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Production of thorium-227 experimental samples: problem of actinium-227 impurity control

Thorium-227 radionuclide is perspective as a part of radiochemicals for therapy of various types of cancer. It forms strong complexes with monoclonal antibodies due to its chemical properties. In case of its full decay, five alpha particles are emitted, though there are some concerns related to the opportunity of its daughter radionuclide radium-223 uncontrolled migration over the patients'organisms. At present, thorium-227 based radiochemicals are undergoing clinical and preclinical studies.

At RIAR thorium-227 was generated from a long-living radionuclide actinium-227, that was produced by irradiating of the targets containing radium-226, in a high-flux SM-3 reactor. 227Th was extracted by anion exchange chromatography from 8 M HNO3 on BioRad AG-1x8 sorbent. 227Th was eluated with 1 M HCl from chromatography column. For additional purification, 227Th solution was evaporated to dryness, the residual was dissolved in 8 M HNO3 and then it was purified by anion exchange again.

One of the most important characteristics of thorium-227 based radiochemicals is the impurity content of a long-living actinium-227 alpha-emitter. At the same time, direct measurement of its activity by alpha and beta spectrometry does not allow achieving the required detection limits. 227Ac decay is not accompanied by a characteristic gamma-radiation. The peaks in alpha-spectrum corresponding to actinium-227 is on the low-energy slope of alpha peaks of thorium-227 and radium-223. The situation is complicated due to the low yield of alpha-radiation (1,38%), that gives the detection limit ~1% at the collected statistics of 1 million pulses in the alpha spectrum. The conversion electrons and beta-radiation of 223Ra daughter decay products namely lead-211 and bismuth-211 interfere with the measurement of 227Ac activity due to beta-radiation.

There are two main approaches to determine actinium-227 content in thorium-227. The first approach is to store the chosen radiochemical sampling for a long time for thorium-227 decay and to measure alpha and gamma spectra. The second one is based on the chemical extraction of actinium-227 traces from the radiochemical aliquot and the following measurement of their activity. Both approaches are used in this work.

The radiochemical thorium-227 aliquot with activity up to 1 mCi were used for chemical extraction. To prevent 227Ac sorption on the lab glassware surface and to estimate its chemical yield, 1 μg of stable europium in the form of a nitric acid solution of Eu(NO3)3 containing the radioisotope label europium-152 was added to the aliquot. The chemical extraction was performed in two stages. At the first stage actinium-227 was separated from thorium-227 by anion exchange chromatography on BioRad AG1x8 resin. At the second stage actinium-227 was separated from radium-223 traces by cation exchange chromatography in the presence of ammonium salt EDTA on BioRad AG50x8 resin. Actinium-227 activity was measured by alpha-spectrometry. Actinium-227 detection limit achieved by this method was from ~(7-9)·10-5%. Full characteristics of the obtained experimental samples are represented in the report.

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