Jointly published by
Elsevier Science S. A., Lausanne and
Akadémiai Kiadó, Budapest

J.Radioanal.Nucl.Chem.,Letters
200 (3) 227-232 (1995)

PRODUCTION OF ^{18}F USING A NATURAL WATER TARGET AT THE CV-28 CYCLOTRON AT IPEN-CNEN/SP

L.L.M. Santos, J.A. Osso, S.G. Araujo

Instituto de Pesquisas Energéticas e Nucleares,
Comissão Nacional de Energia Nuclear,
Travessa R, 400 - Cidade Universitária,
Caixa Postal 11049, CEP 05508-900, São Paulo, Brazil

Received 26 January 1995
Accepted 9 February 1995

The development of an automated water target for the production of ^{18}F is described. The system was fully tested and shown to be reliable and secure. The chemical separation of ^{18}F was carried out using an anion-exchange resin and K_2CO_3 as eluent. The ^{18}F production yields were, on average, (4.81±0.42) MBq/μAh and the specific activity was higher than 6.623 x 10^5 MBq/mmol. Heat transfer measurements and calculations were made.

INTRODUCTION

Up to now in Brazil the diagnosis in Nuclear Medicine has applied only the SPET (Single Photon Emission Tomography) technique, with radioisotopes such as ^{99m}Tc, ^{67}Ga, ^{123}I, ^{131}I and others. But the advances brought by the PET (Positron Emission Tomography) technique make it necessary to introduce it in this country. As a consequence, it is very important to develop methods of

0236-5731/95/US $ 9.50

production of positron emitting isotopes. ^{18}F is one of the most widely used radioisotopes in PET diagnosis[1] and due to its half-life (110 min), it is the only one that does not need to be produced at the PET center.

The purpose of this work was to develop a reliable method for the production of ^{18}F. The main reactions for the production of ^{18}F are:
$^{16}O(^{3}He,n)^{18}Ne \rightarrow ^{2}$, $^{16}O(\alpha,2n)^{18}Ne \rightarrow ^{2}$, $^{16}O(^{3}He,p)^{2}$, $^{16}O(\alpha,d)^{2}$, $^{18}O(p,n)^{2}$, $^{20}Ne(d,\alpha)^{2}$ and $^{20}Ne(p,2pn)^{3}$.

The method chosen initially was the irradiation of natural water with ^{3}He, because of the target holder that already existed. However, IPEN's Cyclotron only accelerates protons with a maximum energy of 24 MeV nowadays. So, the nuclear reaction used was $^{18}O(p,n)^{18}F$, and natural water was employed as target material. In this way, the viability of the irradiation system, the automation of the process and the preliminary heat transfer calculations could be evaluated.

EXPERIMENTAL

The automated irradiation system is shown in Fig. 1. The water circulates through a closed system by means of a pump during all the irradiation, and it is cooled at the target holder and in an external heat exchanger. Two thermocouples were placed at the inlet and the outlet of the target holder to monitor the temperature of irradiated water. The target chamber, made of stainless steel, has a volume of 16 ml and it is separated from the beam line vacuum by either an Al foil (250 μm thick) or a Ag foil (81 μm thick). An open system for the irradiation was chosen in order to prevent pressure build-up on the window. After irradiation, the irradiated water

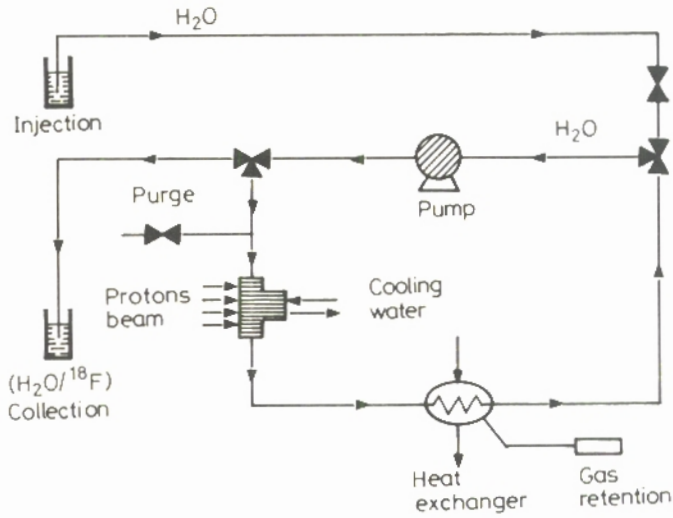

Fig. 1. Automated irradiation system for water

was pumped off the system and it could be directed to a vial, where aliquots were taken for measurement of the production yields and radionuclidic purity on a Ge(Li) detector, or to a column for the chemical separation of ^{18}F.

Both deionized and doubly distilled water were used as target materials, and two different cooling systems were also tested.

The chemical separation of ^{18}F was carried out using an anionic exchange resin Dowex 1X8 (100-200 mesh, ϕ = 1 cm, h = 4 cm) and K_2CO_3 as eluent. The amount of fluorine (^{19}F) was measured by the selective electrode technique in order to evaluate the specific activity of the product.

Heat transfer calculations were made concerning the water that was being irradiated and the results were compared with the experimental data.

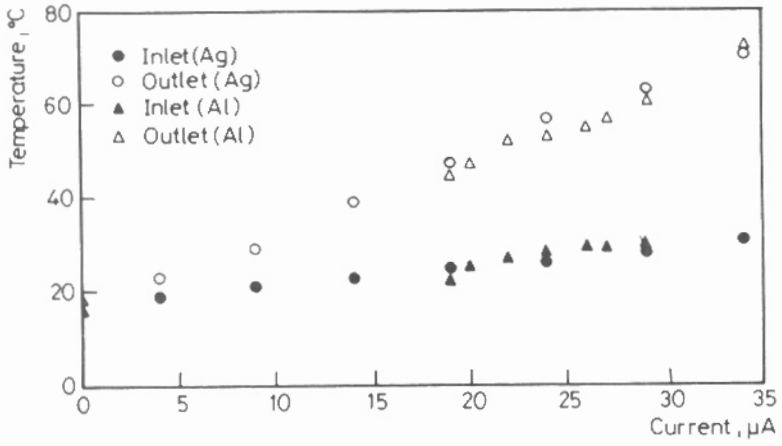

Fig. 2. Variation of the irradiated water temperature with the beam current using two different windows: silver and aluminium

RESULTS AND DISCUSSION

The automated water irradiation system has been operated reliably and safely, and the water loss in the irradiations was nearly 2%.

Figure 2 shows a typical behavior of the temperature of irradiated water with the increase of beam current. The limit of current tested was 34 μA (limit of the Cyclotron), with the water temperature reaching 71 ^{o}C in the outlet of the target holder.

The average production yield of ^{18}F was (4.81±0.42) MBq/μAh and the specific activity was higher than 6.623×10^{5} MBq/mmol. The radionuclidic impurities detected were ^{13}N (T = 10 min), with a production yield of 3145 MBq/μAh, and ^{48}Sc, when doubly distilled water was used as target material. ^{48}Sc is possibly produced by the $^{48}Ca(p,n)^{48}Sc$ reaction.

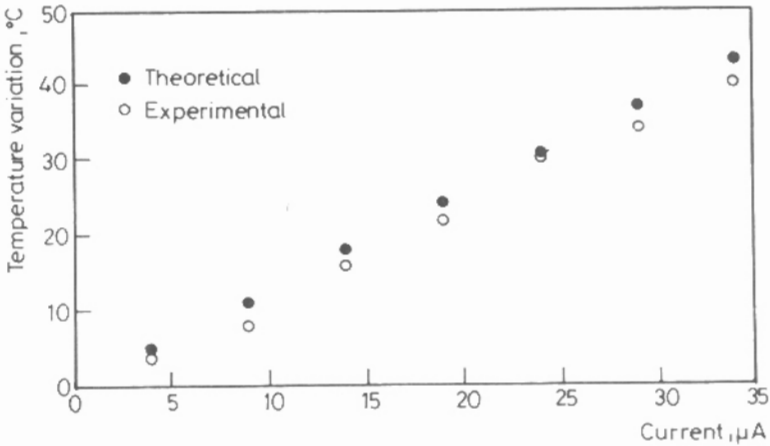

Fig. 3. Comparison between the theoretical and experimental values for the temperature variation of the irradiated water with beam current

The retention of ^{18}F in the resin was nearly 100%, showing it to be in the F^- form, and the maximum elution of ^{18}F from the resin was 86%.

Figure 3 shows the results of calculations concerning the increase of irradiated water temperature with increasing beam current. These values are in good agreement with the experimental data, as can be seen in this graph.

CONCLUSIONS

A reliable and secure irradiation system was developed for the production of ^{18}F and, although enriched water was not used, enough activity was produced (259-296 MBq) to allow the development of labeling procedures with ^{18}F. It was demonstrated to medical users that there are more reasons now to introduce the PET technique in Brazil.

*

The authors thank Osvaldo Luiz da Costa, Mauro Veiga Fernandes, Hélio Antônio Paes and Tarcísio Souza Alves, of the Cyclotron crew at IPEN-CNEN/SP, for their collaboration during this work.

REFERENCES

1. Y.L. Yamamoto, C.J. Thompson, M. Diksic, E. Meyer, W.H. Feindel, Radiat. Phys. Chem., 24 (1984) 385.

2. M. Guillaume, A. Luxen, B. Nebeling, M. Argentini, J.C. Clark, V.W. Pike, Appl. Radiat. Isotopes, 42 (1991) 749.

3. M.C. Lagunas-Solar, O.M. Carvacho, R.R. Cima, Appl. Radiat. Isotopes, 39 (1988) 41.