THE PRODUCTION OF ^{123}I AND ^{84}Rb AT THE UNIVERSITY OF MANITOBA CYCLOTRON LABORATORY

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ABSTRACT

Production of ^{123}I from the reaction ^{124}Te(p,2n)^{123}I is proceeding on a routine basis using a target similar to that developed at the A.V.F. cyclotron laboratory in Milan. It is believed that the current output may be sufficient to meet the Canadian need for thyroid scans at this time. The production of ^{84}Rb has also recently been undertaken using the ^{84}Kr(p,n)^{84}Rb reaction on enriched ^{84}Kr. The Rb is being used at St. Boniface General Hospital to trace blood flow patterns through the heart. Additional plans exist for the production of ^{81m}Rb from irradiation of natural krypton.

1. Introduction

Supply of the radioisotope ^{123}I to hospitals in Manitoba began about three years ago as a joint project between the University of Manitoba Cyclotron Laboratory and the Department of Nuclear Medicine at the Health Sciences Centre. Production has now been carried out on a routine basis in Winnipeg for the past eighteen months and has been sufficient to meet all local needs.

The production of ^{84}Rb has also recently been undertaken to fill the gap created when the Oak Ridge cyclotron was upgraded to a heavy ion facility. St. Boniface General Hospital in Winnipeg has been using the isotope in preliminary experiments designed to study blood flow rates through the heart.

The targetry system that has been developed for the production of ^{84}Rb from enriched ^{84}Kr will also be used in the near future for the production of an ^{81m}Kr generator via the decay of ^{81}Rb obtained from the bombardment of natural krypton.

2. ^{123}I Program

The ^{123}I program at the University of Manitoba was initiated in 1975, at which time the method and targetry developed at the Milan A.V.F. Cyclotron[1,2] was adopted with little modification. We are very grateful to Dr. Francesco Resmini for sharing his expertise with us.

The ^{123}I is produced via the ^{124}Te(p,2n)^{123}I reaction[1] at 24 MeV, the ^{124}Te being enriched to 92-95%. The target assembly (Fig. 1) is loaded with a 5 MeV thick ^{124}Te target and placed in the main 0° beam line of the Manitoba Cyclotron. Cooling water is passed through the target assembly during the irradiation to prevent vaporization and loss of iodine.

Upon completion of the irradiation, the target is removed from the beam line and transported to the Health Sciences Centre, Winnipeg, where the chemical separation, quality control and preparation for distribution take place within the following 6 hours.

Typical yields are 70 mCi of ^{123}I per irradiation with 0.5% ^{124}I impurity. This has been sufficient to meet local demand for both Thyroid scans and pure research during the past year.

An increase in the amount of ^{123}I produced can readily be obtained by one or more of three methods.

1. Increasing the target thickness which will also slightly increase the ^{124}I impurity[1].
2. Improving the target cooling which will allow for increased beam on target.
3. Lengthening the irradiation time.

Despite the high cost of enriched ^{124}Te, target costs are relatively low due to the high efficiency of the recovery process. 99% of the ^{124}Te target is recoverable.

The success of the ^{123}I program, together with the reliability of the University of Manitoba Cyclotron has prompted us to begin national distribution of ^{123}I on a regular weekly basis as of September 1, 1978.

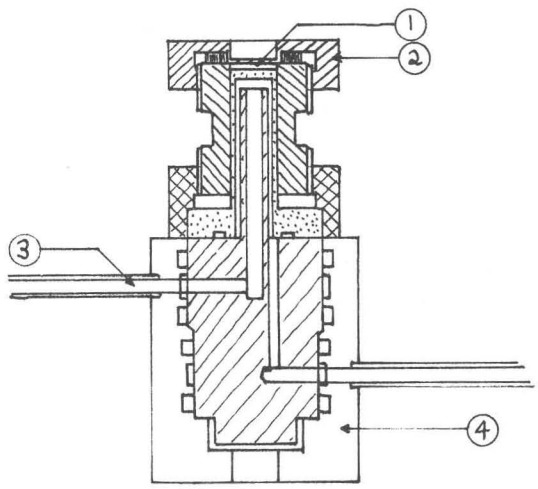

Fig. 1 Schematic diagram of the ^{123}I target assembly:
1. Target chamber 2. Al collimator cap
3. Cooling path 4. Target Holder

3. ^{84}Rb Program

The program for production of ^{84}Rb was undertaken in 1977 following discussions with personnel at Oak Ridge National Laboratory who provided valuable information concerning the design of gaseous targets and the physics of the ^{84}Kr(p,n)^{84}Rb reaction[3].

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The target currently used in this program (Fig. 2) is an 8 inch long by 2 inch diameter stainless steel cylinder. The krypton gas is loaded into the cylinder at a pressure of 2 atmospheres. The krypton is irradiated at an energy of 16 MeV at target center in the main 0° beam line of the Manitoba Cyclotron facility. After irradiation is completed the cylinder is removed from the beam line, the krypton gas is cryopumped from the cylinder and stored.

The entire cylinder is then transported to the Winnipeg Health Sciences Centre, where the ^{84}Rb is prepared for shipment to St. Boniface General Hospital.

The yield of ^{84}Rb is about 0.1 mCi/μA hr. and the recovery of krypton is virtually 100%.

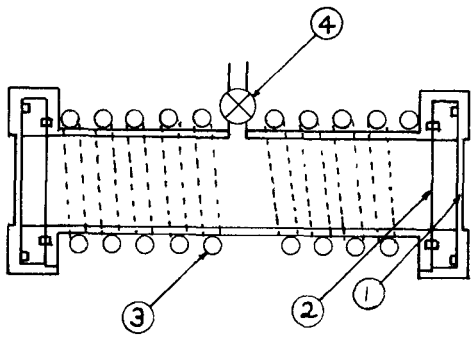

Fig. 2 ^{84}Rb Target Assembly Schematic: 1. Beam degrader 2. End Windows 3. Cooling lines 4. Gas valve

4. Clinical Use of ^{84}Rb

Rb^+ is a K^+ analogue which follows the biological pathways of potassium in the body. There are two ways by which Rb (and potassium) gain entry into the cells. (a) By passive diffusion across the cell membrane and (b) By an energy dependent active transport mechanism called SODIUM-POTASSIUM PUMP which is located in the cell membrane. The later is responsible for the extremely high potassium concentration (95%) within the cell as compared to the very low (5%) concentration in the extracellular fluid where SODIUM is the dominant ion. ^{84}Rb therefore accumulates within the organs where its concentration can then be measured.

Since Rb^+ is transferred into the cell by an active biological mechanism its clearance from the blood is a function of the blood supply received by the particular organ over a given period of time. This is ORGAN BLOOD FLOW which in the case of the heart is the CORONARY BLOOD FLOW. Fractionation of ^{84}Rb into various organs is therefore directly proportional to the fractionation of CARDIAC OUTPUT (amount of blood pumped by the heart over a period of one minute).

$^{84}Rb^+$ clearance from the blood, or its accumulation into a particular organ can therefore be used to measure:

a) cardiac output.

b) organ blood flow.

c) status of cell membrane viability as reflected in the rate of Rb accumulation (Na-K pump).

^{84}Rb is preferred because of the following:

a) it is a positron emitter and the advantages of coincidence counting can be utilized to isolate the organs (Collimation) and measure ^{84}Rb uptake.

b) it has a relatively long half life, and as such is easy to handle.

c) compared to potassium, the plateau in organ activity after a single bolus injection is much longer (2-3 minutes). This permits longer counting time and consequently a lower dose can be given to the patient.

At the St. Boniface General Hospital ^{84}Rb is used to measure:-

a) Coronary blood flow.

b) Cell membrane activity of the heart muscle (Sodium-Potassium ATPase).

c) Identify the margins of the myocardian infarct.

d) Identify the un-oxygenated heart muscle from a study of the depressed uptake of ^{84}Rb.

5. Conclusion

In summary then, routine production of ^{123}I and ^{84}Rb for clinical work is well underway. It is anticipated that several additional radio pharmaceuticals will be added to the production output of the Cyclotron Laboratory in the near future.

References

1) E. Acerbi, et al., "Production of ^{123}I for Medical Purposes at the Milan A.V.F. Cyclotron," Progress Meeting, Louvain, May 29—June 1, 1974.

2) E. Acerbi, et al., Proceedings of 7th International Cyclotron Conference, Zurich, 19-22 Aug., 1975, p. 461; and private discussions at the same Conference.

3) J.J. Pinanion, Proceedings of a Symposium held at the Oak Ridge Institute of Nuclear Studies, Nov. 1-4, 1965, p. 149.

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