity of the organopolymer is significantly higher compared to the original shungite.