

SORPTION OF RHENIUM AND INDIUM BY NANOMODIFIED CARBON COMPOSITES

Gakiev Adam Lechievich

The relevance of the thesis topic is determined by the need to provide the raw material base of the Russian Federation with strategic mineral resources, including rare metals rhenium and indium. Rhenium is indispensable as an alloying additive for heat-resistant superalloys, which are used to produce engine blades in the aerospace industry, as well as in the production of reforming catalysts in the oil refining industry. Indium is widely used to produce liquid crystal screens in electronics.

The main source of rhenium is molybdenum and copper ores, from which it is extracted as an associated component, however, its content in them is insignificant in Russia. Among the unconventional promising sources are fumarole emissions from the Kudryavy volcano (O. Iturup, Sakhalin region), in which rhenium reserves are placed on the state balance sheet. The gas phase of a permanently active volcano of high power contains other valuable elements, such as highly demanded indium, germanium, gallium, etc. When fumarole emissions are cooled, these elements pass into natural waters and condensate. During the processing of solid concentrates of condensation of fumarolic gases from Kudryavy volcano, solutions are also formed, which should be sent for sorption. However, there is no production of rhenium- and indium-selective sorbents in Russia. In this regard, it is important to obtain affordable sorption materials with a lower cost compared to foreign ion-exchange resins - nanomodified activated carbons (carbon composites) in relation to the extraction and concentration of rhenium and indium from solutions of various origins, including those formed during the processing of indium-containing waste.

The aim of the work is to determine the sorption characteristics of nanomodified carbon composites based on carbon nanotubes in the extraction of rhenium and indium from sulfuric acid solutions.

Work objectives:

1. Production of carbon composites based on activated carbons and carbon nanotubes with their different contents. Selection of nanocomposites for the sorption of rhenium and indium, study of their pore characteristics and surface charge.

2. Study of the sorption of rhenium and indium from aqueous solutions by carbon composites to obtain their equilibrium and kinetic characteristics.

3. Mathematical processing of equilibrium and kinetic data on the sorption of rhenium and indium by carbon composites.

4. Determination of conditions for joint sorption of rhenium and indium by carbon composites and study of the possibility of their separation.

5. Approbation of the selected nanomodified carbon composite for the sorption of rhenium and indium from solutions of the fumarole activity of the Kudryavy volcano and solutions of leaching of fumarole gas condensate concentrate.

6. Approbation of indium sorption with a selected carbon composite from waste leaching solutions of liquid crystal displays.

Scientific novelty:

1. The dependence of the sorption and desorption characteristics of rhenium and indium carbon nanocomposites based on activated carbons VSK and Tatsorb on the content of introduced carbon nanotubes has been revealed.

2. It was found that when carbon nanotubes are introduced into Tatsorb activated carbon, the positive charge of the composite surface decreases. The zero charge point has been determined at a pH value of 2.

3. It has been established that the sorption of rhenium and indium by VSK-CNT and Tatsorb-CNT composites modified with carbon nanotubes proceeds in the external diffusion region with rhenium rate constants 6.5×10^{-2} and $6.4 \times 10^{-2} \text{ g} \times \text{mg}^{-1} \times \text{min}^{-1}$ and indium 9.2×10^{-2} and 1.0×10^{-1} calculated according to the pseudo-second order model. $\text{g} \times \text{mg}^{-1} \times \text{min}^{-1}$, respectively.

The theoretical and practical significance of the work:

1. The modes of sorption extraction of rhenium and indium from solutions by nanomodified carbon composites are determined.

2. The possibility of rhenium desorption at room temperature from composites modified with carbon nanotubes, as opposed to its high-temperature desorption from activated carbons, has been proven.

3. The conditions of joint sorption of rhenium and indium from sulfuric acid solutions by carbon nanocomposites and their separate desorption are revealed.

4. The possibility of extracting rhenium using carbon composites VSK-CNT and Tatsorb-CNT from the natural waters of the Molybdenum field, the waters of Lake Teploe, condensate and solutions of condensate concentrate of fumarolic gases of the Kudryavy volcano is shown. The degree of rhenium sorption was 91-97% (test report dated 05/15/25, issued by IVIG LLC).

5. Block diagrams of sorption extraction and separation of rhenium and indium from the condensate of fumarolic gases of Kudryavy volcano and its concentrate are proposed.

6. The possibility of extracting indium from waste leaching solutions of liquid crystal displays with a degree of sorption in one contact of 57,2% is shown.

The novelty of the technical solution for choosing a carbon composite with a certain carbon nanotube content was confirmed by the issuance of RF Patent No. 2802918 with priority dated November 29, 2022.

The provisions to be defended:

1. The dependence of sorption and desorption characteristics of carbon nanocomposites based on activated carbons of rhenium and indium on the number of introduced carbon nanotubes.

2. Sorption characteristics of carbon composites in the extraction of rhenium and indium.

3. Patterns of joint extraction of rhenium and indium by nanomodified carbon composites and their separation.

4. Results of mathematical processing of equilibrium and kinetic data on the sorption of rhenium and indium.

5. Results of sorption of rhenium and indium from solutions of natural waters of the Molybdenum field, waters of Lake Teploe, condensate of fumarolic gases of the Kudryavy volcano and solutions of leaching of its concentrate with a selected carbon composite, as well as sorption of indium from solutions of waste leaching of liquid crystal displays.