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Generators of alpha-emitting radionuclides $^{225}\text{Ac} \rightarrow ^{221}\text{Fr} \rightarrow ^{213}\text{Bi}$ and $^{223}\text{Ra} \rightarrow ^{219}\text{Rn} \rightarrow ^{211}\text{Pb}$

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Generators of alpha-emitting radionuclides are of great interest for targeted therapy of cancer. Among possible generator pairs, $^{225}\text{Ac}/^{213}\text{Bi}$ and $^{223}\text{Ra}/^{211}\text{Pb}$ are the most promising. In addition to α -particle's properties attractive for nuclear medicine such as short range (50-100 μm) and high linear energy transfer (up to 100 keV/ μm) in biological tissue, the mother radionuclides ^{225}Ac and ^{223}Ra have half-lives (9.9 and 11.4 days, respectively) convenient for production, transportation and medical use of the generators. A recently developed method of irradiation of natural thorium with medium-energy protons may provide Ci-amounts of ^{225}Ac and ^{223}Ra monthly [1] and promote large-scale applications.

In a usual generator scheme a mother radionuclide is adsorbed in a small volume at the top of chromatographic resin and a daughter is eluted. This scheme does not work well if used directly because the emitted α - and β -particles destroy the resin by radiation impact and radiolysis. The approach of generators $^{225}\text{Ac} \rightarrow ^{221}\text{Fr}$ (4.9 min) $\rightarrow ^{213}\text{Bi}$ (45.6 min) and $^{223}\text{Ra} \rightarrow ^{219}\text{Rn}$ (4.0 s) $\rightarrow ^{211}\text{Pb}$ (36.1 min) presented in this work consists in obtaining ^{213}Bi and ^{211}Pb via isolation of ultra short-lived intermediates ^{221}Fr and ^{219}Rn .

^{225}Ac was recovered from a proton-irradiated thorium target and contained ~0.2% ^{227}Ac (21.8 y) [2]. Actinium fraction was then adsorbed on a column filled with extraction-chromatographic Actinide Resin (TrisKem) using bis(2-ethylhexyl) methanediphosphonic acid as an extractant. ^{221}Fr was eluted with HCl or HNO_3 solutions of various (0.016-1 M) concentrations. Having passed the column, the eluate was pumped through a pipe long enough for ^{221}Fr decay into ^{213}Bi . ^{213}Bi was concentrated on a second column also filled with Actinide Resin. The solution after the second column was directed to the first column forming a closed loop. As a result, ^{213}Bi was accumulated in the second column up to secular equilibrium with ^{225}Ac which was maintained till the moment of ^{213}Bi elution. Circulation of eluate provided permanent removal of radiolysis products from the columns. In order to strip off ^{213}Bi the second column was switched from the loop to an elution line and solution of 1 M HCl was passed. The total yield of ~90% was obtained. The radionuclidic purity of ^{213}Bi solution was not less than 99.5%.

^{223}Ra was recovered from the same thorium target and contained ~10% ^{224}Ra (3.7 d). The latter generates a similar decay chain $^{224}\text{Ra} \rightarrow ^{220}\text{Rn}$ (55.6 s) $\rightarrow ^{212}\text{Pb}$ (10.6 h). A solution containing radium fraction was evaporated on a quartz support which was then heated at 800°C in argon flow. ^{219}Rn and ^{220}Rn were sublimed and blown out into a silicone pipe where they decayed. Generated isotopes of lead deposited inside the pipe. The values of argon flow, pipe length and accumulation time may be chosen to regulate the impurity of ^{212}Pb in ^{211}Pb down to 0.1-0.5%. After heating, ^{211}Pb was stripped off from the pipe walls with small amount of 0.25 M HNO_3 solution. The total yield of 80-85% ^{211}Pb was obtained. The radionuclidic purity of ^{211}Pb solution was better than 99.9% (except ^{212}Pb). The presented generator based on gas chemical technique is highly resistant to radiation damage.

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2. B.L. Zhuikov, S.N. Kalmykov, S.V. Ermolaev, R.A. Aliev, V.M. Kokhanyuk, V.L. Matushko, I.G. Tananaev, B.F. Myasoedov. Production of ^{225}Ac and ^{223}Ra by irradiation of Th with accelerated protons. *Radiokhimiya*, 2011, v.53, p.73-80.

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