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Short Research Article

Formulation of sodium iodide (Na ^{123}I) oral capsule†

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Abstract: Sodium iodide-123 (Na^{123}I) is well known as a radioisotope that is used for studies of the thyroid and its metastases. ^{123}I was produced from the reaction of 28 Mev protons with 99.99% enriched ^{124}Xe by cyclotron. A home made target was installed and used for this purpose. The main part of the target contained target vessel, target windows and cooling system. In addition, some other part such as a cold finger, decay vessel, vacuum pump and four fingers were also designed and installed on the system. After bombardment, the production of ^{123}I from ^{123}Cs, the target was left for 6 hours and then rinsed with distilled water. A clear and colourless solution containing ^{123}I was pumped to the hot cell. For adjusting the pH, sodium citrate buffer was used. The solution was added directly to the capsules which were already filled with inert powder. Each capsule contained 210 µCi Na^{123}I. Quality control has shown 98% radiochemical and 99.96% radionuclide purity, with the yield of 2 mCi/µA. Quality control results had good accordance with the United States Pharmacopoeia. Copyright © 2007 John Wiley & Sons, Ltd.

Keywords: sodium iodide-123; Na^{123}I; ^{123}I oral capsule; iodide-123 capsule

Introduction

Iodine-123 is a well-known isotope in nuclear medicine. The nuclear properties of ^{123}I are summarized in Table 1.[1]

The most important nuclear reactions which can be used for the production of ^{123}I using the Cyclon-30 at NRCAM with a proton beam of 15–30 MeV and/or deuteron beam of 7–15 MeV are as given in Table 2.

Among the various types of nuclear reactions for ^{123}I production, the reactions of:

^{124}Xe (p, 2n) ^{123}Cs $\rightarrow$ ^{123}Xe $\rightarrow$ ^{123}I

^{124}Xe (p, pn) ^{123}Xe $\rightarrow$ ^{123}I

are favoured due to absence of ^{124}I and ^{125}I impurities.

Characteristics of ^{123}I production system at NRCAM

Figure 1 shows the schematic diagram of the gas target housing, windows and cooling system. These were installed on one of the beam outlets of the cyclotron. The specifications of individual parts of this target system are as follows:

I – A conical target vessel, made of aluminium with a length of 24 cm with 15 and 32 mm diameters at each end. This was mounted in an aluminium cylinder of length 30 cm and diameter 8.5 cm for water cooling during bombardment.

II – Front target window, made of titanium foil of 50 µm thickness in an aluminium holder. This foil window is placed in the direction of proton and secures the expensive xenon gas target from the exhaust.

III – Rear target window, also made of titanium foil of 50 µm thickness in an aluminium holder. This window is put in the direction of proton beam. These two thin windows are 3 cm apart from each other.

IV – Cooling system.

V – Transfer tube, used for transferring the xenon gas from the reservoir capsule to the target, using a cryogenic technique.

Besides the target house, there are also some other important parts which are designed and installed on the system such as:

VI – Cold Finger (CF): This part is an intermediate box between the target house and the reservoir capsule which can be cooled by helium or warmed by a wrap-around electrical heater. Electrical valves and some

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Table 1 Specification of ^{123}I

Half-life	Mode of decay	Main gamma energy
13.2 h	Electron capture	159 kev, no beta emission

Table 2 Nuclear reactions samples for ^{123}I production

Reaction	Energy range (MeV)	^{124}I, ^{125}I impurities (%)	^{123}I purity (%)
^{124}Xe (p, 2n) $^{123}Cs \rightarrow {}^{123}Xe \rightarrow {}^{123}I$	20–30	—, 0.01	>99.99
^{124}Xe (p,pn)$^{123}Xe \rightarrow {}^{123}I$	20–30	—, 0.01	>99.99
^{124}Te (p,2n) ^{123}I	23–26	3.8, —	96.2
^{123}Te (p,n) ^{123}I	10–15	1.7, —	98.3
^{124}Te (d,n) ^{123}I	8–16	0.4, —	97.5

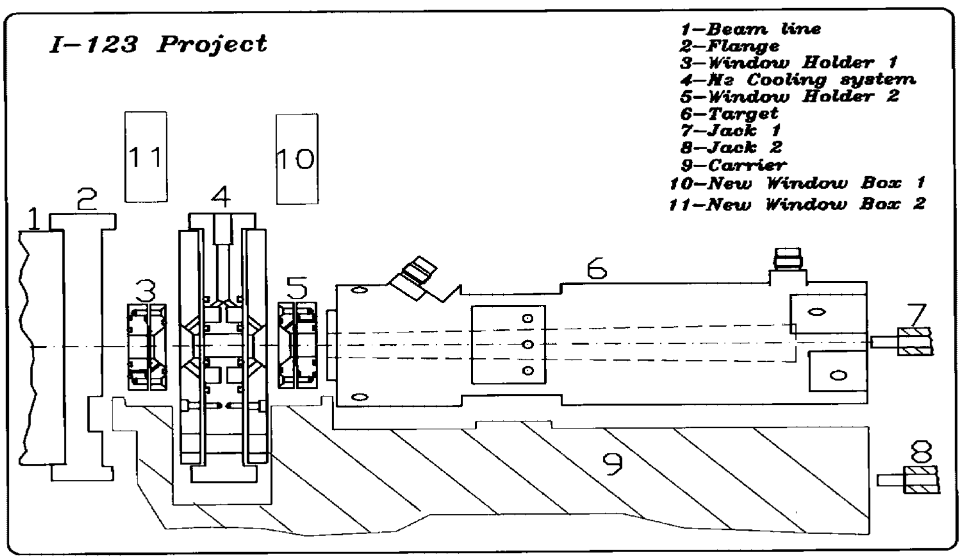

Figure 1 Diagram of Xe-124 gas target.

tubes by which mean xenon-124 gas can be transfered between the target housing and the reservoir capsule without leakage.

VII – Decay vessel (water recovery housing): Bombarded xenon gas will be transferred to this vessel and stored there up to about 6 hours to allow decay to ^{123}I with the maximum efficiency. The remaining xenon gas is then transferred into the reservoir capsule using a cryogenic technique. The iodine-123 produced, which is deposited on the wall of the decay vessel, is then rinsed out by dissolution in water at 80°C. Nitrogen gas pressure is used for the transfer to the chemical hot lab.

VIII – Vacuum pumps: Two vacuum pumps are used in this system for producing the necessary vacuum within the system, both before and after transferring xenon gas into or out of the target housing.

IX – Four fingers: For adjustment of the proton beam just before entering the target. Figure 1 show the schematic diagram of this gas target housing and its windows plus cooling system. These were installed at one of the beam outlets of the cyclotron.

Preparation of Na^{123}I

^{123}I was produced from the reaction of 28 Mev protons with 99.99% enriched ^{124}Xe using a cyclotron. To allow the formation of ^{123}I by decay of ^{123}Cs the target was left for 6 hours. The target was rinsed with 80 ml of distilled (0.05 μz conductivity) water, and then the clear and colorless solution containing ^{123}I was pumped to the hot cell. All steps of production were performed under safe conditions from the view of the health physics. For adjustment of the pH from 5.5 up to around 8, sodium citrate buffer was added to the solution. A sample of the solution was sent for quality control and after quality control, the solution was

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added directly to the capsules which had already been filled by sodium sulfate powder. Each capsule contained 210 μCi of $Na^{123}I$ at the time of calibration. Capsules were finally placed in special lead containers and delivered to hospital.

Results and discussion

Quality control results were in good accordance with United States pharmacopoeia.[2] The results and production parameters are shown in Tables 3 and 4 respectively.

The stability and radiochemical purity were checked 24 and 48 hours after preparation of the final solution. Polarography and ICP Atomic Emission Spectroscopy with an accuracy of 10 ppb has shown no aluminum cation present. Such aluminum cations could have leached from the target body.

Using this system with the above specification, the production yield might be increased by increasing the current. By improving the system used for cooling of the dual titanium windows, the risk of the breakage will be decreased. The authors suggest that two cooling systems could be sufficient for this purpose. We are currently testing and planning upgrades to the cooling systems which would enable us to increase the beam current and hence to achieve higher yields.

Table 3

Produced $Na^{123}I$	USP 2005
Clear solution	Clear solution
pH=7.7	pH=7.5–9
$Na^{123}I$ = 98%	$Na\ ^{123}I \geqslant 95$
^{123}I = 99.96%	$^{123}I \geqslant 99.7\%$

Table 4

Total activity: 80 mCi
Specific activity: 1 mCi/ml
Production yield: 2 mCi/μAh
Current: 20 μA
Time of bombardment: 2 h
Integrated current: 40 μAh

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