Researchers extract in-demand isotope from plutonium leftovers

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Technicians John Dyer and T. Dyer use a manipulator arm in a shielded cave in ORNL's Radiochemical Engineering Development Center to separate concentrated Pm-147 from byproducts generated through the production of Pu-238. Credit: Richard Mayes/ORNL, U.S. Dept. of Energy

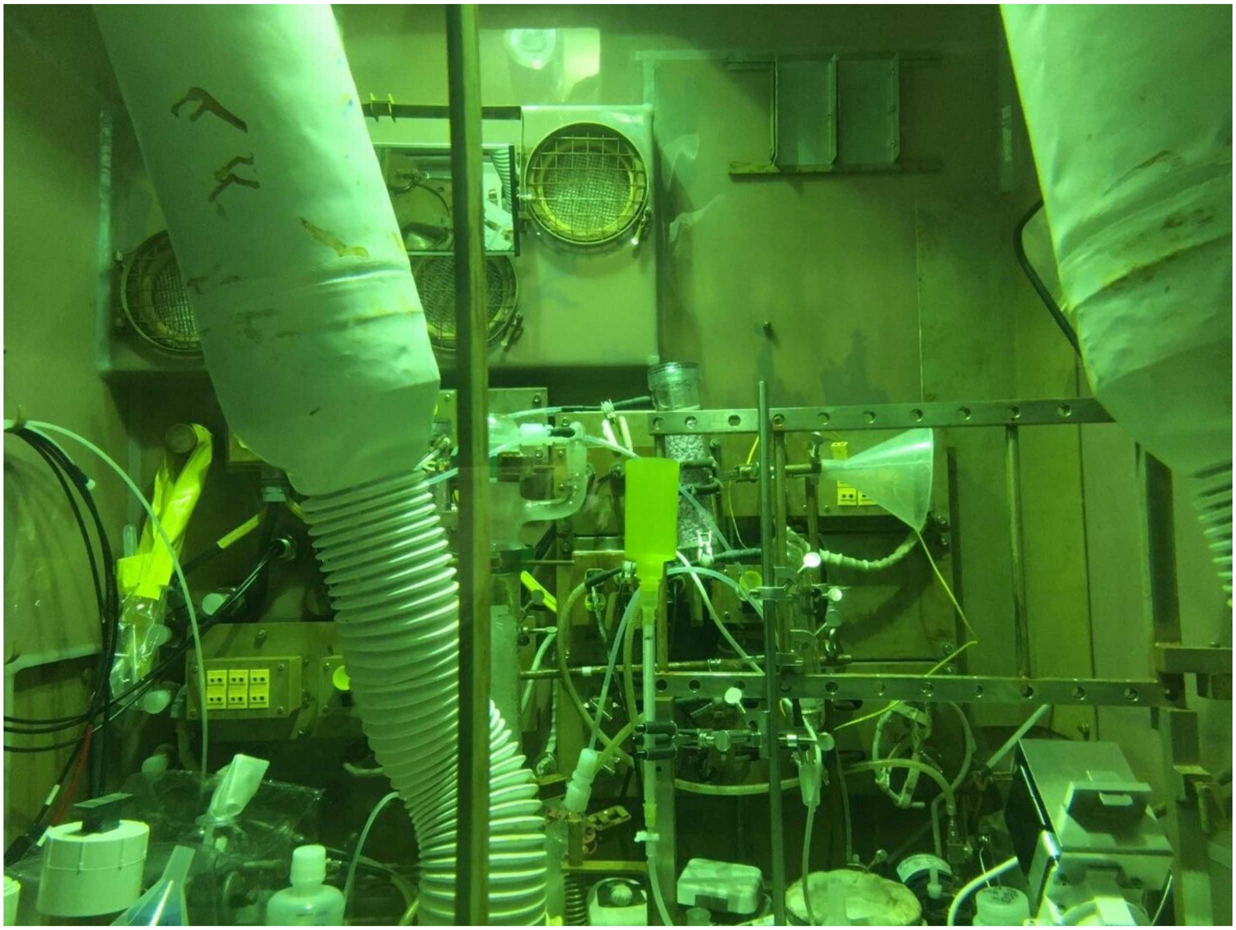
A new method developed at Oak Ridge National Laboratory proves one effort's trash is another's valuable isotope.

One of the byproducts of the Department of Energy lab's national plutonium-238 production program is promethium-147, a rare isotope used in nuclear batteries and to measure the thickness of materials.

It's difficult and costly to dispose of waste containing radioactive elements left over after neptunium-237 targets are irradiated in the High Flux Isotope Reactor, a DOE Office of Science user facility, to produce Pu-238 for space exploration. But last year, a new ORNL project for the DOE Isotope Program began mining Pm-147 from the fission products left when Pu-238 is separated out of the target.

This effort's primary goal is to reestablish domestic production of Pm-147, which is in short supply, and it has a side benefit: reducing the concentrations of radioactive elements in the waste, so that it can be disposed of safely in simpler, less expensive ways both now and in the future.

"In the process of recovering a valuable product that the DOE Isotope Program wants, we realized we can reduce our disposal costs," said ORNL's Richard Mayes, group leader for Emerging Isotope Research. "There's some synergy."



Pm-147, a high-demand isotope that is used in nuclear batteries, is isolated from other byproducts of Pu-238 production in hot cells in ORNL's REDC before it's purified and readied to ship to customers. Credit: Richard Mayes/ORNL, U.S. Dept. of Energy

Pm-147 isn't the only valuable metal in the Pu-238 production waste stream that is of interest to the DOE Isotope Program, but it's the first Mayes' team has successfully extracted. ORNL's Susan Hogle wrote the original proposal to mine Pm-147 from Pu-238 waste and provides computational support detailing potential isotopes present in the solution, and Mayes has been working with Lætitia Delmau, interim group leader for Radiochemical Separations Science Group at ORNL, to develop a process to extract and purify it.

"Currently, we're the only producers of Pm-147 in the U.S., and there's a market for it," Mayes said. Research indicates it could have additional applications in medical imaging and as a radioisotope to generate power for space probes.

While the Pu-238 Supply Program is funded by NASA and managed through DOE's Office of Nuclear Energy, the recovery of Pm-147 is funded by the DOE Isotope Program within DOE's Office of Science.

ORNL is also pursuing research for the DOE Isotope Program in which neodymium-146 is irradiated in the High Flux Isotope Reactor, or HFIR to make Pm-147. This process would provide a new alternative, strengthening the domestic supply chain for this important isotope, and mitigating U.S. dependency on a single foreign supply.

Mayes' team's efforts are tied to the Pu-238 production schedule, which is currently between two and four processing cycles a year. They estimate that there are roughly hundreds of curies of Pm-147 in each batch. Working in around-the-clock shifts for several days, the team uses hot cells in ORNL's Radiochemical Engineering Development Center, or REDC, to isolate a concentrated batch of Pm-147 from the solution of Pu-238 byproducts.

That batch is then transferred into a shielded cave —a smaller type of hot cell—at the REDC, where it's purified and readied to ship to DOE Isotope Program customers. The process involves a few months of effort and around 20 people.

The team will spend the next year demonstrating whether the recovery of Pm-147 from Pu-238 byproducts is sustainable. If so, the project should grow alongside the Pu-238 program. The lab's goal is to produce enough

Pu-238 to yield 1.5 kilograms annually of plutonium oxide, to meet NASA's demands for deep space travel. ORNL-produced plutonium oxide is on board the Perseverance rover now exploring Mars.

Delmau, who specializes in radiochemical separations, said Pm-147 is one of about a dozen elements left after processing Pu-238, and isolating individual elements takes work.

"The separation of lanthanides from each other and from trivalent actinides has been a challenge for decades," she said. "When elements have the same chemical properties, it can be very difficult to pick one out."

At the moment, Pm-147 is the only isotope being harvested from the waste stream, but an important side benefit of the project ultimately could be a substantial decrease in the amount of transuranic material the lab must dispose of. Mayes said successful efforts with Pm-147 may lead to the extraction of other materials at ORNL.

"We have a waste stream that has valuable products in it—products that could have many uses," he said. "Our national labs have the resources and experience to safely and efficiently isolate them."

Provided by Oak Ridge National Laboratory

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