OBTAINING OF RADIOISOTOPES IN THE NUCLEAR REACTOR

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1. INTRODUCTION

Radioactive isotopes are widely used in different spheres of science, technology and medicine. At present the application of radioactive isotopes and other methods of nuclear technology at agriculture, industry and medicine is more important than use of nuclear energy as a source of energy [1]. In many countries of the world the problems of production and application of radioactive isotopes is given great attention [2]. At present volume of sales radioactive isotopes on world market is valued in several million dollars. About 90% this produce fall to the share of medicine [3,4].

Currently, radioisotopes are obtained in nuclear reactors on reaction (n,γ) constitute ~50 % of the nomenclature and ~40 % of total activity of all radioactive preparations. The advantage of nuclear reactors for production of radioactive isotopes provides the following opportunities:

1. Long time irradiation;

2. Ability to load big volume of target materials into the irradiation channels;

3. Simultaneous irradiation of many and various targets.

The problems of production radioactive isotopes and many other problems of the nuclear science are bound up with decision radiochemical tasks and planning of radiochemical investigations. The main methods, which are used in radiochemical investigations and in applied radiochemistry with their share in general volume investigations are presented in table 1.

Table 1. Methods of radiochemical investigations

The method	The share
Extraction	40-45
Ion exchange chromatography	20-22
Chromatography on inorganic sorbents	8-10
Extraction chromatography	8-10
Adsorption	3-5
Sublimation	3-5
Precipitation	3-5
Others	less than 3

Radiocchemical investigations are directed on study the distribution of radioactive isotopes between phase and their chemical forms in various chemical systems. The Results of the studies are used for development technology receptions radioactive isotope and their preparation for commerce.
The present work shows the results of radiochemical research devoted on the development of technology and methods for production of numerous reactor radioisotopes. Radiochemical schemes for production of radioisotopes such as ^{58}Co, ^{89}Sr, ^{99}Mo, ^{153}Sm will be presented.

2. EXPERIMENTAL

Target materials were high-quality oxides of the elements or metal samples, both with natural isotope abundance and enriched isotopes. Irradiation of samples was carried out in vertical channels of the reactor with a thermal neutron flux up to $2 \cdot 10^{14}$ n·cm^{-2}·s^{-1}. For irradiation samples the quartz ampoules and aluminum containers were used.

Radiochemical procedures involve removal of purpose radioisotope from the irradiated target, its purification from the accompanying radioisotope impurities, and concentration in the required chemical form.

Methods:

a) Extraction;

b) Ion exchange chromatography;

c) Chromatography on inorganic sortie agents;

d) Extraction chromatography.

Materials and reagents.

Tri-octylamine (TOA), Di-2-ethylhexylphosphoric acid (DEHPA), Tri-n-butyl phosphate (TBP) is used as liquid extractants for procedure of Extraction and Extraction chromatography. Anion exchange and cation exchange resins (Dowex) are used as ion exchanger for procedure of Ion exchange chromatography. Powder of Tetrafluoroeethylene (F-4) was used as inert carrier for the extractants in the processes of Extraction chromatography. Concentrated and diluted solutions of mineral acids and salts are used as aqueous phases in the process of work.

Radioactive isotopes are received by irradiating of conformable high pure compounds of elements in the nuclear reactor. In case of ^{58}Co and ^{99}Mo the enriched isotopes of Nickel-58 and Molybdenum-98 is irradiated.

We used the next nuclear reactions:

$$^{58}Ni + n \rightarrow {}^{58}Co + p \quad (1)$$

$$^{89}Y + n \rightarrow {}^{89}Sr + p \quad (2)$$

$$^{98}Mo + n \rightarrow {}^{99}Mo + \gamma \quad (3)$$

$$^{152}Sm + n \rightarrow {}^{153}Sm + \gamma \quad (4)$$

3. RESULTS

1. Cobalt-58 radioisotope

Radiochemical scheme of receive of radioisotope:

Preparation for irradiating ^{58}NiO target → irradiation of ^{58}NiO target → transportation of irradiating ^{58}NiO target to Radiochemical Laboratory → carrying out of radiochemical procedure: (1) solution irradiating ^{58}NiO target in the HCl ; (2) separation of ^{58}Co radioisotope from target on extraction chromatographic column with F-4 + TOA; (3) purification of ^{58}Co radioisotope on ion exchange column with Dowex 1x4; (4) elution of ^{58}Co radioisotope from chromatographic columns → analyze of $^{58}CoCl_2$ radioactive preparation.

Product Information

Product Name:	Cobalt chloride Co-58;
Chemical Form:	$^{58}CoCl_2$;
Chemical Medium:	0,1 N HCl;
Specific Activity:	> 5 mCi/mg Co;
Half-life:	70,8 d.;
Content radioisotope impurities:	≤ 0,01%;
Activity Concentration:	0,5 – 10 mCi/ml.

2. Strontium-89 radioisotope

Radiochemical scheme of receive of radioisotope:
Preparation for irradiating Y_2O_3 target → irradiation of Y_2O_3 target → transportation of irradiating Y_2O_3 target to Radiochemical Laboratory → carrying out of radiochemical procedure: (1) solution irradiating Y_2O_3 target in the HNO_3; (2) separation of ^{89}Sr radioisotope from target by extraction into TBPh; (3) purification of ^{89}Sr radioisotope on extraction chromatographic column with F-4 + DEHPA; (4) elution of ^{89}Sr radioisotope from chromatographic column → analyze of $^{89}SrCl_2$ radioactive preparation.

Product Information

Product Name:	Strontium chloride Sr-89;
Chemical Form:	$^{89}SrCl_2$;
Chemical Medium:	aqueous solution;
Specific Activity:	0,5 – 1,0 Ci/mg Sr;
Half-life:	50,4 d.;
Content radioisotope impurities:	≤ 0,1%.

3. Molybdenum-99 radioisotope

Radiochemical scheme of receive of radioisotope:

Preparation for irradiating $^{98}MoO_3$ target → irradiation of $^{98}MoO_3$ target → transportation of irradiating $^{98}MoO_3$ target to Radiochemical Laboratory → carrying out of radiochemical procedure: (1) solution irradiating $^{98}MoO_3$ target in the NaOH; (2) purification of ^{99}Mo radioisotope on chromatographic column with Al_2O_3; (4) elution of ^{99}Mo radioisotope from chromatographic column → analyze of $Na_2{}^{99}MoO_4$ radioactive solution.

The $Na_2{}^{99}MoO_4$ radioactive solution was used for preparation $^{99}Mo \rightarrow {}^{99m}Tc$ generators.

Product Information

Product Name:	Molybdate Sodium Mo-99;
Chemical Form:	$Na_2{}^{99}MoO_4$;
Chemical Medium:	dilute alkalinity solution;
Specific Activity:	≥ 5,0 mCi/mg Mo;
Half-life:	66,7 h.;
Content radioisotope impurities:	≤ 0,01%;

4. Samarium-153 radionuclide

Radiochemical scheme of receive of radioisotope:

Preparation for irradiating Sm_2O_3 target → irradiation of Sm_2O_3 target → transportation of irradiating Sm_2O_3 target to Radiochemical Laboratory → carrying out of radiochemical procedure: (1) solution irradiating Sm_2O_3 target in the HCl; (2) purification of ^{153}Sm radioisotope on chromatographic column with F-4 + DEHPA; (4) elution of ^{153}Sm radioisotope from chromatographic column → analyze of $^{153}SmCl_3$ radioactive preparation.

Product Information

Product Name:	Samarium chloride Sm-153;
Chemical Form:	$^{153}SmCl_3$;
Chemical Medium:	0,1 N HCl;
Specific Activity:	0,5 – 1,0 mCi/mg Sm;
Content radioisotope impurities:	≤ 0,1%.

4. REFERENCES

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