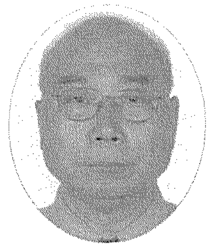
General Aspects of Isotope Production in Nuclear Power Institute of China



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1. Reactors for Radioisotope production and Silicon NTD

In NPIC, there are three reactors (HFETR, MJTR and Pulsed Reactor) used for radioisotope production and silicon NTD. The High Flux Engineering Test Reactor in China mainly used for the irradiation test of reactor fuel elements and structural materials of different kind of reactors, and owing to its high neutron flux and its multitudinous irradiation positions, it is most useful for the production of radioisotopes, especially for the production of high specific activity radioisotopes. The MJTR fueled by spent fuel elements of HFETR and with power of 5 MW is mainly used for NTD of silicon and the production of radioisotopes with medium half life, such as Mo-99, I-131 and so on. The total capacity for NTD of sili-con of HFETR and MJTR is about 30t per year. The Pulsed Reactor with Power of 1 MW is mainly used for neutron activation analysis and production of radioisotope with short and medium half life.

2. Target Structure for Radioisotope Production

According to the characteristics of irradiation position in HFETR and MJTR, and the nuclear characteristics of different kinds of radioisotopes to be produced, there are four kinds of targets that can be used for radioisotope production. The first kind of target is the fuel element type target that can be located in the 63 mm diameter grid hole. The second kind of target is called beryllium assembly type target that can be located in the 20 mm diameter central hole of beryllium assembly. These two kinds of targets mentioned above are useable for the production of long half life radioisotopes, such as Co-60, Ni-63, C-14 and so on. For the target material with large neutron capture cross section, for example, for Co and Ni, in order to decrease self shielding effect of the target material and produce the radioisotopes with high specific radioactivity, the target must have the ring type structure. The third kind of target can be located in the 12mm diameter central hole of fuel element, this kind of target is useable for the production of medium half life radioisotopes, such as S-35, Ir-192, Sn-113, Tm-170, Gd-153 and so on, all these radioisotopes need only one operation cycle irradiation in reactor. The fourth kind of target is suitable for irradiation in different irradiation channel with size of 63mm, 120mm, 150mm, and 230mm diameter hole, these targets can be put in or taken out the irradiation channel with some kind of elevator during the reactor operation. These kinds of targets are mainly used for the production of medium or short half life radioisotopes, such as Mo-99, I-131, P-32, Sm-153, Re-186 and so on.

3. The Main Radioisotopes Produced in NPIC and Some Aspects of Technology Used in Radioisotope Production

In principle, all kind of reactor produced radioisotopes can be produced with HFETR and MJTR. Up to date, the main radioisotopes produced with HFETR are Co-60, Ir-192, Tm-170, C-14, S-35, P-32, Sn-113, Mo-99, I-125,

〈Table 1〉 Sealed Radiation Sources For Medical Uses

Sealed	Co-60	Co-60	Ir-192	Gd-153
Sources	Teletherapy sources	Afterloading sources	Afterloading sources	Densitometry sources
Active materials	Φl×l mm Co metal pellets	Φl×l mm, Φl×2 mm Co metal pellets	Φl×l mm Ir metal pellets	Gd2O3 sintered pellet
Active size (mm)	Φ20×28, Φ22×20	Φl×l, Φl×2	Φl×l	Φ3×l
Source size (mm)	Φ23.4×36.7 Φ26×27	Φl.5 ×3.5, Φl.5 ×5	Φl.5 ×5	Φ6 ×2
Activity (Ci)	3000-5000	0.2-1.2	5-10	1-1.5
Structure	Double stainless steel capsule	Single titanium capsule	Single stainless capsule	Single stainless capsule

〈Table 2〉 Sealed Radiation Sources For Industry Uses

Sealed Sources	Co-60 radiation sources	Co-60 radiography sources	Ir-192 radiography sources	Tm-170 radiography sources
Active materials	Φ1×1 mm Co metal pellets	Co metal wafer	Ir metal wafer	Tm_2O_3 sintered pellet pellet
Active size (mm)	Φ10.8×82	Φ4×4	Φ1×1-, Φ3×3	Φ1×1, Φ1×2
Source size (mm)	Φ15×90	Φ7 ×8-, Φ7×16	Φ6×8-, Φ6×16	Φ5×7
Activity (Ci)	1000-2000	50-100	5-100	3-20
Structure	Double stainless steel capsule	Single stainless steel capsule	Single stainless steel capsule	Single titanium capsule

Zirconyl molybdate gel type Tc-99m generator and zirconia tin oxide gel type In-113m generator were developed in NPIC. Compared with adsorption type generators the gel type generators have following advantages:

A. Low specific activity Mo-99 and Sn-113 produced by irradiation of natural Mo and Sn in reactor can be used for preparation of Tc-99m generator.of up to 2Ci and In-113m generator of up to 100mci with small column.

B. The radioactive waste can be reduced to minimum during generator preparation.

C. Low cost.

The gel type Tc-99m, generator and In-113m generator are being widely used in China and suitable for the developing countries.

Ni-63, Gd-153, Sm-153, Sr-89 and so on. The main radioisotope products are gel type Tc-99m generator, 113mIn generator, Y-90 generator, some kind of radiopharmaceuticals and some kind of sealed radioactive sources. Several kinds of sealed radiation sources with wide application in medicine, industry and agriculture are listed in Table 1 and Table 2. For Co-60 sealed sources and Ir-192 sealed sources, Φ1×1 mm Co metal pellets plated with nickel , Φ2×0.2 mm and Φ3×0.2 mm Ir metal wafers were used as the active materials. Co-60 teletherapy sources and Co-60 radiation sources have double stainless steel (1Cr18Ni9Ti) capsule welded by plasma arc or argon arc. According to the standard of ISO 2919, the sources were tested for tempera-ture, external pressure, impact, vibra-tion and puncture. The safety perfor-mance of the sources achieved the class of E63535. Co-60 radiography sources, Ir-192 radiography sources and Co-60 after loading sources have single stainless capsule welded by argon arc, the safety performance of the sources achieved class of ISO/C53535. For the Tm-170 radiography sources and Gd-153 bone densitometry sources, thulium oxide and godolinium oxide were used as active materials, because they are the low energy gamma sources, in order to decrease gamma attenuation, thin stainless steel or light metal, for example, Ti metal or Al metal, must be used for the capsule materials.

4. The Recent Progress of Radioisotope Production in NPIC

The main progress of radioisotope production in recent years in NPIC is centralized in two fields, that is the development of radiopharmaceuticals for cancer treatment and the development of MIPR for production of Mo-99, I-131, Sr-89 and so on.

In recent years, more and more physicians and doctors in nuclear medicine realized that the treatment of serious disease, typically cancers is very important, and changed the research emphasis on the treatment of cancers with beta emitting radiopharmaceuticals. At present in NPIC, P-32 glass microsphere and Y-90 glass microsphere have been developed and used for the treatment of different kinds of cancers, such as the cancer in liver, tongue, breast and cervix through intra arterial injection or local injection. The preliminary clinical trial of this kind of radioactive glass microsphere has got good results and shows good prospects. I-125 seed also has been developed for the treatment of prostate cancer. In recent years, some kind of monoclonal antibodies label with I-131 or Y-90 for cancer therapy has been developing.

From 1997 to now we have been developing the medical isotope production reactor (MIPR), the main parameters of MIPR is listed in table 3. This reactor is planed to be constructed in 2009. KRIA

〈Table 3〉 The Main Parameters of MIPR

Fuel (90% enriched ^{235}U)	$UO_2(NO_3)_2$ solution
Core loading	~3.8 kg ^{235}U
Volume of fuel solution	100L
Rated thermal power	200kw
Life of the core	20a
Operation time	2.5d×2/week
Planed capacity of isotope production	
Mo-99	100,000 Ci/year
I-131	20,000 Ci/year
Sr-89	400 Ci/year

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주제발표