Progress Report CERN 2023-2	
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1. Competence centre for internal dosimetry CERN-IRA

1. Introduction

Main activities in 2023

- Our research and development efforts were focussed on implementation of incorporation measurements of ^{225}Ac in urine related to the launch of ^{225}Ac production at the CERN-MEDICIS facility.
- We continued the development of the method for ^{63}Ni incorporation method.
- We pursued our collaboration with MEDICIS for determination and quantification of ^{227}Ac impurity in ^{225}Ac samples.

2. Implementation of incorporation measurements of ^{225}Ac in urine

In the course of 2023, the MEDICIS facility continued the production and mass separation of ^{225}Ac, initially by directly collecting the ^{225}Ac, and lately by collecting ^{225}Ra as generator of ^{225}Ac. In collaboration with the Competence centre for internal dosimetry CERN-IRA, we maintained a surveillance programme for personnel handling ^{225}Ac. During the second half of 2023, several urine samples were collected from workers on the days of ^{225}Ac productions and separation, and measurements were carried out. These measurements did not reveal any indication of ^{225}Ac incorporation by the workers involved in the production of this radionuclide. To our knowledge, this is the first systematic surveillance of ^{225}Ac incorporation implemented as part of occupational radiation protection protocols because our method employing Y-imprinted resin is only available at IRA.

To allow for the commercially available resin cartridges, such as DGA, to be used for the chemical extraction of ^{225}Ac from urine and to develop a scalable incorporation measurement method we continued testing alternative methods using ^{225}Ac tracer provided in the frame of a MEDICIS collaboration. Although the experiments with tracers ^{243}Am and ^{225}Ac demonstrated an equivalent recovery of both radionuclides, the experiments with urine at this stage did not enable us to apply DGA resin for the incorporation measurements. Only approximately 30-40 % of ^{225}Ac was recovered compared to a quantitative recovery of ^{243}Am tracer. A different commercially available resin such as Actinide Resin from Triskem will be tested in 2024.

3. Development of a radioanalytical method for ^{63}Ni extraction in urine and in concrete

As a product arising from the neutron activation of metallic elements, ^{63}Ni represents a risk of internal contamination resulting from the demolition and dismantling of concrete structures. To develop a radioanalytical method for determination of ^{63}Ni in the concrete, radiochemical extraction of ^{63}Ni and separation from other activation radionuclides such as ^{60}Co and ^{55}Fe is required. In 2022 we had tested a Ni-imprinted polymer resin developed in-house for the specific extraction of ^{63}Ni in urine and in the concrete. Chemical recovery of Ni from the concrete sample using this method varied between 30-60 %, however approximately 40 % of ^{60}Co was also present within ^{63}Ni fraction compromising the quantification by liquid scintillation counting (LSC). We reproduced these experiments in 2023, adding stable Co carrier to contaminated concrete samples. The addition of stable Co carrier enabled to reduce ^{60}Co interference from 40 % to 5-10 % in the extracted ^{63}Ni samples, however no complete separation was achieved at this stage. Further method optimisation might be necessary. Overall Ni recovery improved, raising to 67-88 %. This method is in a phase of final optimisation. Once all the experimental data are consolidated, this method will be submitted as an original research paper.

4. Determination and quantification of ^{227}Ac impurity in ^{225}Ac sample

^{225}Ac (actinium-225, $t_{1/2}$ 10 days) is an artificial α-emitting radionuclide with emerging applications as a promising radiopharmaceutical. The decay chain of ^{225}Ac gives rise to a series of short-lived radionuclides in equilibrium: α-emitting ^{221}Fr (francium-221, $t_{1/2}$ 4.9 min), followed by α-emitting ^{217}At (astatine-217, $t_{1/2}$ 32.3 ms) which can be detected using α-spectrometry. α-emitting radionuclide ^{243}Am (americium-243, $t_{1/2}$ 7360 years) is a standardized metrological tracer that proved useful in the quantification of ^{225}Ac using α-spectrometry. Accelerator production of ^{225}Ac involves the formation of β-emitting ^{227}Ac (actinium-227, $t_{1/2}$ 21.77 years) impurity that can be removed using the on-line mass separation technique at CERN-MEDICIS facility. Direct determination of ^{227}Ac is challenging owing to its low-energy β-emissions (at 45 keV and 35.7 keV), however its decay chain includes alpha emitters such as ^{227}Th (thorium-227, $t_{1/2}$ 18.72 days) and progenies at equilibrium which may prove useful for α-spectrometry.

We quantified ^{225}Ac and ^{227}Ac in the sample obtained as a result of a mass separation experiment at CERN-MEDICIS facility. We used α-spectrometry to quantify ^{227}Ac impurity by measuring the ingrowth of ^{227}Ac progenies in the presence of a metrological tracer ^{243}Am. Activity of ^{225}Ac eluted from the sample determined with γ-spectrometry (157.51 ± 1.67 Bq) and with α-spectrometry (151.85 ± 2.25 Bq) was in a good agreement. Targets deposited for α-spectrometry shortly after dissolution of the sample are presumably the most suitable for the quantification of ^{227}Ac yielding an activity of 17.40 ± 0.73 Bq. This work will be continued in 2024.