Treatment of Spent Uranium From Medical Radioisotope Production

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1. Introduction

Technetium-99m (Tc-99m), daughter isotope of Molybdenum-99 (Mo-99), is the most commonly used medical radioisotope for nuclear dignostics. Majority of Mo-99 has been produced by the fission of U-235 in research reactors with highly enriched uranium (HEU) targets, historically. [1] However, to reduce the use of HEU in the civilian sector for non-proliferation purpose, all producers are being forced to use low enriched uranium (LEU, 19.75% U-235 enrichment) targets. Use of LEU targets, instead of HEU, significantly increases overall cost for the production. It is not only because of the lower production yield, but also because of the increased radioactive waste by 200%. Therefore, development of modified Mo-99 production process optimized for the use of LEU with decreased radwaste generation is required. [2, 3]

2. Fission Mo-99 Production

2.1 Fission Mo-99 Target

Target with uranium aluminide (UAl_X) meat and aluminum cladding is commonly used for the production of fission-based Mo-99 in commercial scale. Alkaline digestion of the aluminum-based targets with various shapes has been preferred process for production. KAERI developed plate-type LEU target composed of UAl_3/UAl_4 meat dispersed in Al-6061 cladding. LEU powder with spherical morphology was produced using centrifugal atomization technique. Each target plate contains 14.95 g LEU and uranium density of the meat is 2.6 g U/cm^3.

2.2 Irradiation of Target and

The target were irradiated in the research reactor HANARO for three days, and cooled for two days in the reactor pool. Then transferred to the hot cell in the irradiated material examination facility (IMEF) for processing.

2.3 Fission Mo-99 Process

Irradiated targets are dissolved in sodium hydroxide solution for processing. Fission products other than Mo-99 are removed from the solution using multiple separation steps, as shown in the figure 1. Then Mo-99 is eluted and purified to meet international pharmacopoeia standard. [4, 5, 6]

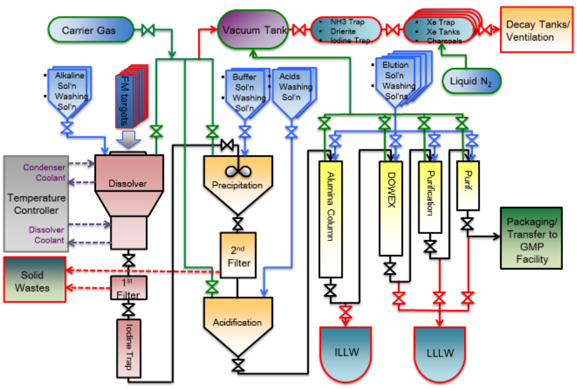

Fig. 1. FM process scheme and processing equipment.

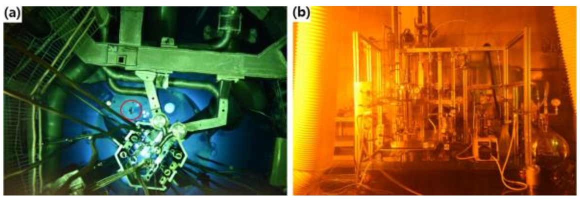

Fig. 2. (a) Irradiation of the FM target in HANARO reactor core. (b) System for target dissolution and processing.

3. Treatment of Spent Uranium in FM Production

3.1 Target Dissolution and Uranium Separation

Irradiated FM targets are dissolved by alkaline solution in a dissolver. This is the first chemical process for Mo-99 production. Uranium aluminide in the target meat transforms to the insoluble oxide forms during dissolution. Most of the uranium and insoluble impurities containing transition metals, part of alkaline earth metals and transuranium elements form colloidal particles. In alkaline solution, aluminum elements originated from the target form soluble sodium aluminide ions. But eventually, it transformed to insoluble aluminum oxides. Therefore, unreacted uranium, transuranium elements and majority of insoluble products can be separated by timely filtration right after dissolution.

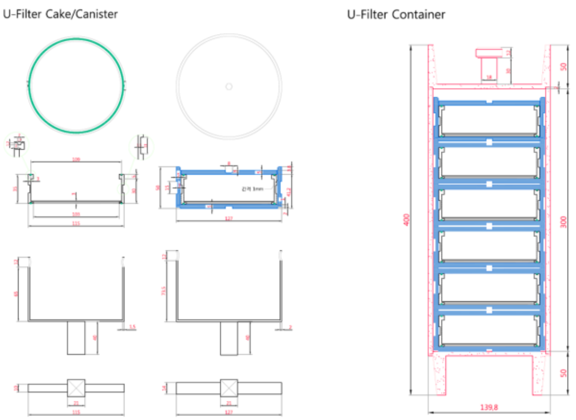

Fig. 3. Drawing for uranium filter, filter canister and filter container with manipulator handling tool.

3.2 Handling of Spent Uranium

The insoluble precipitates is separated as a form of filter cake in the uranium filter. The filter is packed in a canister. The uranium filters are temporarily stored to decay their heat and radioactivity. In a hot cell. The canister shall be stored in a cooling rack for several months to dissipate decay heat. After enough decay, six uranium canisters are sealed in a container and stored in a pit of storage room for up to 50 years.

4. Conclusion

Development of radwaste treatment program for the FM production is one of the most essential piece for the successful construction, licensing and operation of the new research reactor (KJRR), which is being constructed in Gijang, Busan, Korea.

To achieve production objective (2,000 Ci/week) of Mo-99 in KJRR, to cover 100% domestic and 20% of international demand, 10 kg of spent uranium should be treated, every year.

ACKNOWLEDGEMENT

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