

Executive summary actinium-225 feasibility study

This feasibility study on large-scale production of actinium-225 (^{225}Ac), funded through the EU Recovery and Resilience Facility (RRF) under project I-5.08 (M180 – Nuclear Medicine), delivers a comprehensive assessment of the technological package required to enable the large-scale production of ^{225}Ac from radium-226 (^{226}Ra).

The study confirms that Belgium is uniquely positioned to play a leading role in securing European and global supply of this critical radioisotope for targeted alpha therapy (TAT), based on its exclusive legacy stock of ^{226}Ra and the successful development of key enabling technologies across the full production chain.

The project has delivered the following key elements:

1) Operational hot cell installation to handle ^{226}Ra

Development and demonstration of a prototype radon capture system (radon trap) enabling the safe handling of ^{226}Ra ready for implementation at SCK CEN. This radon trapping system allows controlled manipulation of ^{226}Ra sources within existing hot cell facilities and represents a critical enabling step for any large-scale production approach based on radium. The underlying technology has been consolidated through a dedicated European patent, review by authorities and described in a peer reviewed publication.

2) Electron-to-gamma converter design for large-scale production

A high-efficiency electron-to-gamma converter has been designed as part of the preferred photonuclear production route. This technology enables the generation of high-intensity gamma radiation required for the (γ, n) reaction on ^{226}Ra and constitutes a key building block for scalable ^{225}Ac production. The innovation is protected through a dedicated European patent.

3) Target and irradiation module design for large-scale production

The study delivers a design of the ^{226}Ra target and irradiation module, including systems tailored to the selected liquid-gamma irradiation approach. The proposed designs address key challenges such as heat management, radiation safety, and process efficiency, and are supported by experimental validation and patented technological developments.

4) Fully scaled-up radiochemical separation method and ^{226}Ra recycling process

A radiochemical separation process for $^{226}\text{Ra}/^{225}\text{Ac}$ has been developed, validated, and brought to a level compatible with large-scale implementation. The process includes provisions for automation, pharmaceutical-grade production, and efficient recycling of ^{226}Ra , ensuring sustainability and optimal use of the scarce target material. This development is also protected through intellectual property.

5) Conceptual design of a ^{225}Ac production facility

A conceptual design of a dedicated ^{225}Ac production facility has been established. The design integrates all key process steps including irradiation, radiochemical processing, target recycling, and

product handling, while incorporating GMP requirements and radiation protection. This provides a clear pathway towards industrial implementation.

Beyond these CID-aligned deliverables, the project has generated significant innovation outputs, including four European patent applications covering radon trapping, irradiation technology, gamma conversion, and radiochemical processing. Key outcomes of the feasibility study therefore include:

- **Infrastructure** that will ensure the safe handling of ^{226}Ra within hot cell facilities.
- **Scientific publication** – A peer-reviewed article detailing the experimental methodology, resin selection, and performance results of the prototype radon trap.
- **Four key technologies developed and protected** through European patents.
- **Validated technological building blocks** covering the full ^{225}Ac production chain.
- **Conceptual design delivered** for a dedicated large-scale ^{225}Ac production facility.
- **Significant reduction of the technological gap** between current capabilities and industrial-scale implementation.

Together, these results demonstrate that all critical technological components required for large-scale ^{225}Ac production from ^{226}Ra have been successfully developed at feasibility level, with multiple components already advancing beyond a conventional feasibility stage. The integration of these components into a coherent production concept confirms the technical viability and strategic relevance of establishing such a facility in Belgium.

The study concludes that the realization of ^{225}Ac production capacity based on ^{226}Ra is both realistic and strategically important. Its implementation will secure European patients' access to life-saving isotopes while reinforcing Europe's leadership and sovereignty in nuclear medicine.

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