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Iodine-124 Production: Excitation Function for the $^{124}Te(d,2n)^{124}I$ and $^{124}Te(d,3n)^{123}I$ Reactions from 7 to 24 MeV

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ABSTRACT

The excitation function for the production of I-124 and I-123 from deuterons on tellurium-124 has been measured over the energy interval of 7.5 to 23.6 MeV. The target used was a compressed tellurium powder target. The thick target yields for both radioisotopes have been calculated, radiochemical purity was determined and recovery of the isotopically enriched tellurium has been investigated.

KEYWORDS: IODINE-124, IODINE-123, NUCLEAR CROSS-SECTION, TELLURIUM-124

INTRODUCTION

Although Iodine-124 has often been considered only as an impurity in preparations of I-123, it does have attractive attributes for use in some PET radiopharmaceuticals [1,2,3,4]. The half-life of 4.2 days is long enough for accumulation with monoclonal antibodies and the 25% positron decay mode allows imaging of the isotope with PET [5,6,7]. The isotope can also be used for radiotherapy at high dose levels.

The production of this isotope using deuterons has been carried out previously [8] and the production has been measured [9], but there was no detailed cross-section measurement over the entire energy range of interest. Other methods of production such as the $^{121}Sb(\alpha,n)^{124}I$ and the $^{124}Te(p,n)^{124}I$ reactions give either lower yields or poor isotopic purity of the I-124. The yield of I-124 and I-123 versus energy is an important consideration in order to maximize yield of I-124 while minimizing the yield of I-123 in order to minimize the dose received in processing the I-124.

The other important consideration in the use of enriched tellurium is the recovery of the tellurium after irradiation. In order to make the process economically feasible, the tellurium must be recovered at better than 95%.

EXPERIMENTAL

The tellurium-124 was purchased from Isotope sales at Oak Ridge National laboratory at an isotopic enrichment of 96.7% Te-124. The target consisted of tellurium powder pressed into a circular depression in an aluminum plate. The depression in the aluminum plate was 1.2 cm (0.5") in diameters and 0.5 mm (.020") deep. Thirty milligrams of the tellurium powder was pressed into the cavity under a pressure of 20,000 psi. After the powder had been pressed, the targets were transported to the cyclotron and irradiated in a deuteron beam.

The beam was defocussed to prevent hot spots in the target material and to ensure that the beam was distributed over a wide area. The target plates were held in an aluminum target holder during irradiation which also acted as a Faraday up to measure the beam current. The energy and beam current were checked with nickel and copper foils in the same target holder as has been described previously [10]. In most circumstances, the targets were irradiated at a beam current of 1 μA for 10 minutes. The beam energy from 19 to 24 MeV was set with the cyclotron. Lower energies incident on target were achieved with the use of aluminum degrader foils. The energy lost in the foils as well as the energy lost in the target were calculated using standard stopping power tables [11].

After bombardment, the tellurium was removed from the aluminum plate as a disk and placed into a counting vial. Any small pieces which flaked off during removal of the disk were collected and placed into the counting vial. The vials were placed in a Ge(Li) gamma detector calibrated for geometry and efficiency. The output from the Ge(Li) detector was input to a multichannel analyzer (Canberra Series 90). The counts under the peaks for the I-124 and I-123 gamma rays were used to determine the relative amounts of each isotope and any impurities in the samples. The absolute activities of I-124 and I-123 were determined by comparison with known standards of these isotopes supplied by Medi-Physics (Camden NJ). The tellurium was allowed to decay for several weeks and then the levels of I-125 were determined. The tellurium powder was never used more than twice. Production runs have been carried out where the iodine was separated from the tellurium and the tellurium recovered using the basic procedure which has been described previously [12].

RESULTS

The results of the yield and cross-section measurements are shown in Table 1 which list the yields of both I-123 and I-124. These data are plotted in Figure 1. It can be seen that the yield of the ^{124}Te(d,2n)^{124}I reaction has a peak at about 18 MeV while the cross-section of the ^{124}(d,3n)^{123}I reaction continues to rise at 24 MeV which is the upper limit of out measurement. It can be seen that in order to maximize the yield of I-124 while producing as little I-123 as possible, the reaction should be carried out with a incident deuteron energy of about 16 MeV. At very low energies the production of I-125 starts to be a factor in the purity of the I-124. This impurity can be minimized by carrying out the reaction at energies above 6 MeV. If the reaction is carried out over the interval of 16 to 6 MeV, the yield from the target should be 0.64 mCi/μA-hr which can be compared to the value obtained previously [8] of 0.55 mCi/μA-hr.

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REFERENCES

1. Lambrecht, RM, Woodhouse, N, Phillips, R, Wolczak, D, Qureshi, A, Delos Reyes, E, Graser, C, Al-Yanbawi, S, Al-Rabiah, A, Meyer, W, Marlais, W, Syed, R, Banjar, F, Rifai, A, Miliebari, S. Investigational Study of Iodine-124 With a Positron Camera. American Journal of Physiologic Imaging 3:197-200, 1988.

2. Flower, MA, Irvine AT, Ott, RJ, Kabir, F, McReady, VR, Harmer, CL, Sharma, HL, Smith, AG, Thyroid imaging using positron emission tomography -- a comparison with ultrasound imaging and conventional scintigraphy in thyrotoxicosis. Br. J. Radiol. 63:325-30, 1990.

3. Somawardhana, CW, Amartey, JK, Kojima, M, and Lambrecht, RM, NCL-6-124I: a PET agent for the adrenal. Int. J. Rad. Appl. Instrum [A] 41:1223-4, 1990.

4. Somawardhana, CW, Sajjad, M, Amartey, JK, Lambrecht, RM, Synthesis of 2-[123I and 124I]-iodoisonicotinic acid hydrazide-- potential radiotracers for tuberculosis. Int. J. Appl. Instrum. [A] 42:215-20, 1991

5. Pentlow, KS, Graham, MC, Lambrecht, RM, Cheung, NK, Larson, SM Quantitative imaging of I-124 using positron emission tomography with applications to radioimmunodiagnosis and radioimmunotherapy. Med. Phys. 18:357-66, 1991.

6. Snook, DE, Rowlinson, BG, Sharma, HL and Epenetos, AA, Preparation and in vivo study of 124I-labelled monoclonal antibody H17E2 in a human tumour xenograft model. A prelude to positron emission tomography. (PET). Br. J. Cancer Suppl., 1990.

7. Westera, G, Reist, HW, Buchegger, F, Heusser, CH, Hardman, N, Pfeiffer, A, Sharma, HL, Von, SG, Mach, JP, Radioimmuno positron emission tomography with monoclonal antibodies: a new approach to quantifying in vivo tumor concentration and biodistribution for radioimmunotherapy. Nucl. Med. Commun 12:429-37, 1991.

8. Lambrecht, RM, Sajjad, M, Qureshi, MA, and Al-Yanbawi, SJ. Production of Iodine-124 J. Radioanal. Nucl. Chem. Letters 127:143-150, 1988.

9. Zaidi JH, Qaim, SM, Stocklin, G Excitation Functions of Deuteron Induced Nuclear Reactions on Natural Tellurium and Enriched ^{122}Te: Production of ^{123}I via the $^{122}Te(d,n)^{123}I$ -Process. Int. J. Appl. Radiat. Isot. 34:1425-1430, 1983.

10. Firouzbahkt, ML, Schlyer, DJ, and Wolf, AP, Effect of Foil Material on the Apparent Yield of the $^{124}Xe(p,x)^{123}I$ Reaction. Int. J. Radiat. Appl. Instrum. Part A, 43:741-745, 1992.

11. Williamson, CF, Boujot, JP, and Picard, J. Tables of Range and Stopping Power of Chemical Elements for Charged Particles of Energy 0.05 to 500 MeV. Rapport CEA-R

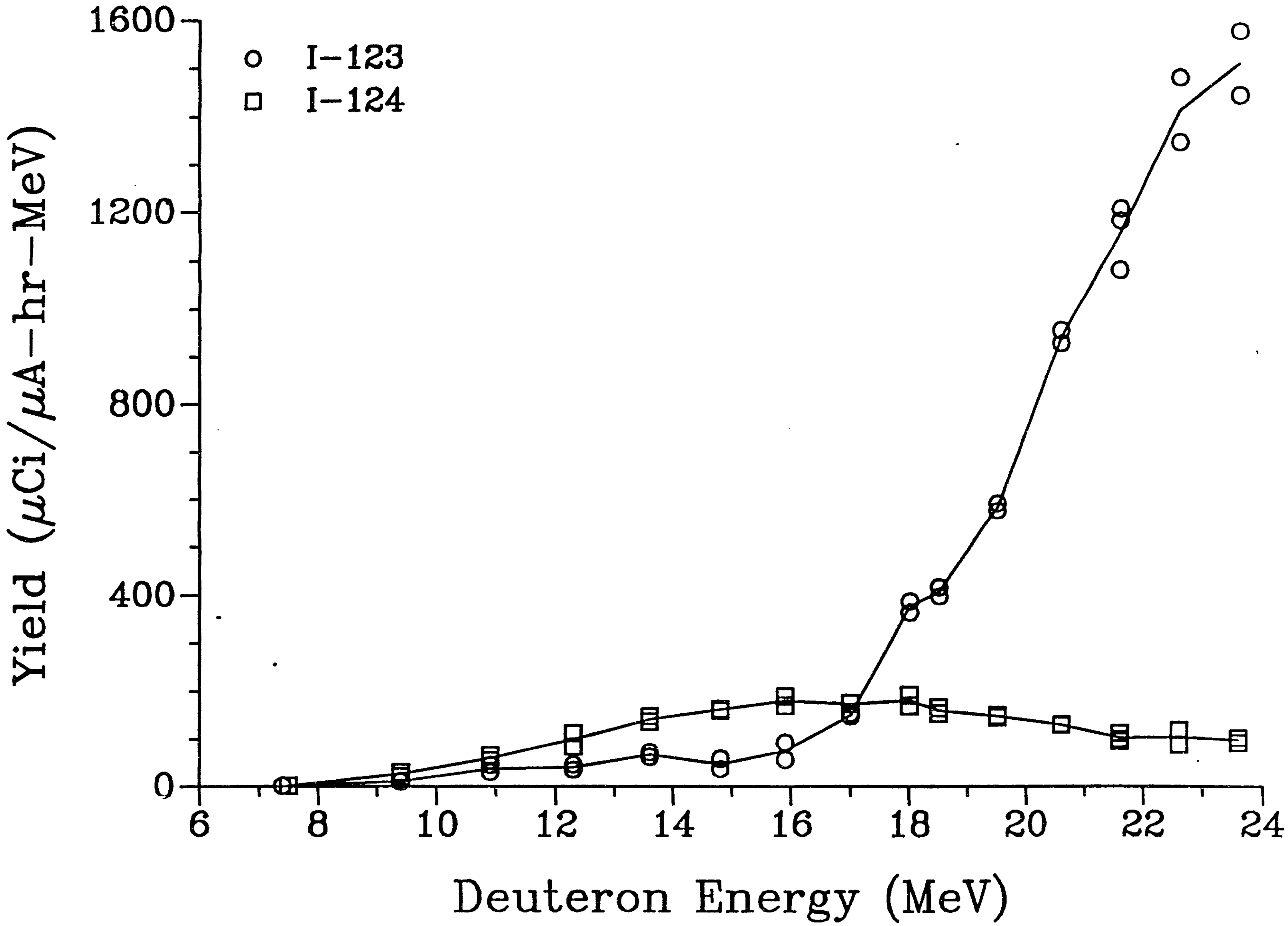
3042, Commissariat a L'Energie Atomique, 1966.

12. Hupf, HB, Eldridge, JS, and Beaver, JE, Int J. Appl. Radiat. Isot. 19:345---, 1968.

Table 1
Yield and cross-section for the $^{124}Te(d,2n)^{124}I$ and $^{124}Te(d,3n)^{123}I$ Reactions

Deuteron Energy (MeV)	I-124 Yield *	I-123 Yield *	$^{124}Te(d,2n)^{124}I$ cross-section (millibarn)	$^{124}Te(d,3n)^{123}I$ cross-section (millibarn)
23.6	97±5	1506±66	34±2	700±28
22.6	103±15	1410±67	38±6	674±32
21.6	102±6	1155±26	39±3	573±25
20.6	130±1	939±14	51±1	484±6
19.5	148±2	580±8	61±1	312±3
18.5	160±6	406±9	69±3	223±6
18.0	180±10	374±16	79±5	216±6
17.0	173±1	151±3	81±1	92±2
15.9	179±9	74±18	83±4	45±11
14.8	162±1	47±10	78±1	30±7
13.6	142±5	67±5	72±3	44±4
12.3	99±13	40±5	59±8	18±9
10.9	60±6	37±7	39±4	31±6
9.4	26±4	10±1	17±3	9±1
7.5	1	1	1.0	1

* The yields are averages of at least 2 runs and the error limits are standard deviations. Units are μCi/μA-hr-MeV


I-123
I-124
Yield (μCi/μA-hr-MeV)
1600
1200
800
400
0
6
8
10
12
14
16
18
20
22
24
Deuteron Energy (MeV)

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