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LEU-based Fission Mo-99 Process with Reduced Solid Wastes

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1. Introduction

Molybdenum-99 (^{99} Mo) has been one of the most important isotopes for more than 50 years. Since its daughter isotope ^{99m}Tc is the most commonly used medical radioisotope which covers 85% of overall nuclear diagnostics. ^{99m} Tc emits 140 keV of very low gamma-ray radiation energy, as low as conventional diagnostic X-ray, and has short half-life of 6.0058 hours. Therefore, as radioactive tracer, ^{99m} Tc provides high quality diagnostic images but keeps total patient radiation exposure low. Depending on the tagging pharmaceuticals and procedures, ^{99m} Tc can be applied for the diagnostics of various target organs and diseases: brain, myocardium, thyroid, lungs, liver, gallbladder, kidneys, skeleton, blood and tumors. More than 95% of ^{99} Mo is produced through fission of ^{235} U worldwide because, ^{99} Mo generated from the fission (fission ^{99} Mo) exhibits very high specific activity (<100 Ci/g). Over 90% of fission ^{99} Mo producers have been used highly enriched uranium (HEU) targets so far. However, the IAEA recommends the use of low enriched uranium (LEU) to the ^{99}Mo producers for non-proliferation reason. These days, worldwide ^{99} Mo supply is not only insufficient but also unstable. Because, most of the main ^{99} Mo production reactors are about 50 years old and suffered from frequent and unscheduled shutdown.

Fig. 1. Kijang new research reactor project for radioisotope production including 2000 Ci/week capacity fission Mo-99 production line.

Therefore, movement to replace old reactors to keep stable supply is now active worldwide. Under these conditions, KAERI is developing LEU based fission ^{99} Mo production process which is connected to the new research reactor, which is being constructed in Busan. (Fig. 1)

2. Methods and Results

In KAERI's fission ^{99} Mo process, plate-type LEU target with UAlx meat and Al-6061 cladding is used. Fabricated targets are assembled and transferred to the fission ^{99} Mo production facility after irradiation in the reactor. Then, irradiated targets are dissolved in sodium hydroxide solution to extract ^{99} Mo into the solution. Other fission products including unreacted uranium and actinides are removed from the solution. Medical-grade ^{99}Mo can be extracted after proper chemical treatments and multi-step separation and purification process.

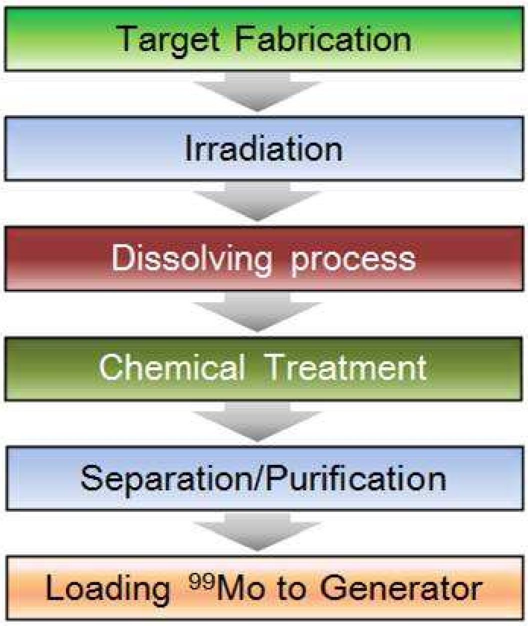

Fig. 2. Scheme for the KAERI's fission Mo-99 process with easier waste treatment and management.

KAERI's research team developed new technology to facilitate waste treatment by converting sludge-type waste, which is difficult to handle, into independent solid and liquid wastes. (Fig. 2) Fission 99 Mo Target fabrication technology has been developed and, pre- and postirradiation tests are undergoing. For the fission Mo production process development, cold-experiments with dummy targets, trace test with active uraium have been performed. In 2014, hot experiments with irradiated or nonirradiated LEU targets will be continued. Then, verification of the production process with quality assurance/ control will be followed until the commercial production of fission ^{99}Mo scheduled in 2017.

3. Conclusions

Planned weekly productivity of 2000 Ci fission ^{99}Mo, in a 6-day reference, will cover 100% domestic demand of Korea, as well as 20% of international market. It is expected to replace 4.3 million USD ($800/Ci) of ^{99}Mo import for domestic market while exporting 82.8 million USD for world market, annually.

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