



Российская академия наук

# Успехи ХИМИИ

**В присутствии  $\alpha\text{-Fe}_2\text{O}_3$**

ENB

pH

Радоний  
Эндотелий  
Витаминная пара  
Капс

ОЯТ

МОКС

Hg mercury 200.6	Tl thallium [204.3, 204.4]	Pb lead 207.2	Bi bismuth 209.0	Po polonium	At astatine	Rn radon
112 Cn copernicium	113 Nh nihonium	114 Fl flerovium	115 Mc moscovium	116 Lv livermorium	117 Ts tennessine	118 Og oganeson
65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.0	71 Lu lutetium 175.0
97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

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### New day of radiochemistry

S.N.Kalmykov

### Synthesis and study of properties of superheavy atoms. Factory of superheavy elements 901

Yu.Ts.Oganessian, S.N.Dmitriev

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The state-of-the-art of studies dealing with the synthesis and properties of new superheavy elements is analyzed. The experiments on the chemical identification and studies of chemical reactivity of superheavy elements and the facilities used for this purpose are described. The attention is focused on the theoretical estimates of the relativistic effects in the properties of these elements. The prospects of these investigations are considered in the light of the creation of the world's first Factory of superheavy elements in Russia. Bibliography — 48 references.

### Quantum chemical modelling of extraction separation of minor actinides and lanthanides. State of the art 917

Yu.A.Ustynyuk,<sup>a</sup> M.Yu.Alyapyshev,<sup>b,c</sup> V.A.Babain,<sup>c</sup> N.A.Ustynyuk<sup>d</sup>

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The review deals with the results of theoretical modelling of the structures and properties of actinide and lanthanide complexes with donor organic ligands used as selective extractants for separation of these elements in liquid high-level waste processing in the nuclear fuel cycle. The advantages and drawbacks of various types of ligands are discussed, including dithiophosphinic acids, tri- and polydentate ligands with *O*-donor centres, ligands based on *N*-heterocycles with softer *N*-donor centres and amides of *N*-heterocyclic carboxylic acids, which contain donor atoms of both types. Critical analysis of the potential of modern quantum chemistry methods for elucidation of structure–extraction behaviour relationships for various types of ligands is presented. Bibliography — 119 references.

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A key problem of nuclear power engineering is a large amount of radioactive wastes. Modern methods for spent nuclear fuel reprocessing produce large amounts of liquid high-level waste containing large amounts of various nuclides. Fractionation is now believed to be the most promising and environmentally safe management strategy for this waste; however, this brings about the problem of recovery of minor actinides and lanthanides. Counter-current extraction in an aqueous solution–organic liquid two-phase system is considered to be most efficient for addressing this problem. The available extraction systems are analyzed, including systems with non-selective extractants (phosphine oxides, phosphoric acids, dicarboxylic acid diamides, *etc.*) for co-extraction of lanthanides and actinides and selective extractants (sulfur compounds, *N*-heterocyclic compounds, *N*-heterocyclic carboxylic acid diamides, *etc.*) for separation of actinides and lanthanides. Modification methods for known extraction systems are considered, in particular, the role of diluents. The use of water-soluble chelating agents selective to actinides is discussed, including the possibility of combining extractants and chelating agents with differently directed affinity.

Bibliography — 232 references.

**Titanates, zirconates, aluminates and ferrites as waste forms for actinide immobilization**

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Titanate, zirconate, mixed titanate–zirconate phases with fluorite and fluorite-derived structures, and aluminate and ferrite phases with perovskite and garnet structures are surveyed. These phases are promising hosts for immobilization of actinides and their lanthanide analogues present in nuclear wastes. The data on chemical durability and radiation resistance of the ceramics based on the above-mentioned phases demonstrating reliability of long-term storage of ceramized actinide wastes are presented. Methods of synthesis of ceramics using sintering and melting stages are considered. The cold crucible inductive melting is shown to be one of the most promising technologies. Bibliography — 423 references.

**Behavior of plutonium in the environment**

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Plutonium is a component of spent nuclear fuel and radioactive wastes, highly toxic for living organisms, which is characterized by very complex chemical behaviour in technological processes and in the environment. The speciation of plutonium largely depends on the source and on the geochemical conditions of the environment. The most recent data about various sources, speciation and migration of plutonium in the environment are reviewed. The recent trends in the description of one of the most important processes in plutonium migration, *i.e.*, its sorption on the components of soils, rocks, colloid particles of various origin, natural organic matter, *etc.*, are discussed. Bibliography — 98 references.

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Radionuclides that emit short-range particles are considered. The methods of production of the most promising  $\alpha$ - and Auger emitters and their application in nuclear medicine are discussed. Most of Auger emitters can be obtained using conventional cyclotrons that accelerate protons to energies of 15 or 30 MeV. The production of  $\alpha$ -emitters is still associated with serious difficulties, which hamper their introduction into clinical practice. The key types of vehicles for radionuclide delivery to tumour cells are considered. Particular attention is paid to modular nanotransporters, as the highest cytotoxic effect of ionizing radiation is achieved when radionuclides are complexed with these vehicles. The use of modular nanotransporters would help to unlock the potential of many radionuclides that have not so far been considered as therapeutic agents, in particular,  $^{67}\text{Ga}$ ,  $^{111}\text{In}$  and so on. Bibliography — 197 references.