A RELIABLE PRESSURIZED WATER TARGET FOR F-18 PRODUCTION AT HIGH BEAM CURRENTS

G.K. Mulholland, R.D. Hichwa, M.R. Kilbourn, and J. Moskwa
Division of Nuclear Medicine, University of Michigan, Ann Arbor, MI 48109

As the clinical use of PET expands, the demand for ^{18}F radiopharmaceuticals derived from [^{18}F]fluoride will increase. In order to produce larger amounts of [^{18}F]fluoride without increasing limited beam time, water targets will have to be irradiated at more intense beam currents. However, a combination of factors presently limit [^{18}F]fluoride ion production from small volume ^{18}O water targets under high current irradiation conditions. Inadequate target cooling or a sharply focused beam strike cause losses due to boiling, cavitation and sometimes complete voiding of the target chamber. Radiolytic loss of target water also increases with more intense irradiation, and the impact of this factor is more severe as target volumes decrease. Finally, loss of reactivity of the produced [^{18}F]fluoride ion is a problem which has been attributed to contaminants leached from target surfaces during irradiation.

We have attempted to address each of these problems in a new 1 mL volume single foil target design. The target body and beam window were made from silver because of its superior chemical and heat transfer properties (1,2). The softness of the pure metal made fabrication easy and enabled a tight seal between the target body and window foil without O-rings. A shallow oval hemispherical target chamber (1.59 cm dia. x 0.95 cm deep) was machined into the front face of a 1.0 x 7.5 cm solid Ag. The depth calculated tobbe thick by 3 fold factor for incident 15 MeV protons in water. Top and bottom ports were drilled to the chamber through the rim of the Ag disk. A water cooled 1.5 mm thick aluminum degrader plate compressed the Ag window foil (0.025 mm) directly against the front target face, thus sealing the chamber. The plate moderately scattered the beam and together with the Ag foil lowered the beam energy to 15 MeV. It also lent support to, and carried heat away from the Ag foil during irradiation. The target body was cooled with 15°C water in contact with the back target face. During operation the target chamber was filled completely without a reflux space. It was pressurized with H_2 (up to 10 atm) through the top port to minimize boiling and cavitation. This port contained a segment of tubing which was packed with Pt wire to catalyze the conversion of radiolysis gases ($^{18}O_2$ and H_2) back to $H_2{}^{18}O$. Using this arrangement, no measurable radiolytic loss of water was observed in 30 µA/60 min irradiations.

Performance: In the last 7 months this target has been irradiated over 170 times (~ 50 hr beam on target) at currents as high as 35 µA without a foil change or target cleanup, and without significant change in production rates or [^{18}F]fluoride reactivity. The upper beam current limit of this target remains to be determined. Several accidental 20-35 µA irradiations on an empty target have had no noticeable adverse effects. The reactivity of [^{18}F]fluoride from this target has been consistently very good as judged by the yields (50-80% EOB) in labeling of FDG precursor by the Hamacher procedure (3) and its use in numerous aromatic [^{18}F]fluorodenitrations. Representative ^{18}F production data from the target, shown in the Table below, compare very favorably with previously reported $H_2{}^{18}O$ target yields (1,2,4,5,6).

Summary: We have developed a simple hydrogen pressurized 1 mL volume silver target which is extremely reliable and durable and can produce large amounts of reactive [^{18}F]fluoride (> 1 Ci) using high beam currents (> 20 µA) and short irradiation times (< 45 min). Fast, reliable [^{18}F]fluoride ion is particularly important in production of ^{18}F radiopharmaceuticals for use in clinical PET.

TABLE. ^{18}F Yields from Target

Current (μA)	Irrad. Time (min)	H_2 Pressure (atm)	mCi* EOB
20	5	1.0+	105
20	5	5.0	129
20	10	1.0+	183
20	10	5.0	241
20	45	5.3	1045
20	60	5.0	1205
30	10	10.0	321
30	20	7.3	630
30	60	7.3	1505
35	10	10.0	360
35	20	10.0	773

*yields normallized to 100% ^{18}O; 85-96% enriched $H_2{}^{18}O$ used.
+ambient pressure

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