^{230}Pa isolation by extracting and chromatographic agents containing oxo- and hydroxo-groups

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Protactinium is poorly explored element having only one long-living and difficult of access isotope ^{233}Pa. Nevertheless, it has a wide application spectrum: geology, nuclear forensics, nuclear medicine. Institute for Nuclear Research (Russia) can produce Ci-amounts of ^{230}Pa ($T_{1/2}$=17.4 d) together with other useful alpha-emitters ^{225}Ac ($T_{1/2}$=9.9 d) and ^{223}Ra ($T_{1/2}$=11.4 d) [1] by irradiation of natural thorium with protons having energies 140-60 MeV. ^{230}Pa partially decays to ^{230}U ($T_{1/2}$=20.8 d), which has potential application in targeted alpha therapy (TAT) of cancer due to 5 emitting a - particles with total energy 33.5 MeV. ^{230}U can be utilized directly or as a parent of ^{226}Th ($T_{1/2}$=31 min) in a generator system.

Separation methods such as liquid-liquid extraction and ion exchange chromatography are usually used for isolation of pure Pa radioisotopes. But in aqueous solutions Pa(V) forms mono-oxo cation PaO^{3+} having strong tendency to hydrolysis, polynuclear species formation as well as complexation with various anions. Pa displays strong affinity to hydroxyl groups and easily forms oxo-complexes. These facts motivated us to investigate Pa extraction with ketones and alcohols as well as chromatographic behaviour of Pa on organic and inorganic sorbents.

Extraction separation. Extraction of Pa from HCl and HNO_3 solutions with methyl-isobutyl ketone, octanol and fluorinated alcohols was investigated. The distribution coefficients were compared. ^{230}Pa was quantitatively extracted from the HCl in the concentration range from 5 to 9M HCl. Octanol extracted up to 95% ^{230}Pa from 6-9M nitric acid. For back-extraction, various media were tasted and it was shown that oxalic acid solutions showed optimal distribution coefficients. Main impurities in Pa after extraction were radioisotopes of Sb, Nb, I and Ru.

Chromatographic separation. According to the literature, Pa forms strong complexes in concentrated HCl solutions, which are destroyed in diluted solutions. Catalytic amounts of HF also resulted in instability of these complexes. This fact was used for Pa separation by anion exchange chromatography on AG 1x8 and Dowex 1x8 in 8M HCl. The most part of radionuclides (mono- and bivalent cations, Th, Ac, Ra, lanthanides and others) were passed through the column. Pa, Nb, partially Sb, Zr, Ru were sorbed onto the column. Then ^{230}Pa was stripped off the column with 8M HCl with the addition of 0.3M HF or 3M HCl. Pa contains Sb as an impurity. One of the most effective method for Pa(V) separation is based on silica gel sorption from acid solutions. It may be used for final purification of Pa.

Thus, pure ^{230}Pa fraction was produced with combination of extraction and chromatographic methods. The total chemical yield of ^{230}Pa was about 80% and radionuclidic purity >99%.

References

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