Dissolution and Solvent Extraction of Sr-89 in Hot cells

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1. Introduction

Strontium-89 is a pure β- emitter with energy of 1.5 Mev. It has a half life of 50.5 days while its biological half life is 14 days. In its chloride form, it is used as a pain palliative medicine for bone metastases [1]. It can be produced by $^{88}Sr(n,\gamma)^{89}Sr$ reaction in thermal reactors or by $^{89}Y(n,p)^{89}Sr$ reaction in fast reactors. This paper describes, the procedure adopted in hot cells for dissolution and solvent extraction of Sr-89 produced by irradiation of Yittria pellets in fast reactor.

2. Description

Yttira pellets prepared by NRCS, of FChD were subjected to irradiation in the Fast Breeder Test Reactor, IGCAR, at various locations by encapsulating them either in quartz tube or SS tube. Three campaigns of irradiation were carried out, the details of which are given in Table 1. After irradiation, the pellets along with the encapsulated tube were transported to the hot cells of MC&MFCG through La-Calhene container Shielded with lead cask. The irradiated yttria pellets were removed from the SS tube remotely. A special quartz cutting device was fabricated (figure 1) for cutting the quartz tube. The photograph of pellets received in quartz and SS tube is shown in figure 2. For the dissolution, a titanium (Ti) dissolver vessel was fabricated (figure 3) with the following features (i) a large base for receiving the heat, (ii) a step for rigid holding of the vessel using manipulator (ii) Double screw lock for tilting purpose (iv) provision for RTD insertions. The all titanium vessel was made by welding two parts as shown in figure 3, so as to provide relieve angles inside the vessel for complete draining of the dissolver solution. A multi task work table was fabricated (figure 4) with the following features (i) vice for hold-up various equipments (ii) dissolver vessel holder (iii) lid open cum closure arrangement (iv) solution transferring system (v) separation fixture and (vi) multi column fixture.

Table 1

Campaign No.	Position of Irradiation	No.of days of irradiation (days)	Pellet encapsulation tube	Solvent extraction route followed
I	Centre Core	72-73	Stainless Steel	TBP
II	4th Ring	118	Quartz	TBP
III	5th Ring	30	Quartz	Crown ether,TBP

The irradiated pellets were removed from the encapsulation and collected in a beaker separately (figure 5). From this, 25 nos. of irradiated yittria pellets were transferred to the Ti dissolver vessel. Two sets of dissolution were carried out, each by transferring 150 ml of 9 M HNO_3 in to vessel (figure 6) and by controlled heating of the dissolver vessel at 120°C for 24 hrs.

Figure 1: Quartz tube cutter

Figure 2: Irradiated Pellets in (a) Quartz tube (b) SS tube

Figure 3: Ti Dissolver Vessel

Figure 4: Multi Task Work Table

Figure 5: Irradiated Pellets

The dissolver solution was retrieved from the vessel after cooling and then subjected to solvent extraction process by two routes. In the first set of experiments involving crown ether, ^{89}Sr from the 150 ml of the dissolver solution was extracted in to 150 ml of the crown ether solution using solvent extraction by batch process. After 3 batches, the bulk of organic solution having ^{89}Sr was taken out of hot cell for further processing and $SrCl_2$ conversion process. During the second set of solvent extraction process, 300 ml of fresh TBP, pre-equilibrated with 12 M HNO_3 was contacted with 300 ml of dissolver solution. The process was repeated for six times and in each time; the same aqueous solution was contacted with fresh organic solution. The aqueous after the sixth stage of solvent extraction containing ^{89}Sr, was taken out of the cell and transferred to radioactive laboratory for further ion-exchange purification and $SrCl_2$ conversion process. The photographs of the remote transfers of pellets and acid for dissolution, the heating unit and

(a) (b) (c)

Figure 6 (a) Transfer of pellets and acid for dissolution (b) Heating unit (c) Transfer of dissolver solution

the remote transfer of dissolver solution are shown in figure 7(a), (b) and (c) respectively. Using the above facility, the dissolution and solvent extraction of ^{89}Sr was carried out successfully inside hot cells.

Reference :

1. Feasibility studies for production of ^{89}Sr in the Fast Breeder Test Reactor (FBTR), Debasish Saha, J. Vithya, G. V. S. Ashok Kumar, K. Swaminathan, R. Kumar, C. R. Venkata Subramani and P. R. Vasudeva Rao, Radiochim. Acta 101, 667–673 (2013)