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J. B. Knauer
C. W. Alexander
J. T. Wiggins

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Oak Ridge National Laboratory*
P. O. Box X,
Oak Ridge, Tennessee 37831

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GLOVE BOX OPERATIONS FOR TRANSPLUTONIUM ELEMENT PRODUCTIONS

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Glove boxes are used in the Transuranium Processing Plant[1] (TRU) at Oak Ridge National Laboratory for (1) completing the final chemical processing steps to isolate and purify the transplutonium elements, (2) packaging transplutonium elements for shipment, (3) preirradiation and postirradiation processing of samples used to produce special transplutonium isotopes in the High Flux Isotope Reactor (HFIR), and (4) conducting special projects, which include providing highly purified transplutonium products in special chemical forms and/or in experimental devices as requested by researchers. During 20 years of operation, the quantities of transplutonium elements produced, and thus the amount of radioactivity handled, have continually increased. At the same time, substantial effort has been expended to reduce personnel radiation exposures. Equipment and techniques have been developed to maintain the desired operational capabilities in the glove boxes while keeping radiation exposures to operating personnel as low as reasonably achievable. Developments have included the design and fabrication of product handling and collection devices, product storage containers, and laminated exterior shields of lead glass, lead acrylic, acrylic sheets, polyethylene, and lead.

The TRU Facility is the production, storage, and distribution center for the heavy-element research program of the U.S. Department of Energy. Along with the neighboring HFIR,[2] TRU was built to produce quantities of the transuranium elements for use in research and has been operating since 1966. Target rods are remotely fabricated at TRU, irradiated in the HFIR, and then processed at TRU for the separation and purification of the heavy actinide elements. Irradiated targets are dissolved and processed in groups of 10 to 15 in a sequence of purification steps called a Campaign. A processing

campaign lasts about 3 months. The initial steps to separate the actinide elements from each other and from the fission products formed during irradiation are performed in the remotely operated TRU hot cells. Then, several of the transplutonium element isotopes are transferred to glove box facilities that are dedicated to individual actinides.

Each transplutonium element undergoes several cycles of purification in a glove box facility prior to distribution for heavy-element research programs. The successive stages of product finishing and product shipment packaging are carried out in glove box facilities because (1) they permit the precise handling of the small-scale equipment needed to carry out the intricate separation procedures and (2) they provide containment in which very low levels of cross-contaminants can be maintained and/or controlled. These conditions, which are very difficult to provide in remote-handling facilities, are vital to the achievement of the required decontamination of transplutonium products from other actinides and rare earth elements.

Routine, product finishing glove box operations at TRU include the final separation, purification, and packaging of ^{248}Cm, ^{249}Bk, ^{249}Cf, ^{253}Es, ^{255}Fm, and ^{257}Fm. The quantities involved generally range from tens of milligrams (^{248}Cm) to ~1 pg (^{257}Fm) of final product. The actinides are routinely separated from each other and from fission products by decontamination factors (DFs) of 10^6 to 10^7. Of this, ~10^3 is accomplished in the hot cells and 10^3 to 10^4 is accomplished in the glove box facilities.

While many different elements are separated and purified in glove boxes, the separation chemistry for all of the transplutonium elements is generally similar.[3,4] Final separation of adjacent actinide elements and purification

from rare earth fission products is accomplished by cation-exchange chromatography using α-hydroxyisobutyric acid as the complexing agent. Purification from monovalent and divalent cationic impurities and additional separation of rare earth fission products are also accomplished by cation-exchange techniques using various concentrations of hydrochloric acid.

Transplutonium element special projects carried out in glove boxes include the preparation of electroplated samples of ^{252}Cf (≤1 μg), californium fission chambers, and small californium neutron sources. Many of the preirradiation and postirradiation operations associated with the production in the HFIR of special isotopes, such as ^{250}Cf, ^{251}Cf, ^{242}Cm, and ^{254}Es, are performed in glove boxes. The preirradiation operations are: final purification of the transplutonium element target material; preparation of transplutonium element oxide; blending, dispensing, and pressing of the oxide into the pellet form; and welding of pellets into HFIR targets. Postirradiation processing consists of the final separation of the transplutonium isotope produced, product finishing, and packaging for shipment.

Chemicals and materials used in the glove box processing steps include α-hydroxyisobutyric acid, ammonium nitrate, nitric acid, ultra-pure hydrochloric acid, ethyl alcohol, trichloroethylene, and cation- and anion-exchange resins with various degrees of cross-linkage.

Generally, transplutonium element product finishing and special project operations are performed in glove boxes using standard laboratory-scale equipment, such as centrifuges, muffle furnaces, water baths, heat lamps, automatic pipetters, and assorted glassware as received from the manufacturer. Certain operations, however, require modification of the standard

equipment or the design and fabrication of special equipment, including evaporation rigs, microseparation and purification columns, quartz shipping cones, radiation (alpha, beta, and gamma) detectors, and containers for special shipments and/or irradiations.

The nature of the separations and the resulting products exposes the glove box interiors to rather harsh corrosive conditions and to alpha, beta, gamma, and neutron radiation fields. Because HCl is used in some of the process steps, the glove boxes are of painted, mild steel, and the interior surfaces of the glove boxes are coated with Hypalon™. Transplutonium products are stored in shielded containers. Radiation damage to the glove boxes and to the materials used in the boxes is not serious. Electrical cords, gloves, and radiation detectors are replaced frequently, based on experience.

References

1. L. J. King, J. E. Bigelow, and E. D. Collins, "Experience in the Separation and Purification of Transplutonium Elements in the Transuranium Processing Plant at Oak Ridge National Laboratory," pp. 133-45, in ACS Symposium Series, No. 161, Transplutonium Elements - Production and Recovery, J. D. Navratil and W. W. Schulz, eds., 1981.

2. J. E. Bigelow, B. L. Corbett, L. J. King, S. C. McGuire, and T. M. Sims, "Production of Transplutonium Elements in the High Flux Isotope Reactor," pp. 3-18, in ACS Symposium Series, No. 161, Transplutonium Elements - Production and Recovery, J. D. Navratil and W. W. Schulz, eds., 1981.

3. R. D. Baybarz, J. B. Knauer, and P. B. Orr, Final Isolation and Purification of the Transplutonium Elements from the Twelve Campaigns Conducted at TRU During the Period August 1967 to December 1971, ORNL-4672, 1973.

4. D. E. Benker, F. R. Chattin, E. D. Collins, J. B. Knauer, P. B. Orr, R. G. Ross, and J. T. Wiggins, "Chromatographic Cation Exchange Separation of Decigram Quantities of Californium and Other Transplutonium Elements," pp. 161-71, in ACS Symposium Series, No. 161, Transplutonium Elements - Production and Recovery, J. D. Navratil and W. W. Schulz, eds., 1981.