

INTERNATIONAL DIRECTORY OF RADIOISOTOPES

VOLUME I

**UNPROCESSED AND PROCESSED RADIOISOTOPE PREPARATIONS
AND SPECIAL RADIATION SOURCES**

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INTRODUCTION

The "International Directory of Radioisotopes" contains information on all radioisotopes which are for sale or distribution by the major suppliers in the world.

For easier handling the directory is divided into two volumes. Volume I contains complete Tables of Radioisotopes, including unprocessed and processed isotope preparations, and solid radiation sources for special applications. Volume II, which will soon follow, will contain a list of the labelled compounds of carbon 14, hydrogen 3, iodine 131, phosphorus 32 and sulphur 35. The information given in Volume I includes the most important current physical data, such as half-lives and radiations. Isotopes are arranged alphabetically which was thought to be a more convenient arrangement for the reader than the systematic arrangement by atomic number frequently used in physical tables. Every effort has been made to achieve a uniform presentation.

Specific activities of unprocessed isotopes, listed by European suppliers who have a range of fluxes available at the same price, have been given for 10^{14} n/cm²/sec. This could not be done in the case of suppliers, such as AECL and ORNL, who have a system of prices varying with fluxes used for irradiation.

Price quotations in local currency have been converted into US dollars to allow comparison.

Definitions of terms used and information on the tables are given. Regarding suppliers, readers are referred to the list of suppliers.

SAFE HANDLING OF RADIOACTIVE MATERIALS

The International Atomic Energy Agency has published a manual entitled: "Safe Handling of Radioisotopes" (IAEA Safety Series No. 1, Vienna 1968). The reader is referred to this manual for all questions concerning transportation, handling and storage of sealed and unsealed sources, including problems of monitoring, decontamination, and waste disposal. The following classifications, indicating the relative toxicity of the more common isotopes, may be of use to the reader as a guide for the precautions to be taken in the handling of unsealed sources:

Class 1 (very highly toxic, minimum significant quantity 0.1 μ c): Sr 90 + Y 90, Pb 210 + Bi 210 (Ra D + E), Po 210, At 211, Ra 226, Ac 227, U 233, Pu 239, Am 241, Cm 242.

Class 2 (highly toxic, minimum significant quantity 1 μ c): Ca 45, Fe 59, Sr 89, Y 91, Ru 106 + Rh 106, I 131, Ba 140 + La 140, Ce 144 + Pr 144, Sm 151, Eu 154, Tm 170, natural Thorium, Th 234 + Pa 234, natural uranium.

Class 3 (moderately toxic, minimum significant quantity 10 μ c):

Na 22, Na 24, P 32, S 35, Cl 36, K 42, Sc 46, Sc 48, V 48, Mn 52, Mn 54, Mn 56, Fe 55, Co 58, Co 60, Ni 59, Cu 64, Zn 65, Ga 72, As 74, As 76, Br 82, Rb 86, Zr 95 + Nb 95, Nb 95, Mo 99, Tc 96, Tc 98, Rh 105, Pd 103 + Rh 103, Ag 105, Ag 111, Cd 109 + Ag 109, Sn 113, Te 127, Te 129, I 132, Cs 137 + Ba 137, La 140, Pr 143, Pm 147, Ho 166, Lu 177, Ta 182, W 181, Re 183, Ir 190, Ir 192, Pt 191, Pt 193, Au 196, Au 198, Au 199, Tl 200, Tl 202, Tl 204, Pb 203.

Class 4 (slightly toxic, minimum significant quantity 100 μ c): H 3, Be 7, C 14, F 18, Cr 51, Ge 71, Tl 201.

Quantities up to 100 times the minimum significant quantity of any isotope can be handled in a general chemical laboratory, taking ordinary precautions. Quantities between 100 and 100,000 times the minimum significant quantity should be dealt with by a radiochemical laboratory; higher quantities only by a special high-level activity laboratory.

In dealing with radiation sources, exposures to radiation should always be as short as possible. The maximum dose for a person occupationally exposed at a constant rate from the age of 18 years is 0.1 rem/week. No person should accumulate the maximum dose at a rate in excess of 3 rems through any 13 consecutive weeks.

When a person is occupationally exposed at an age of less than 18 years, the dose shall not exceed 5 rems in any one year under age 18 and the dose accumulated to age 30 shall not exceed 60 rems.

SUPPLIERS OF RADIOISOTOPES

The following is a comprehensive list of all suppliers appearing in Volume I and/or Volume II of this Directory. It contains information on the range of services and products offered by the different suppliers, and some general price information.

Entries are arranged in the alphabetical order of the abbreviations used for the suppliers' names in this Directory.

Additional information is given at the end of this list concerning countries which intend to manufacture isotopes in the near future. This information is given in the alphabetical order of the names of these countries.

AECL Atomic Energy of Canada Limited, Commercial Products Division, P. O. Box 93, Ottawa, Canada

Principal supplier of radioisotopes in Canada. Supplies naturally occurring radioelements and reactor produced isotopes, and carries out service irradiations. A thermal neutron flux up to $5 \times 10^{12} \text{ n/cm}^2/\text{sec}$ is available.

Charges: for service irradiations with $7 \times 10^{12} \text{ n/cm}^2/\text{sec}$: \$ 25.00 hc + \$ 3.50/day (minimum \$ 46.00);
for service irradiations with $4 \times 10^{12} \text{ n/cm}^2/\text{sec}$: \$ 25.00 hc + \$ 20.00/day (minimum \$ 145.00);
for standard units (prepared by irradiation with $7 \times 10^{12} \text{ n/cm}^2/\text{sec}$): \$ 10.00 hc + charges varying with cost of target and duration of irradiation.

Also supplies an extensive list of special preparations, services and equipment, including Co 60, Ra 226 and Ir 192 radiography sources, teletherapy units, and Ra and Co medical sources in the form of wire, needles, tubes, and in various applicators. I 131, P 32 and S 35 labelled compounds (available in Canada only) have not been included in this Directory. AECL also offers a consulting and advisory service on a commercial basis.

An authorization for procurement of radioisotopes must be obtained from the Canadian Atomic Energy Control Board.

AEE Atomic Energy Establishment, Isotopes Division, Trombay, Bombay, India

Supplies all usual pile produced unprocessed isotopes (no list given). Some of the more important processed isotopes are also produced. The thermal neutron flux available is 3 to $10 \times 10^{11} \text{ n/cm}^2/\text{sec}$. Higher fluxes will probably soon be available.

AERE Atomic Energy Research Establishment, Isotope Division, Harwell, Didcot, Berkshire, England

Principal supplier of radioisotopes in England. Supplies mainly reactor produced unprocessed isotopes. Some processed isotopes, separated fission products and cyclotron produced isotopes are also available.

Prices quoted in this Directory refer to irradiations carried out in BEPO. A thermal neutron flux from 10^{10} to 1.2×10^{12} n/cm²/sec is available. A thermal column is operated at 10^{14} n/cm²/sec.

Irradiations can also be carried out in DIDO with a thermal flux of up to 3×10^{12} (soon to be extended to higher fluxes). Later, orders will be accepted for irradiations in PLUTO with a thermal flux of up to 10^{12} .

Charges: for irradiation in BEPO: £ 3. (\$ 8.40)/week, £ 9. (\$ 25.20)/4 weeks + £ 3. (\$ 8.40) hc;

for irradiation in DIDO: £ 9. (\$ 25.20)/week, £ 27. (\$ 75.60)/4 weeks + £ 10. (\$ 28.00) hc;

for bombardment in the cyclotron, with up to 170 MeV protons: £ 10. (\$ 28.00)/hour (+ costs of processing).

In addition, AERE supplies radioactive standards and various special sources including Co 60, Ir 192 and Tm 170 radiography sources, Co 60, Au 198, Y 90 and P 32 medical sources, Co 60 multicurie sources, Cs 137 teletherapy sources, Sb/Be neutron sources, and H 3 loaded targets. An isotope advisory service, a radio-activation analysis service, a service for the artificial colouring of diamonds by neutron bombardment and facilities for high intensity ionizing irradiations, are among the services listed.

AL Abbot Laboratories Pacific Limited, Merchandise Mart Plaza, Chicago 54, Illinois, USA

Supplies radiopharmaceuticals. Preparations containing short-lived isotopes are precalibrated.

Note: AL has recently issued a revised catalogue and price list which was received too late for inclusion in this directory. Please contact AL for exact information.

ANL Argonne National Laboratory, Special Materials Division, P. O. Box 299, Lemont, Illinois, USA

Supplies isotopes not normally available from ORNL. Thermal neutron fluxes up to 2×10^{12} n/cm²/sec are available at the CP-5 reactor. Offers fast neutron irradiation service at its experimental breeder reactor in Idaho (maximum fast flux 2×10^{14} n/cm²/sec), and 60-inch cyclotron irradiations.

Charges: for irradiations in CP-5 with $< 1 \times 10^{12}$ n/cm²/sec: \$ 15.00/week, \$ 45.00/month;
with $> 1 \times 10^{12}$ n/cm²/sec: \$ 25.00/week, \$ 75.00/month;
for cyclotron irradiations: \$ 50.00/hour.

In addition, a handling fee of \$ 15.00 is charged for each sample.

BIO Bio-Rad Laboratories, 800 Delaware St., Berkeley 10, California, USA

Supplies C 14 and H 3 labelled compounds. Prices are f. o. b. destination in the USA or Canada. A packaging charge of \$ 15.00 is added to the price of each package of less than 0.5 mc. Many compounds are available in 50 µc (licence exempt) quantities.

BN Belgonucleaire, 35, rue des Colonies, Brussels, Belgium

Principal supplier of radioisotopes in Belgium. Supplies a large number of unprocessed and processed reactor produced isotopes, some C 14 and H 3 labelled compounds and a range of Co 60 and Ir 192 radiography sources. Pile irradiations are normally carried out at a thermal flux of 10^{12} n/cm²/sec. For price information please contact BN.

BNL Brookhaven National Laboratory, Associated Universities, Inc., Isotopes and Special Materials Group, Upton, Long Island, New York, USA

Supplies F 18, I 132, I 133, and Mg 28, as well as a standard reactor units (not listed) prepared with a maximal thermal flux of $> 10^{15}$ n/cm²/sec. (Contact supplier for price information). Cyclotron bombardment, gamma ray irradiation and hot laboratory services are offered.

BUCH Bachler & Co., Braunschweig, Frankfurter Strasse 294, Federal Republic of Germany

Supplies natural and some pile produced isotopes in various processed forms. Offers Ra/Be, RaD/Be and Po/Be neutron sources. Supplies Co 60 in a plastic material (Plastobalt-M) and a range of thickness gauges and static eliminators as well as instruments for safe handling of isotopes.

CCBR California Corporation of Biochemical Research, 3625 Medford Street, Los Angeles 63, California, USA

Supplies C 14 labelled biochemicals (including nucleic acid derivatives and amino acids) in 1 µc vials at \$ 8.00 per vial.

CEA Commissariat a l'Energie Atomique, B. P. No. 2, Gif-sur-Yvette (Seine-et-Oise), France

Principal supplier of radioisotopes in France. Supplies unprocessed reactor produced isotopes prepared with a thermal flux of 0.3 to 3.5×10^{15} n/cm²/sec.

Charges are: *F.frs* 8,000 (\$ 16.00)/week, *F.frs* 15,000 (\$ 30.00)/month of irradiation.

Some processed isotopes and many labelled compounds containing C 14, S 35, or H 3 are available. Co 60 and Ir 192 radiography sources are supplied and gamma irradiation services offered. CEA also supplies standard sources of most radioisotopes. Contact CEA for procurement procedure.

CRU Canadian Radium & Uranium Corporation, 630 Fifth Avenue, New York 20, N. Y., USA

Supplies radium and its daughter products in various forms, including radium needles and tubes for therapy and Ra/Be, RaD/Be and Po/Be neutron sources.

DPC Daiichi Pure Chemicals Co., Ltd., No. 1, 3 - Chome, Edobashi, Nihonbashi, Chuo-ku, Tokyo, Japan
Supplies C 14-labelled compounds, Ca 45-EDTA, Fe 59-Hemin and some S 35 compounds.

FALK M. Falk & Co., Ltd., Emefko House, Bell Street, Reigate, Surrey, England

Supplies radiographic sources of Co 60, Cs 137, Ir 192 and Tm 170, and various industrial radiography equipment.

FB Fleischmann, Burd & Co., Inc., 22 West 48th Street, New York 36, N. Y., USA

Supplies Ra 224 (ThX) in alcohol, lacquer or ointment for alpha-ray treatment.

IP Institut Pasteur, Laboratoire des Isotopes, rue du Dr. Roux, Paris 15, France

Supplies C 14-labelled compounds (mainly l-amino acids and sugars) and Co 60 labelled vitamine B₁₂.

IS Isotopes Specialities Co., Inc., 170 W. Providence, Burbank, California, USA

Division of NCA. Supplies various labelled compounds (including C 14 compounds), industrial tracer preparations and radiation sources for radiography, thickness gauging and research. Consulting, film badge, bioassay, waste disposal and decontamination services are offered. Some handling equipment is also available. A \$ 10.00 handling charge is added to all orders of C 14 compounds in quantities of less than 0.5 mc.

JAERI Japan Atomic Energy Research Institute, No. 1, 1-Chome, Tamuracho, Minatoku, Tokyo, Japan

Principal supplier of radioisotopes in Japan. Supplies a small number of isotopes in processed form. Will start overall production of isotopes by the end of 1960. Most isotopes will be available from 1961, C 14 and Co 60 from 1962.

JENER Joint Establishment for Nuclear Energy Research, Isotope Division, P. O. Box 175 — Lillestrøm — Norway

Principal supplier of radioisotopes in Norway. Supplies unprocessed and some processed reactor produced isotopes. Maximum thermal flux available is $1.35 \times 10^{15} \text{ n/cm}^2/\text{sec}$.

Charges are Nkr 60.00 (\$ 8.50)/week, or Nkr 120.00 (\$ 16.80)/month of irradiation. An additional charge is made for expensive target materials. Special irradiations at low power level may be carried out at Nkr 200.00 (\$ 28.00)/hour. A range of Co 60 and Ir 192 radiography sources is listed. An advisory and experimental service is offered.

M Merck Sharp & Dohme International, Division of Merck & Co., Inc., 100 Church Street, New York 7, N. Y., USA

Supplies Co 60-labelled vitamin B₁₂.

MK Merck & Co., Limited, P. O. Box 899, Montreal 3, Quebec, Canada

Supplies C 14 and H 3 labelled compounds. (No list given of H 3 labelled compounds). Prices quoted are f. o. b. Montreal.

ML Mound Laboratory, Monsanto Chemical Company, Miamisburg, Ohio, USA

Supplies alpha, heat, and neutron sources from Po 210, and neutron sources from Pu 239. Prices are f. o. b. Miamisburg, Ohio.

N Nuclear Consultants Corporation, 9842 Manchester Road, St. Louis 19, Missouri, USA

Supplies radiopharmaceuticals. Compounds containing short-lived isotopes are precalibrated. Various therapeutic Co 60 radiation sources, such as needles, tubes and seeds, are listed. Other metallic sources are available as seeds. Consultation, film badge, instrumentation, analytical and training services are offered.

NBS National Bureau of Standards, US Department of Commerce, Washington 25, D. C., USA

Supplies primary and secondary standards of natural and of artificially produced radioisotopes. Price per certified standard is \$ 20.00 (express collect) for almost all preparations listed.

NC Nuclear Chicago Corporation, 223 West Erie Street, Chicago 10, Illinois, USA

Supplies C 14, P 32 and S 35 labelled compounds. The C 14 compounds are sold in 0.5 mc and in 50 μ c (licence exempt) packages. Most compounds are available from stock. Standards of I 131, K 42, P 32, Na 24 and Au 198 are available at \$ 20.00. Prices are prepaid air express within USA.

NCA Nucleonic Corporation of America, 196 Degraw Street, Brooklyn 31, New York, USA

Supplies various processed isotopes, some measuring instruments and a range of C 14 labelled compounds originally manufactured by RS.

NENC New England Nuclear Corporation, 575 Albany Street, Boston 18, Massachusetts, USA

Supplies compounds labelled with C 14 (in large and in licence exempt quantities), H 3, P 32, S 35 and I 131. Offers H 3 random labelling by Wilzbach H 3 irradiation technique (from \$ 100.00 upwards). Some beta and gamma standard sources (including simulated sources of short-lived isotopes) are available. Radioassay and consulting services are offered.

NPL The National Physical Laboratory, Teddington, Middlesex, England

Supplies primary standard solutions of Na 24, P 32, I 131, Au 198, Sr 90 and Co 60.

NS Nuclear Systems, a division of "The Budd Company", 2950 Robert Avenue, Philadelphia 32, Pennsylvania, USA

Supplies Co 60 and Ir 192 sources for radiography and teletherapy. An annual source service is offered for users of Ir 192 sources. Gamma radiography and teletherapy equipment, dosimeters and survey meters are available. Enquiries for thickness-density gauges are invited. Prices are f. o. b. Philadelphia, Pennsylvania.

NSEC Nuclear Science and Engineering Corporation, P. O. Box 10901, Pittsburgh 36, Pennsylvania, USA

Supplies from stock a large number of accelerator produced radioisotopes and undertakes to make available

upon request almost any nuclide which can be produced in a cyclotron or synchrocyclotron. A consultation and training service is offered.

Prices quoted are f.o.b. Pittsburgh, Pennsylvania. A \$ 10.00 handling charge is made for each package.

OR Orlando Research, Inc., 100 Crystal Lake Drive, P. O. Box 6491, Orlando, Florida, USA

Supplies a large number of C 14 labelled compounds and undertakes to supply P 32 and S 35 labelled compounds upon request. C 14 and S 35 compounds are available also in licence exempt quantities.

A \$ 10.00 handling charge is made on orders of less than 0.5 mc.

ORNL Oak Ridge National Laboratory, Union Carbide Nuclear Company, Isotopes Sales Department, P. O. Box X Oak Ridge, Tennessee, USA

Principal US source of radioisotopes. Supplies reactor produced unprocessed and processed isotopes including separated fission products. Irradiations are carried out at the ORNL graphite reactor with a maximum thermal flux of 1.2×10^{15} n/cm²/sec or at the low intensity test reactor with a thermal flux of 5×10^{13} to 2×10^{14} n/cm²/sec.

An 86-inch cyclotron is available for irradiations with up to 22 MeV protons.

Irradiations can also be carried out in a 63-inch cyclotron which accelerates Na⁺ ions to 27 MeV.

Charges: for irradiations with 5×10^{14} n/cm²/sec: \$ 15.00/week, \$ 45.00/4 weeks;

for irradiations with 10^{15} — 10^{16} n/cm²/sec: \$ 23.00/week, \$ 68.00/4 weeks;

for irradiations with 10^{17} — 10^{18} n/cm²/sec: \$ 30.00/week, \$ 90.00/4 weeks;

for cyclotron irradiations \$ 60.00/hour + target preparation charge (if applicable).

Special radiation sources and encapsulation services are offered. Neutron activation analysis and service irradiations are carried out. A waste disposal service is offered. In addition to the items listed in this directory, ORNL also supplies limited amounts of heavy elements in various isotopic abundance. For details please contact ORNL.

A handling charge of \$ 16.00 is made for each shipment.

PIC Picker International Corporation, 19 South Broadway, White Plains, New York, USA

Supplies Co-60 and Cs-137 teletherapy sources and various teletherapy equipment.

PR N. V. Philips Roxane, Isotopen-Laboratorium, Apollolaan 151, Amsterdam, Netherlands

Principal supplier of radioisotopes in the Netherlands. Supplies reactor and accelerator produced unprocessed and processed isotopes. Co 60 and Ir 192 radiography sources are listed. Cs 137 sources are made to specification. Some medical radiation sources are available including Co 60 needles and tubes and Au 198 grains. Some standard and calibration sources are offered. Gamma irradiation, radiochemical, film badge, waste disposal and advisory services are offered.

RC Radio-Carbon Laboratories, 7955 Haskell Avenue, Van Nuys, California, USA

Supplies C 14 and H 3 labelled compounds. Tritium labelling service by Witzbach technique is available at \$ 150.00.

Prices are f. o. b. Van Nuys, California.

RCC The Radiochemical Centre, Amersham, Buckinghamshire, England

Supplies a large number of isotopes as well as C 14, H 3, P 32, S 35 and I 131 — labelled compounds. Various radiation sources for industrial and medical use, neutron sources, standard sources and natural radio-elements are available.

RS Research Specialties Co., 200 South Garrard Blvd., Richmond, California, USA

Supplies a large range of C 14 labelled compounds in large or in 50 μ c (licence exempt) packages.

SQB E. R. Squibb & Sons, Radiopharmaceutical Department, Georges Road, New Brunswick, New Jersey, USA

Supplies radiopharmaceuticals. Preparations containing short-lived radioisotopes are precalibrated. Items listed are available from stock. Some radiomedical equipment is also available.
Prices are f. o. b. New Brunswick, N. J.

SRSUT Ministry of the Chemical Industry of the USSR, "SOYUZREAKTIV" State Union Trust, Moscow, USSR

Supplies an extensive range of reactor and accelerator produced isotopes, both unprocessed and processed. Labelled compounds include compounds of C 14, H 3, P 32, S 35 and I 131. Special radiation sources are available for industrial and medical use. Please contact suppliers for more detailed information.

SWZ Schwarz Laboratories, Inc., 230 Washington Street, Mount Vernon, New York, USA

Supplies compounds of C 14, H 3, S 35 and (on special order) P 32 prepared by biosynthesis. Main products are labelled amino acids and nucleic acid derivatives.
Prices are f. o. b. destination in the USA.

TL Tracerlab, Inc., 1601 Trapelo Road, Waltham 54, Massachusetts, USA

Supplies C 14, H 3, S 35, P 32 and I 131 labelled compounds. C 14 compounds are available also in 50 μ c (licence exempt) packages. H 3 compounds can be prepared by random labelling using Witzbach technique at \$ 100.00. In addition, various industrial tracer preparations, radiography sources of Co 60 and Cs 137, Co 60 needles and tubes, Sr 90 applicators and several standard sources are listed. Services offered include custom labelling, radioanalysis, research, training, decontamination and consulting. A \$ 10.00 handling charge is made on orders smaller than the minimum orders listed.

TO Technical Operations, Inc., Burlington, Massachusetts, USA

Supplies encapsulated Co 60, Ir 192, and Tm 170 in multicurie amounts for use in industrial radiography equipment manufactured by TO.

USR United States Radium Corporation, Morristown, New Jersey, USA

Supplies beta, gamma and neutron sources of various specifications. Light sources for marking and signalling applications are also available. Other products include bulk radium, radioactive batteries, luminous compounds, phosphors, static eliminators, fluorescent and phosphorescent pigments. Consulting and engineering services are offered.

VK Volk Radiochemical Company, 5412 North Clark Street, Chicago 40, Illinois, USA

Supplies C 14, P 32 and S 35 labelled compounds, C 14 compounds also in 50 μ c (licence exempt) quantities. Precalibrated radiopharmaceuticals containing P 32 and I 131 are available. Laboratory equipment, film badge and consulting services are also available.

ADDITIONAL INFORMATION ON RADIOISOTOPE PRODUCTION

Argentina

A certain amount of radioisotopes — mainly for research purposes — are being produced in a reactor owned by the Comisión Nacional de Energía Atómica, Radioisotope Department, Avda. del Libertador Gra. San Martín 8230, Buenos Aires. The list arrived too late for inclusion in this directory. Prices have not been established. A Philips Synchrocyclotron is available for irradiations with up to 30 MeV deuterons or 56 MeV alpha particles, and a Cockcroft Walton accelerator for irradiations with protons or deuterons of up to 1.2 MeV.

Australia

According to information supplied by the Australian Atomic Energy Commission Liaison Office the following production and services are planned for 1959:

Production of short-lived isotopes not at present available in Australia and in demand by Australian industry, research and medicine.

Preparation and re-activation of gamma radiography sources, particularly short-lived ones.

Special irradiation of compounds and materials as required by Australian research or medicine.

Cobalt 60 teletherapy sources at the 1,000 curie level and higher, depending on local demand and export possibilities.

Denmark

The Research Centre of the Danish Atomic Energy Commission at Risø is preparing to commence production in the field of radioisotopes. Negotiations are in progress for co-ordination of the production of radioisotopes in Denmark, Norway and Sweden. It is intended to draw up a joint price list and uniform terms of delivery for radioisotopes from the three Scandinavian countries.

Federal Republic of Germany

The production of radioisotopes will be started at the end of 1959 or the beginning of 1960 when the reactor at Karlsruhe is put into operation. The four research reactors in Munich, Frankfurt, Hamburg, and Berlin will not produce radioactive material for distribution.

Netherlands

In addition to the radioisotopes produced by Philippe-Roxane, isotopes are made on a non-commercial basis by the Institute for Nuclear Research, Amsterdam, Ooster Ringdijk 18 a. These radioisotopes, exclusively cyclotron products, are intended for scientific research and, to that end, are made available free of charge.

Portugal

The "Junta de Energia Nuclear" is planning the establishment of a research reactor of the swimming-pool type when the production of radioisotopes will be started in 1960.

Switzerland

Some radioisotopes, such as Na 24, are already in production at the reactor "Saphir". Activations can be carried out upon request. When the new reactor "Diorit" is put into operation in 1960, an extensive range of these isotopes will be produced which are in demand in Switzerland, and which cannot well be imported because of their short half-lives. Later on production will be extended to include other radioisotopes of interest in Switzerland.

Yugoslavia

A few isotopes are produced with a 1.5 MeV Cockcroft Walton accelerator and 200 keV neutron generators. A 16 MeV cyclotron will be in operation in 1959 and will produce about 50 kinds of isotopes in small quantities, and for research purposes only. The construction of a 6.5/10 MW reactor has reached the final stage. When this reactor is operating it will produce a greater variety of radioisotopes for export purposes.

DEFINITIONS OF TERMS

Activation Cross Section

The thermal neutron activation cross section is a measure of the probability of interaction between a target nucleus and thermal neutrons to produce a specified radioactive nuclide. It is expressed as a unit of effective area of the nucleus. 1 barn = 10^{-28} cm².

Annihilation radiation

Two 0.51 MeV γ -rays are produced when a positron is annihilated. This radiation is called "annihilation radiation".

Carrier free (CF)

A carrier free (CF) radioisotope of an element is one in which all the atoms of the element that are present are radioactive. High specific activity material to which no inactive carrier has been added is often loosely referred to as 'carrier free'.

Curie

A curie is that quantity of an isotope which gives 3.7×10^{10} disintegrations per second (dps), or 2.22×10^{10} disintegrations per minute (dpm):

1 curie (1 c) = 3.7×10^{10} dps = 2.22×10^{10} dpm
1 millicurie (1 mc) = 3.7×10^7 dps = 2.22×10^7 dpm
1 microcurie (1 μ c) = 3.7×10^4 dps = 2.22×10^4 dpm
1 millimicrocurie (1 m μ c) = 3.7×10 dps = 2.22×10^0 dpm

Daughter

Synonym for radioactive decay product.

Electron capture (EC)

A mode of radioactive decay involving the capture of an orbital electron by its nucleus. Accompanied by X-radiation in virtually all cases.

Enriched material

Material containing a ν element in which the abundance of one of the isotopes has been increased above its natural isotopic abundance.

Half-life

The time required for the decay of one half of the atoms of a radioisotope.

Internal conversion (IC)

A nuclear de-excitation process competing with gamma-ray emission. The transition energy is communicated to an orbital electron which is then ejected from the atom. The internal conversion coefficient (α) is the ratio of the number of conversion electrons to the number of photons emitted in a given transition.

Isomeric transition (IT)

Transition from an upper to a lower energy level of the same nuclide (occurs with a definite half-life).

Isotopic abundance

The fraction of the atoms of an element which have a particular mass number.

Labelled compound

Chemical compound of a radioisotope.

Metastable state

An excited unstable state of the nucleus denoted in the catalogue by superscript "m" (e. g. Ag^m).

MeV

Million electron volt = 10^6 keV = 10^6 eV.

Parent

A nuclide that undergoes decay into another nuclide, the "daughter".

Rad

A unit of absorbed radiation dose. 1 rad = 100 erg/g of absorbing medium.

RHM

A measure of radiation. 1 RHM = 1 roentgen per hour at 1 meter.

RMM

A measure of radiation. 1 RMM = 1 roentgen per minute at 1 meter.

Röntgen (r)

A unit of absorbed radiation dose. The quantity of X- or γ -radiation such that the associated corpuscular emission per 0.001293 g of air (1 cm³ of air at STP) produces, in air, ions carrying 1 electrostatic unit of quantity of electricity of either sign. A roentgen is equivalent to the absorption of 83.8 ergs of energy per gram of air.

Roentgen-equivalent-man (rem)

Biological unit of absorbed radiation dose. That dose which, delivered to man (or mammal) exposed to any ionizing radiation, is biologically equivalent to the dose of 1 rad of hard X- or γ -radiation.

Dose in rem = dose in rad $\times$ RBE (relative biological effectiveness) where, for a given biological action, the RBE values are the inverse ratios of the energy absorptions of different radiations which produce equal biological effects.

Roentgen-equivalent-physics (rep)

The quantity of ionizing radiation required to produce an energy absorption of 93 ergs per cm³ of tissue.

Specific activity

The activity of the isotope per unit of material to which reference is made.

Thermal neutrons flux

The number of thermal neutrons (neutrons of average velocity 2200 m/sec) passing through unit area in any direction in unit time and defined as the product of the number per unit volume, and their average speed.

The specific activity reached at any time during irradiation can be calculated with the aid of the formula:

$$S = \frac{0.6 \Phi \sigma a}{3.7 \times 10^{10} A} (1 - e^{-0.693 T/t})$$

where S

Φ = specific activity of product in curies/gram

σ = neutron flux in n/cm²/sec

a = activation cross section in barns

A = abundance of target isotope (expressed as fraction of target element)

t = atomic weight of bombarded element

T = irradiation time

T = half-life of the radioisotope (in same units as t).

The bracketed part of the formula can be neglected when irradiation is carried out for more than 6-7 half lives of the radioactive product. At this time saturation is practically achieved, and the amount of radioisotope which decays per unit time is equal to that which is newly produced. Saturation is indicated by the letters "sat". The mass of radioactive material produced per gram of a particular element is given by:

$$M = 7.7 \times 10^{-9} \text{ ATS grams.}$$

In this case T is measured in days.

The following abbreviations are used most frequently in this column:

"irr." for irradiation, "w" for week, "d" for day, "CF" for carrier free, "mm" for millimol, "not spec'd" for (specific activity) not specified.

Price

Prices are quoted as they appear in the various catalogues. Discounts are frequently available on large orders and in some cases on purchases made by educational and research institutions. Allowance must be made, on the other hand, for encapsulation, certification and packaging charges, and for transportation costs.

The following abbreviations are used:

"ac" for activation charge, "hc" for handling charge, "ndc" for material and target charge, "pc" for preparation charge, "ea. add." for each additional.

Remarks

This column contains miscellaneous additional information. "Minimum" means minimum order or minimum charge, "r. c. purity" means radiochemical purity.

CONTENTS

Preface	
Introduction	
Safe Handling of Radioactive Materials	I
Suppliers of Radioisotopes	II
Additional Information on Radioisotope Production	IX
Definitions of Terms	XI
Information on Tables	XII
Tables of Radioisotopes	1-263
Index	264