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Innovative medical radioisotopes for theranostic application, and how they are produced

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Nowadays, there are several developments focused on the expanding of the availability of innovative medical radioisotopes. One of them is the use of mass separators, which can extract a desired isotope from a mixture of others of the same element, a task nearly impossible just by means of chemical methods. An electromagnetic mass separator, dedicated for medical isotope production, has been launched in the frame of CERN-MEDICIS facility. This R&D project is intended: to study and to establish production routes for radionuclides, having a potential for the theranostic approach, like terbium isotopes (Tb-149, Tb-152, Tb-155, Tb-161); to test a purification method for carrier-added Lu-177; and to demonstrate the availability for other innovative isotopes, like Er-169, a nearly pure short-range beta-emitter with similar chemistry to Lu-177.

To identify the optimal requirements for extraction of isotopes of interest, different types of ion sources were studied. It was done by a direct comparison of the performance of surface ion source with laser ion source in a separation of a quantified sample of elements of interest. The ratio between a number of atoms collected after separation and known number of atoms in the sample initially gives an ionization efficiency value, which can serve as a direct measure of the performance. The experiments were performed at the MEDICIS facility in-situ (surface ion source), and at the Mainz University mass separator setup RISIKO (laser ion source).

During the in-situ measurements with the surface ion source, the production of Tb-155 and Er-169 with a high specific activity was demonstrated. On the other side, the collected quantity was only enough for preclinical tests. Thereby, the obtained ionization efficiency was around 5 % for Tb-155 and 0.3 % for Er-169. The experiments with laser ion source gave exceptionally high ionization efficiency results above 50%, what should increase the production performance of terbium and erbium at least by one or two orders of magnitude respectively.

The highly efficient laser ionization process of considered elements has a clear potential to be applied to radioactive ion beam facilities. It will allow the production of radionuclides in a quantity being sufficient for a regular supply of nuclear medicine institutions. In 2019, the MEDICIS Laser Ion Source Setup MELISSA is going to be launched. The combination of the laser resonance ionization and electromagnetic separation will become a starting point for production of many other nuclides, not accessible before because of a strong isotopic contamination. Several experiments are foreseen, to test additionally the performance for scandium and actinium isotopes.

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