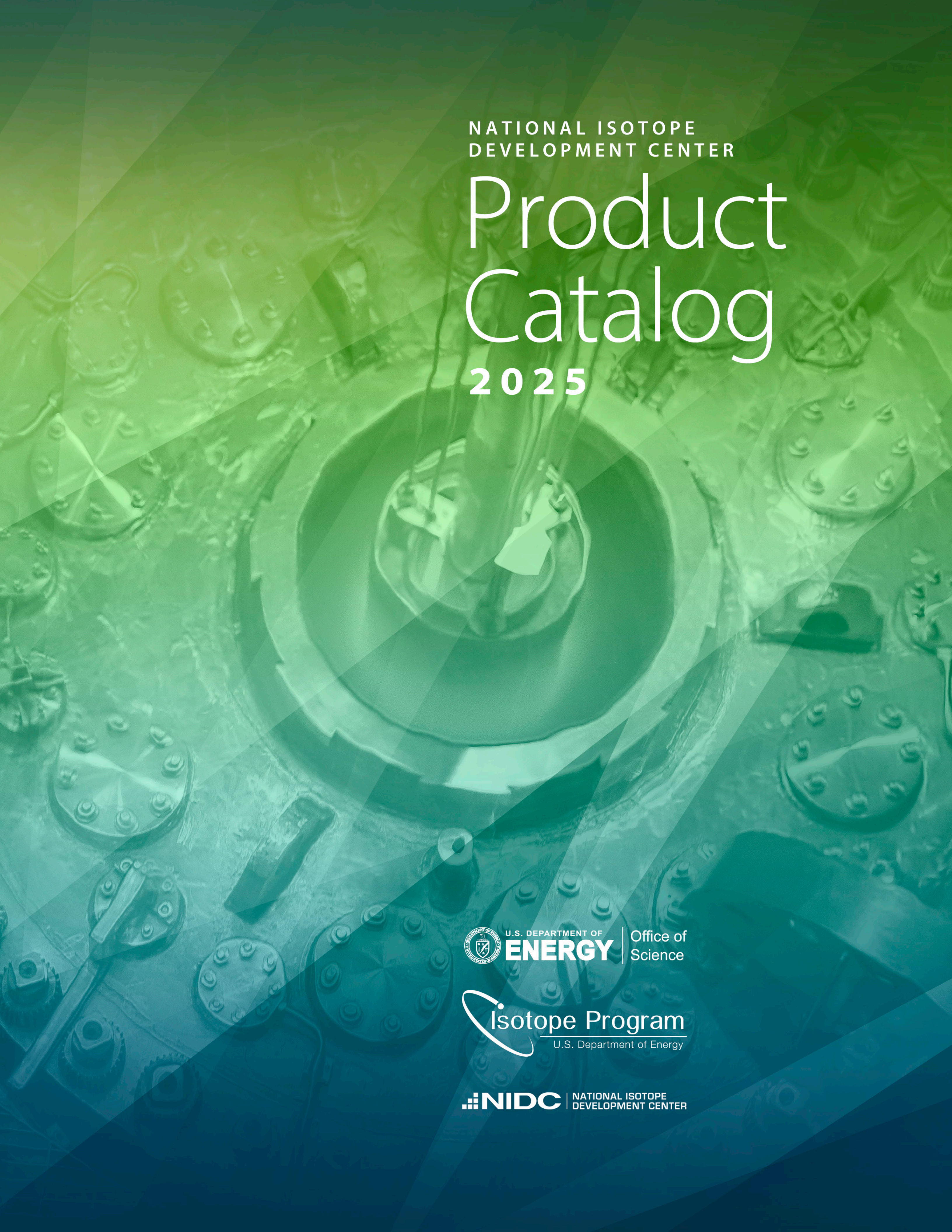

NATIONAL ISOTOPE DEVELOPMENT CENTER

Product Catalog

2025

U.S. DEPARTMENT OF ENERGY | Office of Science

Isotope Program
U.S. Department of Energy

NIDC | NATIONAL ISOTOPE DEVELOPMENT CENTER

Providing the Nation with Critical Isotopes

The U.S. Department of Energy Isotope Program (DOE IP) provides a wide range of isotope products and services to customers worldwide. Continuing a long tradition within the DOE and its predecessor organizations, we are committed to producing and distributing radioisotopes and enriched stable isotopes for research or development purposes (R&D), medical diagnoses and therapy, industrial, homeland security, agricultural, and other useful applications in the national interest.

The program is centrally managed from DOE Headquarters in Germantown, Maryland. Currently, the DOE IP is maintaining isotope production facilities at Argonne, Brookhaven, Idaho, Los Alamos, Oak Ridge, and Pacific Northwest National Laboratories. These facilities produce stable and radioactive isotopes in short supply using nuclear reactors, linear accelerators, and other methods.

The program also partners with universities to invest in R&D and to develop production capabilities. Not only do these universities present unique infrastructure capabilities and expertise, but they are also essential to workforce development.

The DOE IP has established the National Isotope Development Center (NIDC) as an organization that interfaces with the user community and provides corporate services to the DOE IP.

For ordering isotopes or for additional information on isotope products and services, please contact the NIDC or visit our online catalog at www.isotopes.gov.

National Isotope Development Center

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Products and Services

Products that are offered for sale are listed in this catalog. Materials either exist in inventory or can be scheduled to be produced at one or more facilities. Isotopes are sold in forms suitable for incorporation into diverse pharmaceuticals, generator kits, irradiation targets, radiation sources, or other finished products. Stable enriched isotopes may be purchased or leased for nonconsumptive use.

Services are available based on the DOE's extensive expertise derived from many years of isotope R&D, and production operations. These services include chemical processing, target and source irradiations, R&D and testing capabilities, chemical form conversions, and source encapsulations.

To order, contact the NIDC or request a quote on the NIDC website (www.isotopes.gov). Buyers will be required to provide documentation and reason for purchase. Buyers can obtain order forms, instructions, and assistance necessary for a transaction from the NIDC.

Availability of products and services described in this catalog varies, and distribution of some products may not be feasible at some times. However, the DOE is eager to work with current and potential customers to establish new means of production and new products as warranted by demand and national need. If specific products and services are not listed, inquiries are welcome and encouraged.

Prices, terms, and other conditions of purchase are established by the DOE. Price changes may be necessary at any time. However, confirming a purchase order ensures that the stated prices will apply for the term of the order. Price estimates can be obtained from the NIDC. Firm quotations are developed during the ordering process.

Radioactive Isotopes

Isotope	Half-Life/Daughter	Chemical Form	Radionuclidic Purity
Actinium-225 (Th-229 Decay Product)	9.920 days to francium-221	Solid actinium nitrate	>98% Ac-225; <2% Ra-225
Actinium-225 (Accelerator-Produced)	9.920 days to francium-221	Solid actinium nitrate	>99% Ac-225 by activity <2% Ac-227 at shipment
Actinium-227	21.772 years to thorium-227	Solid actinium nitrate	≥99%
Aluminum-26	7.17×10^5 years to magnesium-26	Aluminum(III) in 1 N HCl	>99%
Americium-241	432.6 years to neptunium-237	Oxide powder	>99%
Americium-243	7.364×10^3 years to neptunium-239	Oxide powder	>99%
Arsenic-73	80.30 days to germanium-73	Arsenic(V) in 0.1 N HCl	>99% (exclusive of As-74)
Astatine-211	7.214 hours to polonium-211 and bismuth-207	Astatide as Na salt in NaCl	>99.9%
Barium-133	10.551 years to cesium-133	Nitrate in dilute HNO_3	>99.9%
Berkelium-249	330 days to californium-249	Nitrate or chloride solid	>98%
Beryllium-7	53.22 days to lithium-7	Beryllium(II) in 0.5–5.0 N HCl	>95%
Bismuth-207	31.55 years to lead-207	Bismuth(III) in ≥4 M HNO_3	>99%
Bromine-77	57.0 hours to selenium-77 (stable)	Ammonium bromide in 0.1 M NH_4OH	>99.5%, <0.5% Br-76 at time of shipment
Cadmium-109	461.4 days to silver-109	Cadmium(II) in 0.1 N HCl	>99% (excluding Cd-113m and Cd-115m)
Californium-249	351 years to curium-245	Nitrate or chloride solid	>98%
Californium-252	2.645 years to curium-248	Solution or custom form	>60–80 atom %
Cerium-134	3.16 days to lanthanum-134	Ce(III) in 0.1M HCl	> 99.8% (excluding Ce-135, Ce-137m, Ce-139 and La daughters), Ce-135 < 1%, Ce-137m <5%, Ce-139 <3%
Cerium-139	137.641 days to lanthanum-139	Cerium (III) in 0.5 N HCl	>99%
Cobalt-55	17.53 hours to iron-55	Cobalt(II) in 0.05 N HCl	>99.9%
Cobalt-60	1925.28 days to nickel-60	Nickel-plated pellets (1 mm × 1 mm)	>99%

*Now available from domestic producers

Isotope	Half-Life/Daughter	Chemical Form	Radionuclidic Purity
Curium-244	18.11 years to plutonium-240	Nitrate solid	Variable; analysis provided
Curium-248	3.48×10^{5} years to plutonium-244	Nitrate or chloride solid	>96%
Gadolinium-148	71.1 years to samarium-144	Gadolinium(III) in 0.1 N HCl	>95%
Germanium-68*	270.93 days to gallium-68	Germanium(IV) in <1 N HCl	Product commercially available, contact the NIDC with supply concerns
Gold-199	3.139 days to mercury-199	Chloride solution (0.5 M HCl)	
Holmium-166m	1.20×10^{3} years to erbium-166	Oxide powder	>98%
Iridium-192	73.829 days to platinum-192	Solid metal	>99%
Iron-55	2.744 years to manganese-55	Chloride solution (0.5 N HCl)	Determined on each lot
Iron-59	44.5 days to cobalt-59	Chloride solution (1 to 2.5 N HCl)	
Lead-203	51.7 hours	PbCl2 in <500 µL HCl	>98%
Lutetium-177	6.647 days to hafnium-177	Chloride solution (0.05 N HCl)	≥99%
Manganese-52	5.591 days to chromium-52	Manganese (II) in 0.1 M HCl	<1% Mn-54
Magnesium-28	20.915 hours to aluminum-28	Magnesium chloride in 0.1 N HCl	No gamma emitters detected (<0.5%)
Mercury-194	444 years to gold-194	2 N HNO_3	>99%
Neptunium-237	2.144×10^{6} years to protactinium-233	Oxide powder	>99%
Neptunium-237 Fission Monitors	2.144×10^{6} years to protactinium-233	Ceramic oxide wire encapsulated in high purity vanadium	<40 ppm fissionable atoms
Nickel-63	101.2 years to copper-63	Chloride solution 0.1 M HCl or dried chloride solid	>99%
Plutonium-238	87.7 years to uranium-234	Oxide powder	>99%
Plutonium-239	2.411×10^{4} years to uranium-235	Oxide powder	>99%
Plutonium-240	3.6319 days to radon-220 6,561 years to uranium-236	Oxide powder	>99%
Plutonium-241	14.329 years to uranium-237	Nitrate or chloride solid or oxide powder	80–93%

*Now available from domestic producers

Isotope	Half-life/Daughter	Chemical Form	Radionuclidic Purity
Plutonium-242	3.73×10^5 years to uranium-238	Oxide powder or nitrate or chloride solid	>99%
Polonium-209	124 years to lead-205	5 M HNO_3 solution	>99%
Promethium-147	Coming soon	Coming soon	Coming soon
Radium-223	11.43 days to radon-219	Nitrate solid	≥99.9%, not including decay products
Radium-224	3.6319 days to radon-220	Radium chloride in 1 M HCl solution or solid radium nitrate	>99.9% Ra-224; <0.1% Th-228
Radium-224/ Lead-212 Generator	Radium-224: 3.6319 days to radon-220 Lead-212: 10.64 hours to bismuth-212	Ra-224 absorbed on AG MP-50 resin	>99.9% Ra-224; <0.001% Th-228
Radium-225	14.9 days to actinium-225	Nitrate solid	>99%
Radium-226	1,600 years to radon-222	Radium carbonate or radium nitrate salt	>99%
Rhenium-186	3.7183 days to osmium-186	Sodium perrhenate solution or solid	>99%
Rubidium-83	86.2 days to krypton-83	Rubidium (I) in 0.05–0.5 N HCl	Rb-86/Rb-83: <0.05% Rb-84/Rb-83: <0.1%
Selenium-72	8.40 days to arsenic-72	Selenium(IV) in 0.5–5.0 N HCl_3	Determined on each lot
Selenium-75	119.78 days to arsenic-75	Selenium(IV) in 6 N HNO	High purity. TBD after inital processing
Silicon-32	153 years to phosphorus-32	Silicon(IV) in 0.1 N NaOH	>99.9%
Sodium-22	2.6018 years to neon-22	Sodium chloride in H_2O	>99%
Strontium-85	64.849 days to rubidium-85	Strontium (Sr^2+) chloride in 0.1 N HCl	>99%
Strontium-89	50.563 days to yttrium-89	Strontium chloride in 0.1–0.5 N HCl	>99.8%
Strontium-90	28.79 years to yttrium-90	Nitrate solid	>99.99%
Technetium-99	2.111×10^5 years to ruthenium-99	Solid ammonium pertechnetate or technetium metal	>99%
Tellurium-123m	119.2 days to tellurium-123	Elemental	Major impurity is I-131 at ~150 µCi/mg Te
Thorium-227	18.697 days to radium-223	Nitrate solid	≥99%
Thorium-228	1.9116 years to radium-224	Nitrate solid	≥99%

*Now available from domestic producers

ISOTOPE	HALF-LIFE/DAUGHTER	CHEMICAL FORM	RADIONUCLIDIC PURITY
Thorium-229	7,880 years to radium-225	Nitrate in 0.1 N HNO_3 or dry nitrate salt	≥99%
Tin-117m	14.00 days to tin-117	Tin metal in quartz tube or tin(IV) in 0.1 N HCl	>99%
Titanium-44	60 years to scandium-44	Ti(IV) in 6 M HCl	
Tungsten-188	69.78 days to rhenium-188	Sodium tungstate solution	>99%
Uranium-234	2.455×10^5 years to thorium-230	Oxide powder	>94%
Uranium-235	7.038×10^8 years to thorium-231	Oxide powder	>98%
Uranium-238	4.468×10^9 years to thorium-234	Oxide powder	>99.9%
Uranium-238 Fission Monitors	4.468×10^9 years to thorium-234	Ceramic oxide wire encapsulated in high purity vanadium	<40 ppm fissionable atoms
Vanadium-48	15.9735 days to titanium-48	Vanadium(V) in 6 N HCl	>99%, excluding vanadium-49
Xenon-127	36.346 days to iodine-127	Elemental gas	≥99% radioxenons; ≥ 80% xenon-127
Yttrium-86	14.74 hours to strontium-86	Yttrium(III) in 0.05–0.5 N HCl	>96%
Yttrium-88	106.626 days to strontium-88	Yttrium(III) in 0.1 N HCl	>99%
Zinc-65	243.93 days to copper-65	Zinc(II) in 0.05–0.5 N HCl	>99%
Zirconium-88	83.4 days to yttrium-88	Zirconium(IV) in 0.1 N HCl	>99% (excluding yttrium-88 daughter)

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*Now available from domestic producers

Product Highlight

Actinium-225 Products

Intended Use: Actinium-225 is of considerable interest for its uses in targeted alpha therapy because of its relatively short half-life and high-energy radiation capable of breaking bonds in DNA. Multiple clinical trials are underway in both the United States and Europe to study its effect on a variety of malignant cells including those found in acute myeloid leukemia, non-Hodgkin's lymphoma, brain tumors; gastric, prostate, bladder, ovarian, and pancreatic cancers; and melanoma. Bismuth-213, a daughter isotope of actinium-225 and fellow alpha emitter, is also available through the DOE IP via an Ac-225/Bi-213 generator.

To help mitigate anticipated shortages as Ac-225 progresses from clinical trials to developed radiopharmaceutical drugs, the DOE IP now routinely produces Ac-225 via high energy proton accelerators located at Brookhaven and Los Alamos National Laboratories, in addition to regular "milking" of a Th-229 cow housed at Oak Ridge National Laboratory. Furthermore, the program continues to actively pursue and invest in additional production routes to further augment global supply.

Actinium-225 (Thorium-229 Decay)

Half Life/Daughter: 9.920 days to francium-221
Chemical Form: Solid actinium nitrate
Radionuclidic Purity: >98% Ac-225; <2% Ra-225

PRODUCTION

Production Route: Decay of thorium-229
Processing: Separated by ion exchange

DISTRIBUTION

Shipment: Glass screw cap bottle in nonreturnable container
Availability: Weekly; 4–6 weeks advance order
Special Ordering Information: Can also be supplied as a low-activity Bi-213 generator
Unit of Sale: Millicuries

Actinium-225 (Accelerator-Produced)

Half Life/Daughter: 9.920 days to francium-221
Chemical Form: Solid actinium nitrate
Radionuclidic Purity: ≥99% by activity (gamma spectroscopy), not including daughter isotopes or Ac-227; ≤2% Ac-227 at shipment (value extrapolated from earlier runs)

PRODUCTION:

Source: Proton irradiation of a natural thorium target at Brookhaven or Los Alamos National Laboratory, chemically processed at Brookhaven or Oak Ridge National Laboratory.
Processing: Separated by ion exchange and extraction chromatography

DISTRIBUTION:

Shipment: Glass screw top V-vial in nonreturnable container
Availability: Every 3 weeks
Special Ordering Information: Can also be supplied as a Bi-213 generator
Unit of Sale: Millicuries

To request a quote for actinium-225 (thorium decay or accelerator produced),
please visit www.isotopes.gov

Product Highlight

Astatine-211

Intended Use: Astatine-211 is of interest for use in targeted alpha therapy. This short-lived alpha-emitting radionuclide ($t_{1/2}$ = 7.214 hours) is well suited for this purpose, as it offers the potential for extremely localized irradiation of malignant cells when attached to cancer-targeting agents while leaving neighboring cells intact. Currently, clinical trials are underway to study the effectiveness of an At-211-labeled radiopharmaceutical in treating patients with leukemia and lymphoma.

The DOE IP works with the University of Washington and Texas A&M University, DOE IP university partners, to routinely produce At-211 via the ^{209}Bi(α,2n)^{211}At reaction by bombarding a natural bismuth metal target with alpha particles. As the DOE IP's University Isotope Network continues to expand, At-211 and other short-lived alpha-emitting isotopes will benefit from a more robust and reliable regional production network.

Half Life/Daughter: 7.214 hours to polonium-211 and bismuth-207

Chemical Form: Sodium astatide in 0.05 N sodium hydroxide

Activity: 370–1,850 MBq (10–50 mCi) at shipment

Radionuclidic Purity: >99% At-211 (based on gamma spectroscopy, evaluated quarterly)

Radioisotopic Purity: >99.5% (based on gamma spectroscopy, evaluated quarterly)

Radiochemical Purity: ≥85% (area%) Na[^{211}At] At; other ^{211}At species may be present (e.g., [^{211}At]astatate)

PRODUCTION

Production Route: Alpha irradiation of bismuth metal

Processing: Special order

DISTRIBUTION

Shipment: Screw cap vial in approved Department of Transportation package

Availability: Special order

Unit of Sale: Millicuries

Grade: Non-cGMP grade

To request a quote for astatine-211,
please visit www.isotopes.gov

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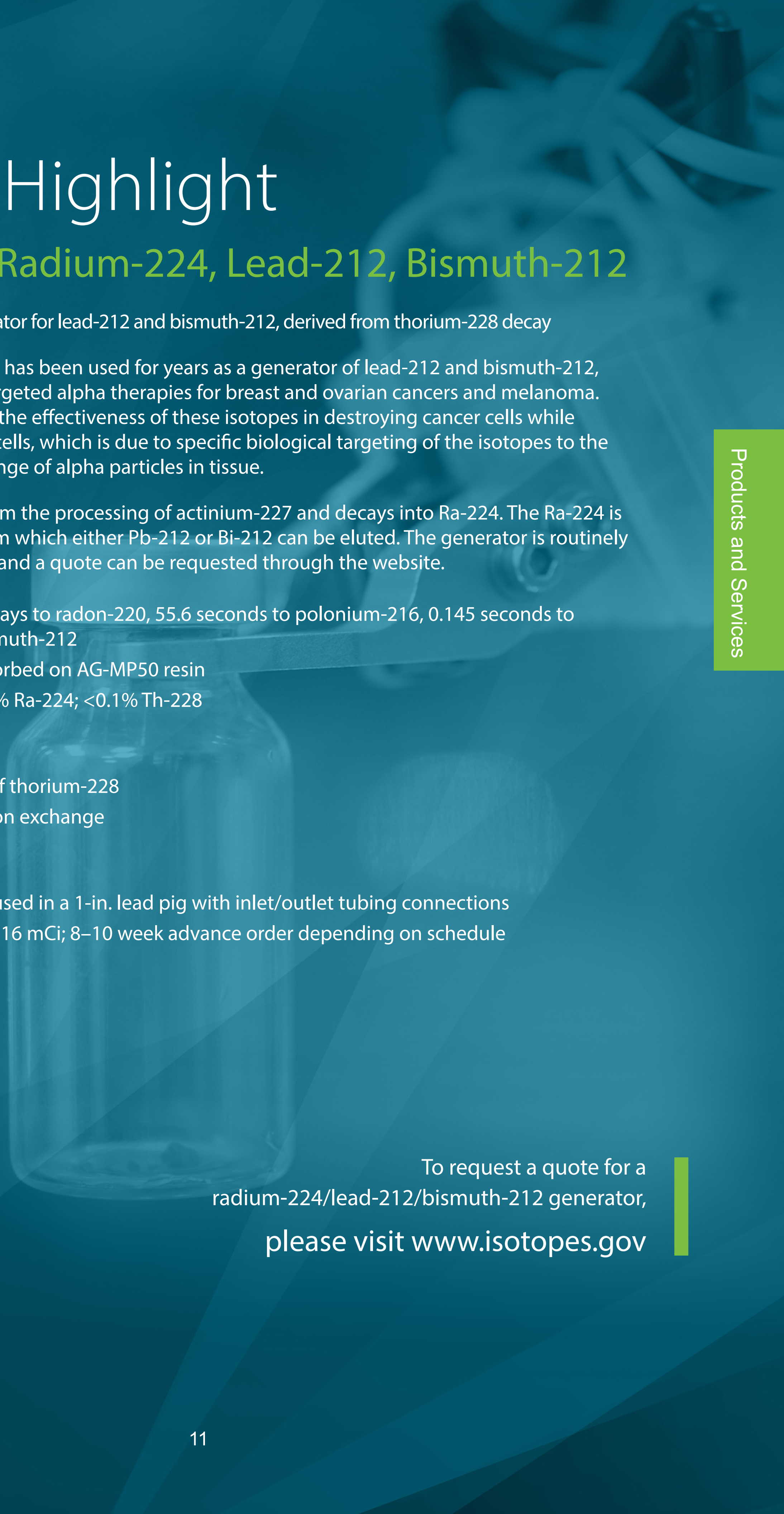


Product Highlight

Thorium-228, Radium-224, Lead-212, Bismuth-212

Product: Radium-224 generator for lead-212 and bismuth-212, derived from thorium-228 decay

Intended Use: Radium-224 has been used for years as a generator of lead-212 and bismuth-212, both of which are used in targeted alpha therapies for breast and ovarian cancers and melanoma. Research has demonstrated the effectiveness of these isotopes in destroying cancer cells while limiting damage to healthy cells, which is due to specific biological targeting of the isotopes to the cancer cells and the short range of alpha particles in tissue.

Thorium-228 is extracted from the processing of actinium-227 and decays into Ra-224. The Ra-224 is loaded onto a generator from which either Pb-212 or Bi-212 can be eluted. The generator is routinely available through the NIDC, and a quote can be requested through the website.

Half-Life/Daughter: 3.66 days to radon-220, 55.6 seconds to polonium-216, 0.145 seconds to lead-212, 10.64 hours to bismuth-212

Chemical Form: Ra-224 absorbed on AG-MP50 resin

Radionuclidic Purity: >99.9% Ra-224; <0.1% Th-228

PRODUCTION:

Production Route: Decay of thorium-228

Processing: Separated by ion exchange

DISTRIBUTION:

Shipment: Generator is housed in a 1-in. lead pig with inlet/outlet tubing connections

Availability: Monthly up to 16 mCi; 8–10 week advance order depending on schedule

Unit of Sale: Millicuries

To request a quote for a
radium-224/lead-212/bismuth-212 generator,
please visit www.isotopes.gov

Product Highlight

Tungsten-188

In recent years tungsten-188 and its daughter isotope rhenium-188 have gained traction in the nuclear medicine community for their gamma and beta emissions, offering both therapeutic and diagnostic value. For example, Re-188's beta emissions have demonstrated impressive results when penetrating malignant tumors, especially bone metastases.

Tungsten-188 ($t_{1/2}$ = 69.78 days) is produced at the DOE High Flux Isotope Reactor at Oak Ridge National Laboratory through the neutron bombardment of the enriched stable isotope, tungsten-186. The W-188 product is offered as sodium tungstate in NaOH solution.

Half-Life/Daughter: 69.78 days to rhenium-188
Chemical Form: Sodium tungstate solution
Radionuclidic Purity: >99%

PRODUCTION

Production Route: Double neutron capture on enriched tungsten-186 metal targets
Processing: Target dissolved in excess sodium hydroxide and hydrogen peroxide

DISTRIBUTION

Shipment: Screw cap bottle in nonreturnable container
Availability: Special order; 10–12 weeks advanced notice requested

To request a quote for tungsten-188,
please visit www.isotopes.gov

Product Highlight

Strontium-89

Strontium-89 has been identified as an effective radioisotope for use in cancer therapy to relieve pain associated with cancer that has spread to bone. Belonging to the same periodic family as calcium, strontium metabolizes in a similar fashion and once reaching areas of active bone growth, will emit low doses of radiation, damaging any adjacent tumors.

Strontium-89 is produced via neutron capture on an enriched strontium-88 oxide target using the DOE’s High Flux Isotope Reactor, located at Oak Ridge National Laboratory. Following radiochemical processing, the product has a radionuclidic purity of >99.8% and is sold as strontium chloride solution in 0.1 N HCl.

Half-Life/Daughter: 50.563 days to yttrium-89
Chemical Form: Strontium chloride in 0.1–0.5 N HCl
Radionuclidic Purity: >99.8%

PRODUCTION

Production Route: Neutron capture on strontium-88 oxide target

Processing: Dissolution and ion exchange

DISTRIBUTION

Shipment: Screw cap bottle

Availability: Special order

To request a quote for strontium-89,
please visit www.isotopes.gov

Stable Isotopes

ELEMENT	ISOTOPE	ENRICHMENT (%)	ABUNDANCE (%)	PRODUCT FORM
Antimony	Sb-121	>99.4	57.21	Metal, oxide, sulfide
	Sb-123	>99	42.79	
Argon	Ar-36	>99.8	0.3336	Gas*
	Ar-40	>99.95	99.6035	
Barium	Ba-130	8–37	0.106	Carbonate, chloride, metal, nitrate
	Ba-132	21–28	0.101	
	Ba-134	73	2.147	
	Ba-135	78–93	6.592	
	Ba-136	92–95	7.854	
	Ba-137	81–89	11.232	
	Ba-138	>97	71.698	
Bromine	Br-79	>98	50.69	Ammonium bromide*
	Br-79 non EM	90–91	50.69	Potassium bromide, silver bromide, sodium bromide
	Br-81	>97	49.31	Potassium bromide, silver bromide, sodium bromide
Cadmium	Cd-106	79–88	1.25	Bromide, chloride, iodide, metal, oxide, sulfide
	Cd-108	68–69	0.89	
	Cd-110	93–97	12.49	
	Cd-111	92–96	12.80	
	Cd-112	97–98	24.13	
	Cd-113	91–95	12.22	
	Cd-114	>98	28.73	
	Cd-116	93–98	7.49	
Calcium	Ca-40	>99.8	96.94	Carbonate, chloride, iodide, metal, nitrate, oxide
	Ca-42	92–94	0.647	
	Ca-43	61–83	0.135	
	Ca-44	79–98	2.09	
	Ca-46	4–30	0.004	
	Ca-48	66–97	0.187	
Cerium	Ce-136	21–50	0.185	Chloride, hydrated nitrate, metal, oxide
	Ce-138	17–26	0.251	
	Ce-140	>99	88.45	
	Ce-142	83–92	11.114	
Chlorine	Cl-35	>99.3	75.76	Barium chloride, lead chloride, potassium chloride, silver chloride, sodium chloride
	Cl-35 non EM	>99.6	75.76	
	Cl-37	95–98	24.24	
Chromium	Cr-50	75–97	4.345	Metal powder, oxide
	Cr-52	>99.7	83.789	
	Cr-53	95–98	9.501	
	Cr-54	90–96	2.365	
Copper	Cu-63	>99.6	69.15	Metal, oxide
	Cu-65	>99.4	30.85	

* Material sold as is

ELEMENT	ISOTOPE	ENRICHMENT (%)	ABUNDANCE (%)	PRODUCT FORM
Dysprosium	Dy-156	20–22	0.056	Chloride, metal, nitrate, oxide
	Dy-158	20–32	0.095	
	Dy-160	69.6	2.329	
	Dy-161	90–95	18.889	
	Dy-162	92–96	25.475	
	Dy-163	89–96	24.896	
	Dy-164	92–98	28.26	
Erbium	Er-162	27–34	0.139	Chloride, metal, nitrate, oxide
	Er-164	62–73	1.601	
	Er-166	96	33.503	
	Er-167	91	22.869	
	Er-168	95–97	26.978	
	Er-170	95–96	14.91	
Europium	Eu-151	91–96	47.81	Chloride, metal, nitrate, oxide
	Eu-153	98	52.19	
Gadolinium	Gd-152	32–34	80.2	Chloride, metal, nitrate, oxide
	Gd-154	65–66	2.18	
	Gd-155	84–94	14.80	
	Gd-156	82–99	20.47	
	Gd-157	79–88	15.65	
	Gd-158	81–97	24.84	
	Gd-160	>97	21.86	
Gallium	Ga-69	>99.4	60.108	Metal, oxide
	Ga-71	>99.2	39.892	
Germanium	Ge-70	84–98	20.57	Metal, oxide
	Ge-72	90–98	27.45	
	Ge-73	83–94	7.75	
	Ge-74	94–98	36.50	
	Ge-76	73–92	7.73	
Hafnium	Hf-174	6–19	0.16	Metal, oxide
	Hf-176	63–77	5.26	
	Hf-177	84–91	18.60	
	Hf-178	87–94	27.28	
	Hf-179	81–86	13.62	
	Hf-180	93–98	35.08	
Helium	He-3	>99.80		
Indium	In-113	59–96	4.29	Metal, oxide
	In-115	>99.9	95.71	
Iridium	Ir-191	95–98	37.3	Metal powder
	Ir-193	>98	62.7	
Iron	Fe-54	95–98	5.845	Chloride, metal, nitrate, oxide, sulfate
	Fe-56	>99.6	91.754	
	Fe-57	72–92	2.119	
	Fe-58	65–84	0.282	

* Material sold as is

ELEMENT	ISOTOPE	ENRICHMENT (%)	ABUNDANCE (%)	PRODUCT FORM
Krypton	Kr-78	8–99	0.355	Gas*
	Kr-80	71–97	2.286	
	Kr-82	71–92	11.593	
	Kr-84	90–92	56.987	
	Kr-86	50–99	17.279	
Lanthanum	La-138	6	0.08881	Chloride, nitrate, oxide
	La-139	>99.9	99.9119	
Lead	Pb-204	63–99	1.4	Acetate, carbonate, chloride, metal, nitrate, oxide, sulfide
	Pb-206	>98	24.1	
	Pb-207	91–92	22.1	
	Pb-208	>97	52.4	
Lithium	Li-6	95–99	7.59	Hydroxidemonohydrate, carbonate, chloride, flouride, metal, sulfate oxide
	Li-7	>99.5	92.41	
Lutetium	Lu-175	>99.8	97.401	Metal, nitrate, oxide
	Lu-176	39–74	2.599	
Magnesium	Mg-24	>99.6	78.99	Carbonate, chloride, metal, oxide, sulfate
	Mg-25	97–98	10.00	
	Mg-26	>98	11.01	
Mercury	Hg-196	13–73	0.15	Chloride, metal, oxide, sulfide
	Hg-198	82–93	9.97	
	Hg-199	85–91	16.87	
	Hg-200	88–96	23.10	
	Hg-201	74–96	13.18	
	Hg-202	>95	29.86	
	Hg-204	83–98	6.87	
Molybdenum	Mo-92	90–98	4.53	Metal, oxide
	Mo-94	82–92	9.15	
	Mo-95	89–96	15.84	
	Mo-96	91–96	16.67	
	Mo-97	83–94	9.60	
	Mo-98	95–98	24.39	
	Mo-100	91–99	9.82	
Neodymium	Nd-142	84–98	27.152	Chloride, metal, nitrate, oxide
	Nd-143	90–91	12.174	
	Nd-144	97	23.798	
	Nd-145	73–91	8.293	
	Nd-146	63–97	17.189	
	Nd-148	87–95	5.756	
	Nd-150	68–97	5.638	
Neon	Ne-22	71	9.25	Gas*
Nickel	Ni-58	>99.5	68.077	Chloride, metal, oxide
	Ni-60	>98	26.223	
	Ni-61	84–99	1.1399	
	Ni-62	86–99	3.6346	
	Ni-64	90–99	0.9255	
Nitrogen	N-15	67-69	0.37	Ammonium sulfate

* Material sold as is

ELEMENT	ISOTOPE	ENRICHMENT (%)	ABUNDANCE (%)	PRODUCT FORM
Osmium	Os-184	5	0.02	Dioxide, metal powder
	Os-186	67–79	1.59	
	Os-187	34–73	1.96	
	Os-188	86–94	13.24	
	Os-189	81–95	16.15	
	Os-190	95–96	26.26	
	Os-192	>98	40.78	
Oxygen	O-16	>99.9	99.757	Water*
Palladium	Pd-102	73–78	1.02	Chloride, metal, oxide
	Pd-104	86–95	11.14	
	Pd-105	90–97	22.33	
	Pd-106	96–98	27.33	
	Pd-108	96–98	26.46	
	Pd-110	97–98	11.72	
Platinum	Pt-190	1–4	0.012	Metal
	Pt-192	41–56	0.782	
	Pt-194	91	32.86	
	Pt-195	93–97	33.78	
	Pt-196	94	25.21	
	Pt-198	91	7.36	
Potassium	K-39	>99.9	93.2581	Carbonate, chloride, nitrate
	K-40	2–3	0.0117	
	K-41	>98	6.7302	
Rhenium	Re-185	96	37.40	Metal
	Re-187	>96	62.60	
Rubidium	Rb-85	>99.4	72.17	Carbonate, chloride, iodide, nitrate
	Rb-87	>97	27.83	
Ruthenium	Ru-96	93-99	5.54	Metal powder, oxide
	Ru-98	82–89	1.87	
	Ru-99	96–97	12.76	
	Ru-100	95–97	12.60	
	Ru-101	96–97	17.06	
	Ru-102	>98	31.55	
	Ru-104	>98	18.62	
Samarium	Sm-144	85	3.07	Chloride, metal, nitrate, oxide
	Sm-147	98	14.99	
	Sm-148	90–96	11.24	
	Sm-149	91–97	13.82	
	Sm-150	87–99	7.38	
	Sm-152	>97	26.75	
	Sm-154	98	22.75	

* Material sold as is

ELEMENT	ISOTOPE	ENRICHMENT (%)	ABUNDANCE (%)	PRODUCT FORM
Selenium	Se-74	55–77	0.89	Metal, oxide
	Se-76	93–97	9.37	
	Se-77	91–94	7.63	
	Se-78	97–98	23.77	
	Se-80	>99.3	11.24	
	Se-82	87–97	8.73	
Silicon	Si-28	>97	92.223	Metal, oxide, silicic acid
	Si-29	88–95	4.685	
	Si-30	83–96	3.092	
Silver	Ag-107	>98	51.839	Acetate, chloride, metal, nitrate
	Ag-109	>97	48.161	
Strontium	Sr-84	80–99	0.56	Carbonate, chloride, fluoride, metal, nitrate, oxide
	Sr-86	95–97	9.86	
	Sr-87	84–94	7.00	
	Sr-88	>99.8	82.58	
Sulfur	S-32	>98	31.55	Cadmium sulfide, calcium sulfate, calcium sulfide, elemental, iron sulfide, lead sulfide, magnesium sulfate, potassium sulfate, sodium sulfate, zinc sulfide
	S-33	17–88	0.75	
	S-34	85–94	4.25	Cadmium sulfide, calcium sulfate, calcium sulfide, elemental, iron sulfide, lead sulfide, magnesium sulfate, potassium sulfate, sodium sulfate, zinc sulfide
	S-34 non EM	9–97	4.25	Carbon disulfide*
	S-36	1–3	0.01	Cadmium sulfide, calcium sulfate, calcium sulfide, elemental, iron sulfide, lead sulfide, magnesium sulfate, potassium sulfate, sodium sulfate, zinc sulfide
	S-36 non EM	5–30	0.01	Carbon disulfide*
Tantalum	Ta-180	5	0.01201	Oxide
Tellurium	Te-120	41–56	0.09	Metal, oxide
	Te-122	94–97	2.55	
	Te-123	77–90	0.89	
	Te-124	93–98	4.74	
	Te-125	93–95	7.07	
	Te-126	98	18.84	
	Te-128	>98	31.74	
	Te-130	>98	34.08	
Thallium	Tl-203	92–97	29.524	Nitrate, oxide
	Tl-205	>99	70.48	
Tin	Sn-112	67–68	0.97	Chloride, metal, oxide
	Sn-114	51–69	0.66	
	Sn-115	17–40	0.34	
	Sn-116	95–96	11.24	
	Sn-117	84–92	7.68	
	Sn-118	96–97	24.22	
	Sn-119	84–89	8.59	
	Sn-120	97–98	32.58	
	Sn-122	90–92	4.63	
	Sn-124	92–96	5.79	

* Material sold as is

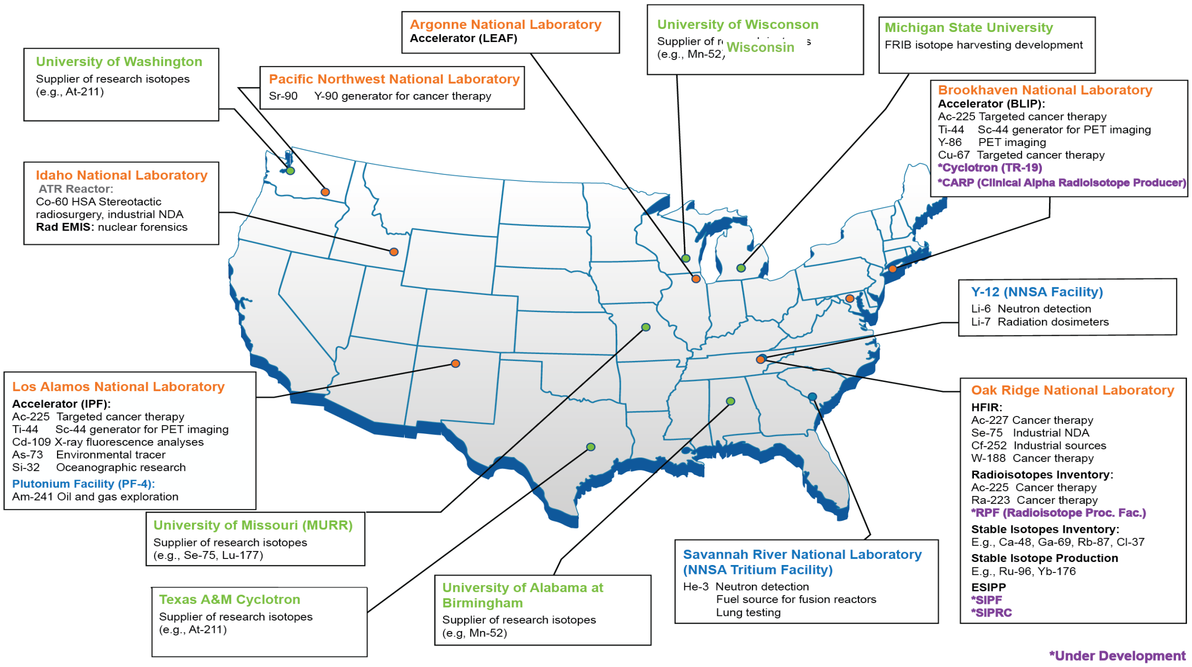
ELEMENT	ISOTOPE	ENRICHMENT (%)	ABUNDANCE (%)	PRODUCT FORM
Titanium	Ti-46	73–96	8.25	Metal powder or solid, crystal bar, oxide
	Ti-47	80–94	7.44	
	Ti-48	>99	73.72	
	Ti-49	66–96	5.41	
	Ti-50	67–83	5.18	
Tungsten	W-180	6–11	0.12	Ammonium tungstate, metal powder, oxide
	W-182	92–94	26.50	
	W-183	73–87	14.31	
	W-184	92–95	30.64	
	W-186	>96	28.43	
Vanadium	V-50	36–44	0.25	Oxide
Xenon	Xe-124	5–99	0.0952	Gas*
	Xe-126	99	0.089	
	Xe-129	80–88	26.4006	
	Xe-131	81–87	14.09	
	Xe-134	51	10.4357	
	Xe-136	89–94	8.8573	
Ytterbium	Yb-168	13–33	0.123	Chloride, metal, nitrate, oxide
	Yb-170	64–78	2.982	
	Yb-171	87–95	14.09	
	Yb-172	92–97	21.68	
	Yb-173	89–94	16.103	
	Yb-174	96–98	32.026	
	Yb-176	96-99.7	12.996	
Zinc	Zn-64	>97	49.17	Acetate, chloride, metal, oxide, sulfate, beads
	Zn-66	>98	27.73	
	Zn-67	88–94	4.04	
	Zn-68	>99	18.45	
	Zn-70	65–99	0.61	
Zirconium	Zr-90	>96	51.45	Metal, oxide
	Zr-91	88–94	11.22	
	Zr-92	94–98	17.15	
	Zr-94	96–98	17.38	
	Zr-96	58–95	2.80	

* Material sold as is

Aligning the Nation's Key Isotope Producers

The DOE IP has stewardship over the Brookhaven Linear Isotope Producer (BLIP) Facility at Brookhaven National Laboratory (BNL); the Isotope Production Facility (IPF) at Los Alamos National Laboratory (LANL); and hot cell facilities for processing isotopes at Oak Ridge National Laboratory (ORNL), BNL, and LANL. Additionally, it supports the production of isotopes at several of other facilities, including the High Flux Isotope Reactor at ORNL; the Enriched Stable Isotope Prototype Plant (ESIPP) and the Advanced Test Reactor (ATR) at Idaho National Laboratory (INL); the Plutonium Facility at LANL; the Facility for Rare Isotope Beams at Michigan State University; the Tritium Facility at Savannah River National Laboratory (SRNL); the Low-Energy Accelerator Facility at Argonne National Laboratory (Argonne); and Pacific Northwest National Laboratory (PNNL).

In addition, the DOE IP's University Isotope Network (UIN) comprises five schools: the University of Washington, the University of Missouri Research Reactor Center, the University of Wisconsin, University of Alabama-Birmingham and Texas A&M University.



University of Washington
Supplier of research isotopes
(e.g., At-211)

Pacific Northwest National Laboratory
Sr-90 Y-90 generator for cancer therapy

Argonne National Laboratory
Accelerator (LEAF)

University of Wisconson
Supplier of r[illegible]s
(e.g., Mn-52)
Wisconsin

Michigan State University
FRIB isotope harvesting development

Brookhaven National Laboratory
Accelerator (BLIP):
Ac-225 Targeted cancer therapy
Ti-44 Sc-44 generator for PET imaging
Y-86 PET imaging
Cu-67 Targeted cancer therapy
***Cyclotron (TR-19)**
***CARP (Clinical Alpha Radioisotope Producer)**

Idaho National Laboratory
ATR Reactor:
Co-60 HSA Stereotactic radiosurgery, industrial NDA
Rad EMIS: nuclear forensics

Y-12 (NNSA Facility)
Li-6 Neutron detection
Li-7 Radiation dosimeters

Los Alamos National Laboratory
Accelerator (IPF):
Ac-225 Targeted cancer therapy
Ti-44 Sc-44 generator for PET imaging
Cd-109 X-ray fluorescence analyses
As-73 Environmental tracer
Si-32 Oceanographic research
Plutonium Facility (PF-4):
Am-241 Oil and gas exploration

Oak Ridge National Laboratory
HFIR:
Ac-227 Cancer therapy
Se-75 Industrial NDA
Cf-252 Industrial sources
W-188 Cancer therapy
Radioisotopes Inventory:
Ac-225 Cancer therapy
Ra-223 Cancer therapy
***RPF (Radioisotope Proc. Fac.)**
Stable Isotopes Inventory:
E.g., Ca-48, Ga-69, Rb-87, Cl-37
Stable Isotope Production
E.g., Ru-96, Yb-176
ESIPP
***SIPF**
***SIPRC**

University of Missouri (MURR)
Supplier of research isotopes
(e.g., Se-75, Lu-177)

Texas A&M Cyclotron
Supplier of research isotopes
(e.g., At-211)

University of Alabama at Birmingham
Supplier of research isotopes
(e.g, Mn-52)

Savannah River National Laboratory (NNSA Tritium Facility)
He-3 Neutron detection
Fuel source for fusion reactors
Lung testing

***Under Development**

Argonne's Low-Energy Accelerator Facility (LEAF)

LEAF Description

The Low-Energy Accelerator Facility (LEAF) combines an electron linear accelerator (LINAC) with a Van de Graaff (VDG) electron accelerator. The LEAF has undergone significant improvements since its construction in 1969, including an increase in beam energy to 50 MeV and power up to 25 kW (average exceeding 20 kW in energies relevant to radioisotope production).

The LEAF's LINAC provides continuous or pulsed beams, and multiple target station locations facilitate remote operations and post-run target transfers. The low energy (3 MeV) VDG electron accelerator complements the LINAC by delivering high levels of electron/photon dose rates (in pulsed or continuous mode) to critical components, testing for radiation hardness and stability while avoiding activation and handling hazards of the irradiated targets.

General Applications

Radioisotope separation and purification method development, radioisotope production, targetry, radiation testing and material response to received dose, and material activation.

Supporting Facilities

Hot cells, radiochemical laboratories, and an analytical chemistry laboratory are housed at the LEAF to support separations, processing, and purity analysis activities.

Examples of Routinely Produced Radioisotopes:

Scandium-47 (under development)

Technical Contact

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Brookhaven Linac Isotope Producer (BLIP)

BLIP Description

Built in 1972, the Brookhaven Linac Isotope Producer (BLIP) uses high energy protons for radioisotope production by diverting excess beam off of the 200 MeV BNL proton Linac.

Proton Energies: Energies of 118, 140, 162, 184, or 202 MeV are diverted down a 30 m long beamline.

Target Channels: Six mechanically independent target channels are available. Most recently, target channels have been grouped into two boxes holding up to four targets each.

Operating Cycles

Production of isotopes in the BLIP is dependent upon the operating cycle of the linac. The schedule and duration of linac operation is determined by the plans and funding of the nuclear physics experiments.

Supporting Facilities

Eight radiochemistry development labs and nine lead and steel hot cells are housed at the BLIP. In addition, BNL has an instrumentation lab for radionuclide assay by high-purity germanium detector, gamma ray spectroscopy, NaI spectroscopy, liquid scintillation, and elemental assay by inductively coupled plasma optical emission spectroscopy, inductively coupled plasma mass spectrometry, and labeling determinations with HPLC. Isotopes may be produced under cGMP conditions when a customer quality agreement is in place.

Examples of Routinely Produced Radioisotopes

Actinium-225
Beryllium-7
Cerium-134
Rubidium-83
Selenium-72
Strontium-85
Titanium-44
Zinc-65
Yttrium-86

Technical Contact

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INL Advanced Test Reactor (ATR)

Reactor Description

The INL Advanced Test Reactor (ATR) is the only U.S. research reactor that offers large-volume, high-flux neutron irradiation in a prototype environment, making it a prime candidate for studying the effects of intense neutron and gamma radiation on reactor materials and fuels. The 250 MW reactor operates at low pressure and low temperature with a high neutron flux up to ~10^{15} neutrons/cm^2 per second. The reactor is cooled by light water with a beryllium reflector for high neutron efficiency.

Irradiation Positions

The ATR can accommodate an extensive range of irradiation testing. It is equipped with a unique serpentine core that allows the reactor's corner lobes to be operated at different power levels, making it possible to conduct multiple simultaneous experiments under different testing conditions. Other key characteristics include large test volumes, up to 48 in. long and 5 in. in diameter; 77 testing positions; fast/thermal flux ratios ranging from 0.1 to 1.0; constant axial power profile; power tilt capability for experiments in the same operating cycle; frequent experiment changes; and a seismic shutdown system that can automatically shut down the plant if certain levels of seismic activity are detected.

Examples of Routinely Produced Radioisotopes

High specific activity cobalt-60

Technical Contact

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LANL Isotope Production Facility (IPF)

Accelerator Description

The Isotope Production Facility (IPF), commissioned in 2004, is a 100 MeV proton beam line extracted from the Los Alamos Neutron Science Center (LANSCE) 800 MeV accelerator at Los Alamos National Laboratory. The target station has three standard irradiation positions used for large-scale isotope production, with the option to operate at lower currents and/or thinner targets for smaller productions or nuclear data measurements. The energy range of the irradiation positions can also be customized to accommodate specific experiments. Small targets may be activated in the high energy secondary neutron flux to produce research quantities of isotopes.

IPF operates routinely at beam currents up to 275 μA for approximately 3,500 hours year but can be operated in a dedicated mode for additional operation hours. The standard run cycle for LANSCE is from June to December. Efforts are underway to increase the maximum current for target irradiation to 450 μA and beyond.

Irradiation Positions

High energy slot: 90–70 MeV (p,xn) and (p,xnyp) reactions
Medium energy slot: 65–45 MeV (p,xn) and (p,αxn) reactions
Low energy slot: 30–0 MeV (p,xn) and (p,αxn) reactions

Cross Section Measurements

In addition to measurements up to 100 MeV at IPF, other facilities at the LANSCE accelerator may also be used for the measurement of proton-induced cross sections at 800 MeV and 200–100 MeV using low intensity (~100 nA) proton beam.

Hot Cell and Processing Facilities

The LANL Hot Cell Facility at TA-48 contains 13 hot cells with shielding sufficient for handling 1 kCi of cobalt-60, is equipped for performing routine separations via standard techniques including chromatography and liquid-liquid extraction. Laboratories are equipped with robust counting capabilities and analytical equipment for qualifying final products. Isotopes may be produced under Current Good Manufacturing Practice conditions when a customer quality agreement is in place.

Examples of Current Routinely Produced Radioisotopes

Actinium-225
Aluminum-26
Arsenic-73
Bismuth-207
Cadmium-109
Cerium-134
Cerium-139
Gadolinium-148
Germanium-68
Silicon-32
Sodium-22
Titanium-44
Yttrium-88
Zirconium-88

Technical Contact

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ORNL High Flux Isotope Reactor (HFIR)

Reactor Description

Oak Ridge National Laboratory's High Flux Isotope Reactor, or HFIR, offers the highest flux (up to 2.6 × 10^{15} neutrons/cm^2 per second at 85 MW) and is one of the most versatile irradiation facilities in the world. It was constructed to meet production needs of heavy element isotopes, but its mission has since expanded to include materials irradiation, neutron activation, and neutron scattering. More than 500 researchers conduct neutron scattering experiments each year at HFIR.

The reactor is beryllium-reflected, light-water-cooled, and moderated, and uses highly enriched uranium-235 as fuel. With its beryllium reflector last replaced in 2002, operation is expected through at least 2030.

Irradiation Positions

Hydraulic Tube (HT) Facility

An HT facility with nine HT high-flux irradiation positions in the core region permit insertion/removal of targets any time during reactor operation. This facility is ideally suited for short-term irradiations.

High-Volume/High-Flux Large Target Positions

The core region also has unparalleled space for very large targets.

Peripheral Target Positions

Located on edge of flux trap. Permit thermal flux values of 1–1.7 × 10^{15} neutrons/cm^2 per second at 85 MW and 6 positions available for full-cycle irradiations. Accessible only during refueling and used for long-term and multicycle irradiations.

High-Volume Irradiation Positions

Located in the beryllium reflector region, control rod access plugs holes, vertical experiment facility positions, etc.

Examples of Current Routinely Produced Radioisotopes

Actinium-225
Actinium-227
Barium-133
Californium-252
Nickel-63
Radium-223
Radium-224/Lead-212
Radium-226
Selenium-75
Strontium-89
Thorium-227
Thorium-228
Tungsten-188

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