Production of Cl-34m via the (d,α) reaction on Ar-36 gas at 8.4 MeV.

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Introduction

The radioisotope ^{34m}Cl (β+, $t_{1/2}$=32.2 m) is of interest to the medical community, especially in drug development. However, ^{34m}Cl production is currently limited to facilities capable of accelerating alpha particles.[1] Proton-only accelerators can make use of reasonable yields for enriched ^{34}S targets, but must contend with the poor thermal and electrical properties of sulphur and its compounds, which reach the molten state at even limited beam currents. The utility of the ^{20}Ne(d,α)^{18}F reaction[2] suggests an alternative route to ^{34m}Cl via the corresponding noble gas, argon. The excitation function and yield measurements for ^{36}Ar(d,α)^{34m}Cl near 8.4 MeV, the nominal deuteron energy on a PETtrace cyclotron, elude a careful search of the literature.

Test Irradiations of ^{nat}Argon

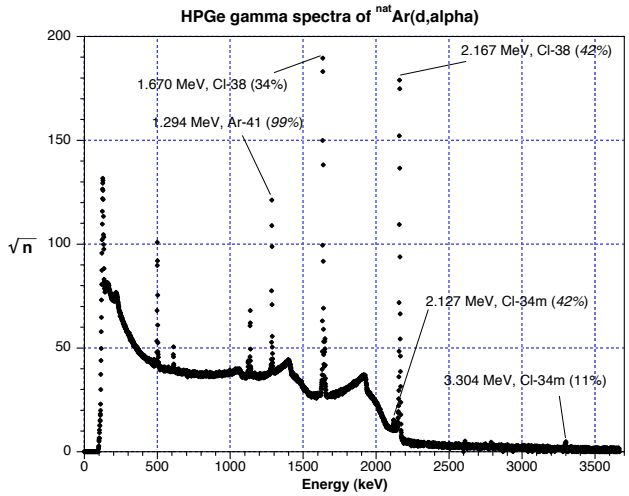
A gas target (21 cm x 1.4 cm ID) was built with removable endplates for rapid removal of a quartz tube with trapped ^{38,34m}Cl- from ^{40,36}Ar(d,α). Exploratory deuteron irradiations were conducted on a thick target of ^{nat}Ar 130 psig. Following irradiation, the target was "cooled" briefly to allow the overwhelming 511 keV gammas from ^{16}O(d,n)^{17}F in the quartz tube to decay and then flushed twice into a 1 L syringe to remove ^{41}Ar prior to target disassembly and analysis. The quartz tube was removed and assayed with an HPGe detector (spectra shown below). Gamma spectroscopy revealed the production of 0.9 ± 0.1 mCi/uA of ^{38}Cl ($t_{1/2}$=37.2 m) and 5.1 ± 0.4 mCi/uA of ^{41}Ar ($t_{1/2}$=109 m) at end of saturated bombardment (EoSB). More importantly, the production of ^{34m}Cl in approximately 1:300 ratio with ^{38}Cl mirrors the abundance ratios of their target isotopes.

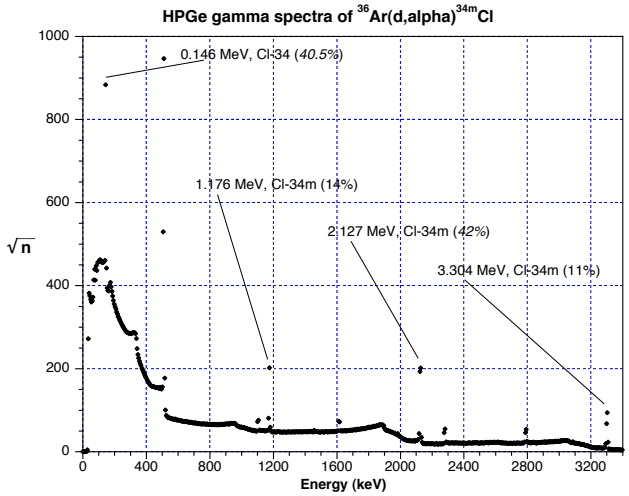
Yield Measurements with ^{36}Argon

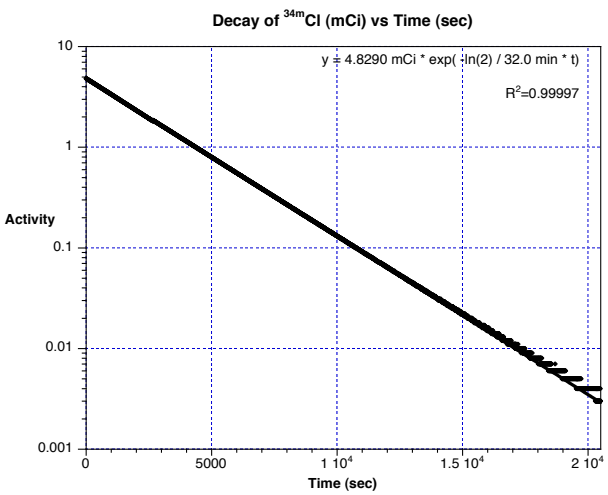
Enriched ^{36}Ar (99.993%, 1 L at STP) was obtained from Isoflex (San Francisco). The high cost (~$5000/L) of the target material necessitated cryotrapping ^{36}Ar post-irradiation in a 50 mL stainless steel vessel.[3] Vacsorb greatly improved the cryorecovery of argon at -196°C (<1 mm Hg) compared to vapor pressures achievable in its absence (0.3 atm), in agreement with the Clausius-Clapeyron relation's prediction. A second target (21 cm x 1.9 cm ID) better accomodated the width of our deuteron beam, albeit at some cost in target pressure. The ^{36}Ar-filled target was irradiated at an initial pressure of 68 ± 1 psig by beam currents between 5 and 20 uA for 30 minutes. After the run, 10 minutes of cryotrapping recovered >99.5% of target material at -196°C. The target was vented and the quartz insert removed for analysis. To date, 12 irradiations have been completed, revealing radionuclidically clean production of desired ^{34m}Cl trapped in the quartz tube. EoSB yields and decay over more than 3 decades are shown below, averaging 1.8 ± 0.2 mCi/uA for thick-target runs, reflecting the larger ID target's accomodation of the PETtrace deuteron beam. The target appears to thin beyond 10 uA, reducing effective yield. Phosphor plate imaging of the quartz tubes' adsorbed activity confirms this hypothesis, as the activity peak progresses steadily towards the back of the target with increased beam currents.

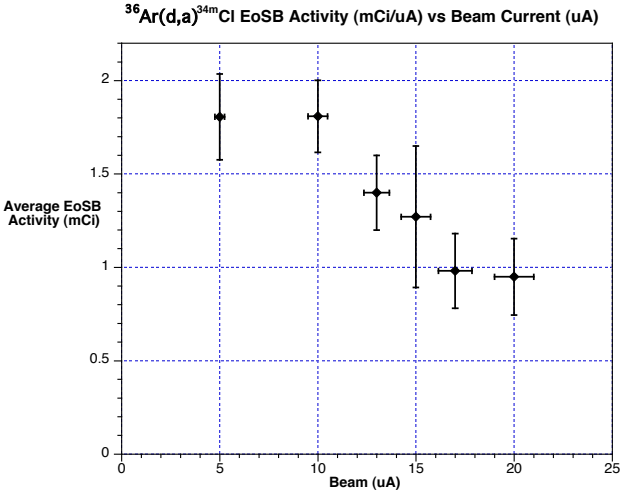
Conclusion

These results suggest the possibility of subsequent labeling with ^{34m}Cl; nucleophilic test reactions to confirm the reactivity of the product will follow.









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[1] Takeia M b, Nagatsua K, Fukumuraa T, Suzuki K (2007). Remote control production of an aqueous solution of no-carrier-added $^{34m}Cl^-$ via the $^{32}S(\alpha,pn)$ nuclear reaction. Applied Radiation and Isotopes 65(9), 981-986.

[2] Casella V R, Ido T, Wolf A P, Fowler J S, MacGregor R R, Ruth T J (1980). Anhydrous F-18 labeled elemental fluorine for radiopharmaceutical preparation. Journal of Nuclear Medicine, 21, 750-757.

[3] Nickles R J, Daube M E, and Ruth T J (1984). An $^{18}O_2$ target for the production of $[^{18}F]F_2$. International Journal of Applied Radiation Isotopes 35(2), 117-122.