Abstract

The creation of high-tech innovative technologies depends to a large extent on the production of rare elements. Among these elements, rhenium and scandium are strategically important materials. Rhenium is used as a component of superalloys for the aerospace industry and catalysts for reniforming, scandium is part of the ligatures of light aluminum alloys for the aviation and shipbuilding industries, as well as materials for the manufacture of high-strength sports products. Rhenium production in Russia should increase by ~8 times in 10 years, and scandium-by half.

Scandium is part of the group of rare earth elements (REE). In contrast to rhenium, which has a very low Clarke of 7×10^{-8} %, scandium Clarke (1×10^{-3} %) indicates a wide prevalence of this element. The global annual production of rhenium in recent years is ~70 t, and scandium oxide –10-15 t.

These elements are extracted only in passing: rhenium - from molybdenum and copper sulfide ores, scandium-when processing bauxite, ilmenite, cassiterite, and zircon. Hydrometallurgical processes are most applicable for the extraction of rhenium and scandium from technological solutions: the main raw source of rhenium - washing sulfuric acid, solutions for leaching scandium from various concentrates, usually sulfuric acid due to the relatively low cost of sulfuric acid . Cleaning of the resulting solutions from macro-and micro-mixtures, as well as the concentration of elements is carried out by both extraction and sorption methods.

In recent years, weak-base anionites with functional groups of secondary and tertiary amines, as well as strong-base anionites, have been used for the sorption process of rhenium extraction. For the sorption of scandium, along with inorganic sorbents – phosphates of titanium, zirconium and phosphorus-containing resins (CMDF, AFI-21, AFI-22), complex-forming sorbents combining the properties of extractants and sorbents (impregnates, "Solvent Impregnated Resins" (SIR), Twexes) are being studied in greater volume. Since the extractant is not chemically bound to the carrier, there is a deterioration in the capacitance properties of this

type of material, which significantly reduces their practical value. Raw sources of rhenium and scandium include polymetallic uranium ores processed by underground sulfuric acid leaching. It is advisable to use the sorption method for processing productive or circulating sulfuric acid solutions with a micro-content of valuable elements. However, there is currently no production of the most scandium-selective and expensive phosphorous-containing ampholites and amino-containing sorbents for rhenium extraction in Russia.

In this regard, the study of the properties of cheaper activated carbons, as well as new materials – carbon nanocomposites in relation to the recovery and concentration of rhenium and scandium from sulfuric acid solutions, is relevant.

Scientific novelty

1. Equilibrium and kinetic characteristics of rhenium and scandium sorption by activated carbons of DAS, PFT and VSC and carbon nanocomposites NWC-Z and PANI-CNT from sulfuric acid and sulfuric-chloride solutions were determined.

2. It was found that the sorption of rhenium and scandium by activated carbons of DAS, PFT and VSC and carbon nanocomposites NWC-Z and PANI-CNT occurs in the diffusion region.

3. The value of sorption energy calculated using the Dubinin-Radushkevich equation (5.46 kJ/mol) indicates a large influence of physical adsorption on the absorption of scandium ions by a nanocomposite based on carbon nanotubes and polyaniline.

Practical importance of work

1. Modes of sorption extraction of rhenium and scandium from sulfuric-chloride solutions with activated carbons and carbon nanocomposites were determined.

2. The possibility of associated extraction of rhenium and scandium with activated carbon DAS and nanomodified coal NWC-Z from productive solutions of underground leaching of polymetallic ores of the Dalmatov Deposit is shown. The degree of sorption of rhenium and scandium by DAS coal per contact (with the

ratio of coal : solution phases equal to 1 : 4) was 96.0 and 21.1%, and nanocomposite NWC-Z was 96.2 and 56.0%, respectively. Block diagrams of sorption recovery and separation of rhenium and scandium by these sorbents are proposed.

The claims for discussion

1. Sorption characteristics of activated carbons of the latest generation made from various raw materials when extracting rhenium and scandium from sulfuric and slightly acidic sulfate-chloride solutions.
2. Sorption characteristics of activated carbon modified with carbon nanotubes when extracting rhenium and scandium from sulfuric and slightly acidic sulfate-chloride solutions.
3. Sorption characteristics of polyaniline/carbon nanotubes nanocomposite in the extraction of rhenium and scandium from sulfuric and slightly acidic sulfate-chloride solutions.
4. Results of approbation of rhenium and scandium sorption with activated carbon DAS and nanomodified coal NWC-Z from real solutions of borehole underground leaching of polymetallic ores of the Dalmatov Deposit.