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PRODUCTION OF Xe<sup>131m2</sup>

R. E. McHenry



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PRODUCTION OF Xe<sup>131m2</sup>

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## PRODUCTION OF Xe<sup>131m2</sup>

### INTRODUCTION

A method is described for the production of large quantities of Xe<sup>131m2</sup>, where a high degree of purity is required in routine preparation. The method involves separating the Xe<sup>131m2</sup> from the parent I<sup>131</sup> and then purifying with calcium vapor.

Xenon-131<sub>m2</sub> is produced by the decay of I<sup>131</sup> with a yield of 0.7%. This isomer decays by isomeric transition, emitting a 163-kev x ray.<sup>1</sup> Its half life is 12 days.

This procedure was developed to meet the quality requirements for use in the radioisotope distribution program at Oak Ridge National Laboratory and to supply the customer demand for this radioisotope.

Xenon-131<sub>m2</sub> has previously been separated from I<sup>131</sup> by Bergstrom<sup>2</sup> by freezing a solution containing NaI<sup>131</sup> and removing the Xe<sup>131m2</sup> which is in equilibrium with the parent.

### EQUIPMENT AND PROCEDURE

All the processing described in this procedure is done in a remote manipulator cell.<sup>3</sup> Processing equipment consists of a precipitation and filtration vessel (Fig. 1), a production tube (Fig. 2), and a storage and purification container (Fig. 3). A shielded container is used to store the production tube for decay of the I<sup>131</sup>. The shielded container is designed so that the valve and thermocouple gage tube assembly of the production tube extends outside the shielded container. By this arrangement the transfer of Xe<sup>131m2</sup> from the production tube to the storage container is made outside the manipulator cell.

The iodine, from which the Xe<sup>131m2</sup> daughter is obtained, is produced at ORNL<sup>4</sup> as NaI in a basic solution of Na<sub>2</sub>SO<sub>3</sub>. The I<sup>131</sup> is precipitated from

the product solution with the use of an iodine carrier. Approximately 15 to 20 mg of iodine is added as a solution of NaI to the solution containing the I<sup>131</sup> activity. After agitation the iodide is precipitated by addition of excess AgNO<sub>3</sub>. The solution is then agitated for 10 min and made slightly acid with dilute nitric acid. The AgI precipitate is allowed to settle, and most of the supernate is removed by decantation. The AgI precipitate is collected in the small filter shown in Fig. 1. The filter tube is removed and placed in the stainless steel production tube, which contains 1 g of outgassed calcium metal. The tube is evacuated and heated to red heat to react the calcium metal with the AgI. The calcium metal prevents the iodine from being removed from the production tube when the Xe<sup>131m2</sup> daughter is

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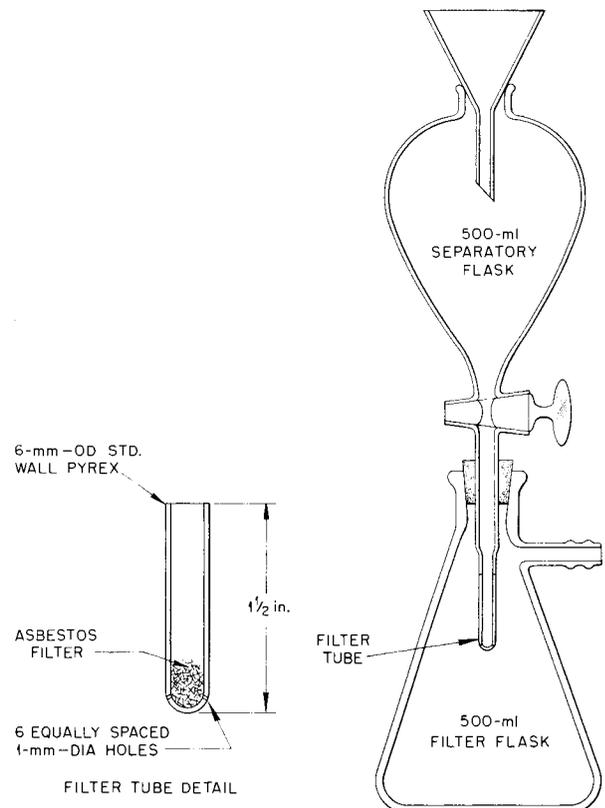


Fig. 1. Xe<sup>131m2</sup> Precipitator.

1. Bergström, *Phys. Rev.* 80, 114 (1950).
2. Bergström, *Arkiv Fysik* 5, 191-295, esp 265-266 (1952).
3. A. F. Rupp, E. E. Beauchamp, and J. R. Farmakes, *Production of Fission Product Iodine-131*, ORNL-1047 (Dec. 18, 1951).
4. J. R. Farmakes and E. Lamb, ORNL CF-52-10-230 (July 31, 1953) (Classified).

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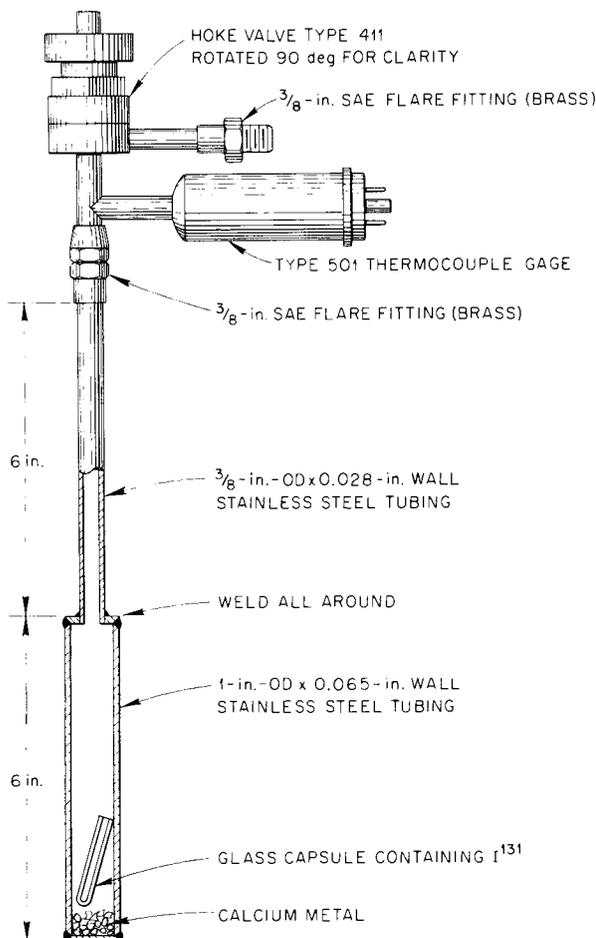


Fig. 2. Xe<sup>131</sup> Production Tube.

removed and also purifies the Xe<sup>131m2</sup> from all impurities that are present. The production tube is then placed in a shielded container, removed from the cell, and stored to allow the I<sup>131</sup> to decay to Xe<sup>131m2</sup>. The I<sup>131</sup> is allowed to decay for 10 to 14 days.

After the decay time, the tube containing the I<sup>131</sup> and the Xe<sup>131m2</sup> daughter is removed from the shielded container and heated in a remote manipulator cell for 10 min to release the Xe<sup>131m2</sup> from the molten calcium.

The production tube is again placed in the shielded container and removed from the cell. The purified Xe<sup>131m2</sup> is removed to the storage container (Fig. 3) either by pumping or by expansion

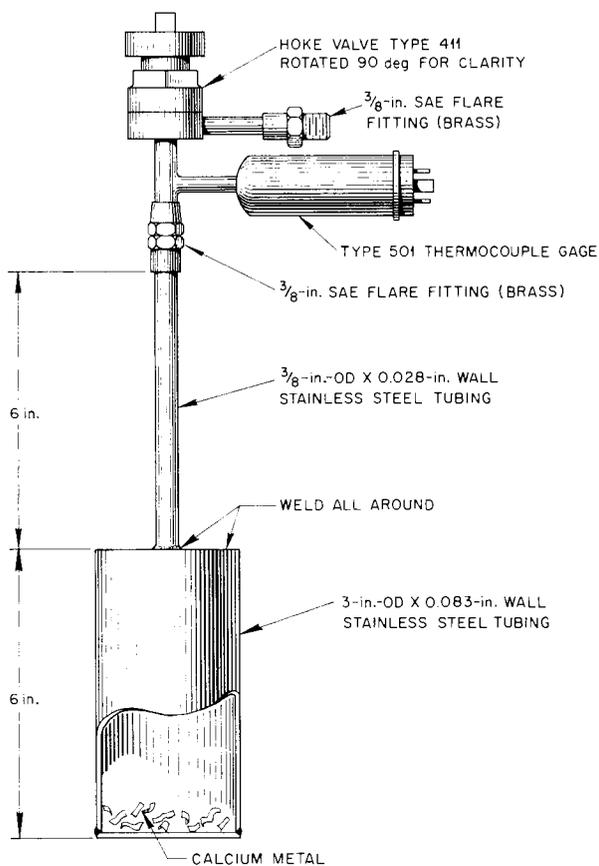


Fig. 3. Xe<sup>131</sup> Container.

into the larger volume. If it is necessary, the calcium metal in the storage container can be used to repurify the Xe<sup>131m2</sup> from air.

#### DISCUSSION

The optimum time of decay of the I<sup>131</sup> for a maximum amount of Xe<sup>131m2</sup> can be expressed as

$$\ln \frac{\lambda_1}{\lambda_2} = (\lambda_1 - \lambda_2) T ,$$

where

- $\lambda_1$  = decay constant of I<sup>131</sup>,
- $\lambda_2$  = decay constant of Xe<sup>131m2</sup>,
- $T$  = time.

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The optimum time is 14.1 days. The quantity of  $Xe^{131m_2}$ , as per cent of the  $I^{131}$  activity, is:

$$\frac{N_2 \lambda_2 (0.007)}{N_1^0 \lambda_1} = \frac{\lambda_2}{\lambda_1 - \lambda_2} \left( e^{-\lambda_2 T} - e^{-\lambda_1 T} \right),$$

where

$N_2 \lambda_2$  = activity of  $Xe^{131m_2}$  at time  $T$ ,

$N_1^0 \lambda_1$  = activity of  $I^{131}$  at time of canning.

After 14.1 days the  $Xe^{131m_2}$  activity will be 0.2078% of the starting  $I^{131}$  activity.

The  $Xe^{131m_2}$  product will contain amounts of  $Xe^{133}$ , depending on the amount of  $I^{133}$  in the  $I^{131}$  product. At reactor discharge time  $I^{133}$  activity is 69% of the combined  $I^{133}$  and  $I^{131}$  activities. Since the half life of  $I^{131}$  (8.05 days) is 9.3 times longer than that of  $I^{133}$  (20.8 hr), the ratio of  $I^{133}$  to  $I^{131}$  decreases very rapidly with time.

If  $Xe^{133}$  is objectionable in the  $Xe^{131m_2}$  product, the mass-133 chain is removed by allowing sufficient time for the decay of  $I^{133}$  to  $Xe^{133}$ . The  $I^{131}$  is then precipitated and separated from the xenon decay products.

If the xenon daughters were collected from iodine activities containing  $I^{133}$ , the ratio of  $Xe^{131m_2}$  to  $Xe^{133}$  would not be greatly changed by decay, since the half life of  $Xe^{131m_2}$  is only 2.3 times longer than that of  $Xe^{133}$ .

The calculated analysis of the xenon activities prepared after several different decay periods is given in Table 1. Sample A was prepared from iodine activities which decayed for seven days from their reactor equilibrium ratio before being

separated from the xenon daughters and sealed in the production tube. After the iodine activities had decayed for ten days in the production tube, the xenon daughters were collected. Sample B was the same as sample A except that the iodine activities decayed in the production tube for 14 days before removal of the xenon daughters. Sample C decayed for 17 days from the reactor equilibrium ratio before being separated from the xenon daughters and sealed in the production tube. The iodine activities decayed for 14 days in the production tube before the xenon daughters were collected.

The last column in Table 1 is the yield (in milluries) of  $Xe^{131m_2}$  recovered from 100 mc of  $I^{131}$ . The quantity of activity is based on the analysis date, which is seven days after reactor discharge.

A total of 12 production runs has been made using 20 to 60 curies of  $I^{131}$  in each run. The  $Xe^{131m_2}$  has contained no detectable amount of iodine activity.

Table 1. Analysis and Yield of Xenon Product from 100 mc  $I^{131}$

Sample	$Xe^{131m_2}$ (%)	$Xe^{133}$ (%)	Yield (mc) of $Xe^{131m_2}$ (100-mc $I^{131}$ samples)
A	71.1	28.9	0.192
B	81.9	18.1	0.204
C	99.98	0.02	0.087