

Radiochemical procedures for the extraction, separation and purification of Ac-225 and Ra-226 from Ra-irradiated targets at the 22 MeV cyclotron of the Technical University of Munich

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Abstract

In this work important aspects related with the scale up production of ²²⁵Ac based on the irradiation of up to 100 mg of Ra nitrate targets with protons at the 22 MeV compact cyclotron of the TUM will be presented and discussed.

The isochronous 22 MeV proton cyclotron and external beam as well as the rotating target cup containing radium nitrate used for the irradiation are described in a separate paper. Actinium and Ra were extracted from the irradiated target cup by applying a leaching process with diluted mineral acid. Actinium was separated and purified from ²²⁶Ra, ²¹⁰Pb and ²¹⁰Po and chemical (e.g. Al, Si, Na, Mg, etc) and radionuclide impurities by extraction chromatography using the RE or DGA and Sr Resins. Radium was concentrated and purified from all liquid fractions originated from the Ra/Ac separation process by cation exchange using the MP-50 Resin.

A portable Ge-detector (Canberra) was used to monitor the behaviour and recovery of Ra and Ac and daughters in all relevant processes and also for their quantification.

Low activity levels of ²²⁶Ra and ²¹⁰Pb in the purified Ac were quantified by alpha-spectrometry and liquid scintillation counting respectively, after the radiochemical separation of Ac by extraction chromatography. Liquid scintillation counting was also used to measure the gross alpha - beta activity in an aliquot of the purified Ac. The chemical purity in the Ac and Ra fractions was determined by Inductively Coupled Optical Emission Spectroscopy (ICP-OES). A full automation of main production processes enabled to safely handle up to 100 mCi of ²²⁶Ra and to significantly scale up the production of ²²⁵Ac. The breakthrough of Ac into the Ra fractions was negligible which showed the feasibility of using the relevant chromatography systems at high radioactivity levels. The chemical purity of the Ac was estimated to be of less than 4 µg of total inorganic impurities per 1 mCi of ²²⁵Ac being Na the most important contributor and in a minor extent K and Si. Radioisotopic purity was typically higher than 99%. This parameter quickly increases with time as the major impurity ²²⁶Ac decays faster than ²²⁵Ac.

The production of ²²⁵Ac via irradiation of ²²⁶Ra at the cyclotron was successfully scale up using full automation of processes. The Ac was produced with a very high level of chemical and radioisotopic purity as required for its use in alpha-radioimmunotherapy.

Actions that have been taken to further optimize the production yield of Ac, maximize the recovery of Ra and Ac and further improve the quality of the product will be discussed.

Keywords: Ac-225, Ra-226, alpha-radioimmunotherapy, extraction chromatography, cation exchange