PRODUCTION OF RADIOISOTOPES IN THE ORNL 86-INCH CYCLOTRON

J. W. Terry
Oak Ridge National Laboratory
P.O. Box X, Oak Ridge, Tennessee

Summary

The radioisotope production facilities and programs of the 86-Inch Cyclotron are reviewed in this presentation. The 86-Inch Cyclotron is designed to accelerate protons to a maximum energy of 22 MeV for internal targets. These protons are used to bombard metals that are electroplated, potted or soldered to water-cooled plates. Additionally, metals and inorganic compounds are bombarded in water-cooled tube targets. High radioisotope production rates are obtained by beam currents as large as 3 mA. Production rates for ^{11}C , ^{57}Co , ^{67}Ga , ^{68}Ge , ^{109}Cd , and other isotopes are presented. The production of ^{11}C for the carboxyl labeling of amino acids in cooperation with Oak Ridge Associated Universities is discussed. The 86-Inch Cyclotron is used for those programs requiring a larger beam current than is available from commercial cyclotrons.

Introduction

The Oak Ridge National Laboratory (ORNL) 86-Inch Cyclotron is operated by a prime contractor, Union Carbide Corporation, for the Department of Energy (DOE). The cyclotron accelerates protons to an energy of 22 MeV with a maximum internal beam current of 3 mA. It is a fixed-frequency machine operating at a frequency of 13.3 MHz, a dee-to-dee voltage of 450 to 500 kV, and a magnetic field strength of 699 kA/m. These operating conditions give an orbit separation of 5 mm at the target. The beam spreads over an area of 19 to 26 cm² on a water-cooled plate target.

Targets

Water-cooled flat plate targets are used when the highest yields from metal targets are required. For good thermal conductivity the base plate typically is made of copper. To this copper plate the target material is electroplated, potted, or soldered. Up to the maximum 3 mA of beam current is applied to this target to produce isotopes by (p,n), (p,2n), (p,2p), and (p,pn) reactions.

Tube-type, water-cooled, encapsulated targets are assembled for bombardment of metal powders and inorganic compounds at beam currents up to 200 μA . These are used when the development of a flat plate coating is prohibitively difficult or high production rates are not necessary. The primary reaction is taken to be (p,n) for these targets.

Production Rates

Production rates which are achieved on a routine basis are shown in Table 1. These radioisotopes — with the exception of ^{11}C — are available through the Isotope Sales Office of ORNL. Information about the production rates of many other isotopes is available.

Table 1. Typical production rates in the 86-Inch Cyclotron

Target	Product	Rate (mCi/hr)
^NLi potted metal	^7Be	30
$^{11}\text{B}_2^{16}\text{O}_3$	^{11}C	3000
^NFe soldered metal	^{56}Co	15
^NNi electroplated metal	^{57}Co	25
^{58}Ni electroplated metal	^{57}Co	40
^{68}Zn electroplated metal	^{67}Ga	1000
^NGa potted metal	^{68}Ge	5
^NGe powder	^{74}As	17
^NMo metal	$^{95\text{m}}\text{Tc}$	2
^{95}Mo powder	$^{95\text{m}}\text{Tc}$	3
^NAg metal	^{109}Cd	9
^NPt soldered metal	^{195}Au	8

Carbon-11 Production

The production of ^{11}C for the carboxyl labeling of amino acids has been established on a routine basis in cooperation with Oak Ridge Associated Universities (ORAU). Beam currents of 150 to 175 μA at 22 MeV are used to produce the ^{11}C as a mixture of $^{11}\text{C}^{16}\text{O}$ and $^{11}\text{C}^{16}\text{O}_2$.

The $^{11}\text{B}_2^{16}\text{O}_3$ target is prepared by the ORAU personnel.¹ The $^{11}\text{B}_2^{16}\text{O}_3$ is drawn into rods and positioned within a graphite mold with exterior dimensions chosen to assure a good fit within an aluminum tube.

The inner aluminum tube containing the target material has an outer diameter of 5 mm. This tube target is centered by indentations within an aluminum jacket that has an outer diameter of 6.3 mm. Cooling water flows between the tubes at 15 L/min. The proton beam energy is reduced from 22 MeV to approximately 16 MeV by the two aluminum walls and the layer of water.

The target material is purged with helium prior to a run and an overpressure of helium is maintained during bombardment. The target material liquifies and the ^{11}C reacts with available oxygen in the target to form ^{11}CO and $^{11}\text{CO}_2$. After a short cooling time to solidify the target material following the end of bombardment, the ^{11}CO and $^{11}\text{CO}_2$ are swept through the connecting tubing into the hot cell by the helium gas. The hot cell operator in coordination with ORAU personnel performs the necessary catalytic conversion of the ^{11}C oxides to H^{11}CN and the trapping of the H^{11}CN . The ^{11}C cyanide is then used to produce the desired ^{11}C -carboxyl-labeled amino acid.

Conclusions

It is seen that the ORNL 86-Inch Cyclotron can produce large quantities of radioisotopes on a daily basis. This production also is seen to be most applicable to those programs requiring a larger beam current than is available from commercial cyclotrons.

Reference

1. L.C. Washburn, T.T. Sun, B.L. Byrd, R.L. Hayes, T.A. Butler, and A.P. Callahan, High-Level Production of C-11-Carboxyl-Labeled Amino Acids, Radiopharmaceuticals II, Proc. 2nd Int. Symp. on Radiopharmaceuticals (Society of Nuclear Medicine, New York, NY, 1979), pp. 768-772.