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PRODUCTION OF ^{123}I USING THE CV-28 CYCLOTRON AT IPEN-CNEN/SP

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These studies had the purpose of establishing the optimal conditions for the production of ^{123}I through the $^{124}Te(p,2n)^{123}I$ reaction, using the CV-28 Cyclotron (E_{max} = 24 MeV for protons) at IPEN-CNEN/SP. Two different targets (TeO_2 and TeO_2 + 2% Al_2O_3) were irradiated in order to check their physical resistance against beam current (up to 12 μA) and length of irradiation (10 min - 2 h), and to evaluate the recovery of the radioiodine produced, by a dry distillation process with a high frequency induction furnace. Later on, enriched $^{124}TeO_2$ (96.2%) targets were irradiated, and ^{123}I was produced routinely with a production yield of (3.31 ± 0.07) mCi/μAh, 1.7% of ^{124}I at EOB and radiochemically pure.

INTRODUCTION

^{123}I is a very widely used radioisotope in Nuclear Medicine diagnosis, due to its favorable decay characteristics ($t_{1/2}$ = 13.2 h and single photon emission,

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E = 159 keV). It can advantageously replace ^{131}I, reducing the radiation dose given to the patient. It has been used in the iodide form for studying thyroid metabolism, or attached to organic molecules for other purposes: IMP (n-isopropyl-p-I-amphetamine) for dynamic brain studies; MIBG (metaiodobenzylguanidine) for myocardial studies, and monoclonal antibodies for tumor detection[1].

There are two ways of producing ^{123}I:

1. Direct method, through reactions such as $^{123}Te(p,n)$, $^{124}Te(p,2n)$, $^{122}Te(d,n)$ and $^{121}Sb(\alpha,2n)^{123}I$;

2. Indirect method, through the decay of ^{123}Xe and reactions such as $^{127}I(d,6n)$, $^{127}I(p,5n)^{123}Xe \rightarrow {}^{123}I$ and $^{124}Xe(p,2n)^{123}Cs \rightarrow {}^{123}Xe \rightarrow {}^{123}I$.

The advantage of the latter method is the higher radionuclidic purity of ^{123}I, but it requires high energy beams or high investiment (enriched xenon target).

The method chosen for the production of ^{123}I was the direct one, through the $^{124}Te(p,2n)^{123}I$ reaction[2], due to the characteristics of IPEN's Cyclotron (model CV-28 from TCC) that can accelerate protons with maximum energy of 24 MeV. The only radionuclidic impurity in this method is ^{124}I, produced through the $^{124}Te(p,n)^{124}I$ reaction. Its presence affects the image quality and increases the radiation dose given to the patient. This contamination can be reduced by using enriched $^{124}TeO_2$ as target material and by an adequate choice of the energy interval for the irradiation. For an enrichement of 96.2% of ^{124}Te, the level of ^{124}I reaches 4.5%, its permissible upper limit for use, 36 h after EOB[3].

EXPERIMENTAL

In the preliminary experiments, two different targets (TeO_2 and TeO_2 + Al_2O_3) were studied[4] in order to check their physical resistance[5] against beam current and to evaluate the influence of Al_2O_3 in the release of radioiodine during the separation.

The targets were prepared by melting TeO_2 or TeO_2 + Al_2O_3 (277 mg cm^{-2}) on platinum plates with a 0.78 cm^2 recess. The targets had a 4π water cooling arrangement, and were irradiated with 24 MeV proton beams and currents of up to 12 μA for several periods of time (10 min - 2 h). A wobbling system was used for homogenizing the beam.

The chemical separation of radioiodine was carried out by the dry distillation technique in an oxygen atmosphere and using a high frequency induction furnace (model "I", 8.0 kW, supplied by POLITRON). The volatilized radioiodine was collected into a 0.01N NaOH solution. Figure 1 shows the apparatus used for the separation of ^{123}I.

After setting all the parameters for iodine separation with irradiated TeO_2 targets with natural composition, enriched $^{124}TeO_2$ (96.2%) targets were irradiated. The ^{123}I production yields, the level of ^{124}I and the ^{123}I radiochemical purity (by thin layer chromatography[6]) were then measured.

RESULTS AND DISCUSSIONS

The results obtained for the release of radioiodine when the two different types of target were irradiated are shown in Table 1. They show that when Al_2O_3 was

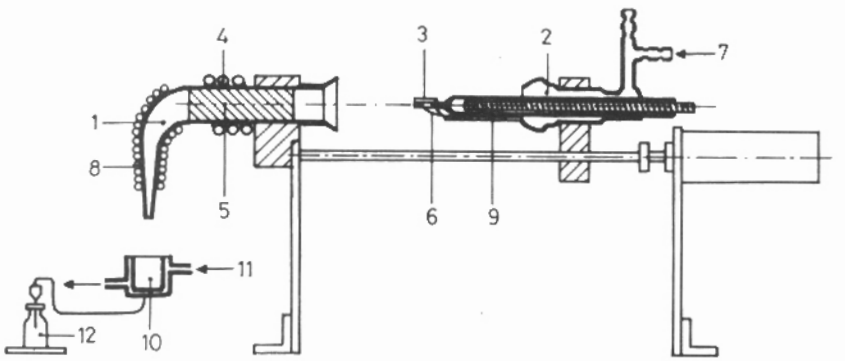

Fig. 1. Apparatus for the radiochemical separation of radioactive iodine from the target
Schematic diagram of remotely controlled apparatus for dry distillation of radioiodine: 1 - Outer quartz tube (fixed); 2 - Inner quartz tube (movable); 3 - Platinum support with TeO_2; 4 - Induction coil; 5 - Pt tube ø = 22 mm; 6 - Thermocouple; 7 - O_2 flow (30-40 ml min^{-1}); - 8 Heating ribbon; 9 - Electrical resistance; 10 - NaOH solution; 11 - Cooling water circulation; 12 - Collecting flask

added to the target, about 40% of the activity remained in the target after the distillation, whereas only 5% remained when pure TeO_2 was employed. Probably, Al_2O_3 worked as an adsorber for radioiodine[2]. There was no significant loss of target material when pure TeO_2 was irradiated with 12 μA for 2 h. These results agree with Michael et al.[7]

The loss of target material during the distillation process was 0.5% for both targets. This shows the advantage of inductive heating when compared with the resistive one, in agreement with the work of Oberdefer et al.[8].

Based on the above results, it was decided to use pure enriched $^{124}TeO_2$ targets for the routine produc-

TABLE 1

Separation yield of radioiodine from TeO_2 and TeO_2 + 2% Al_2O_3 targets by the dry distillation method using an induction furnace. Furnace temperature = (760 ± 5) °C. Diffusion time = 2 min. Oxygen flow rate = 30-40 ml min^{-1}

	Targets			
	Pure TeO_2		TeO_2 + 2% Al_2O_3	
	Target 1	Target 2	Target 1	Target 2
Release of radioiodine from the target (%)	92.1±2.9	97.1±2.0	50.7±2.2	47.2±4.4
Radioiodine collected in 0.01N NaOH solution (%)	73.2±8.2	73.2±8.0	40.1±6.3	38.9±1.9

Number of experiments = 6.

tion of ^{123}I. The results obtained for a total of seven irradiations of $^{124}TeO_2$ were:

- Production yield: (3.31±0.07) mCi $^{123}I/\mu Ah$,
- ^{124}I impurity level: 1.7% at EOB,
- Radiochemical purity: 100% I^-.

The conclusion of this work is that ^{123}I produced as described here is adequate for medical use, with the only limitation of using it within 21 h after the EOB, so that the level of ^{124}I remains below 4.5%.

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