Development of Fission Mo-99 Process and Facility for Kijang New Research Reactor

Seung-Kon Lee*, Suseung Lee, Sung-Hee Jung, Soon-Bog Hong, Kyung-Duk Jang, Sang Mu Choi, Jun Sig Lee
Division of Radioisotope Research, Korea Atomic Energy Research Institute, 989-111 Daedoek-daero, Yuseong-gu, Daejeon, 305-353 Republic of Korea
**Corresponding author: seungkonlee@kaeri.re.kr*

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. More than 95% of ^{99}Mo is produced through fission of ^{235}U because, ^{99}Mo generated from the fission (fission ^{99} Mo) exhibits very high specific activity (~10^4Ci/g). Fission ^{99}Mo producers have been used highly enriched uranium (HEU) targets so far. However, for non-proliferation reason, ^{99}Mo producers are forced to convert their HEU-based process to use low enriched uranium (LEU) targets. Economic impact of a target conversion from HEU to LEU is huge. Profitability on the production of the fission ^{99}Mo decreases significantly. It is not only because of the 75% decrease in the yield of LEU, but also 400% increase in the wastes. On the basis, worldwide efforts on the development of more effective ^{99}Mo are ongoing. SHINE project is based on the photo fission of ^{235}U by LINAC. Additionally, ^{99}Mo productions from liquid homogeneous reactor and proton accelerator are also ongoing, respectively.

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. Therefore, movement to replace old reactors to keep stable supply is now active. 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 Gijang, Busan, Korea. (Fig. 1) In KAERI's fission ^{99}Mo process, plate-type LEU target with UAlx meat and aluminum 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 in 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. 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. Fission ^{99}Mo target fabrication technology has been developed and, pre- and post-irradiation tests are undergoing. For the fission ^{99}Mo production process development, cold-experiments with dummy targets have been completed, and active test is undergoing. Dissolution experiments with non-irradiated DU and LEU targets have been started since 2014. Then, verification of the production process with quality assurance/control will be followed until the commercial production of fission ^{99}Mo scheduled in 2019. First criticality of the new research reactor is also scheduled in 2019.

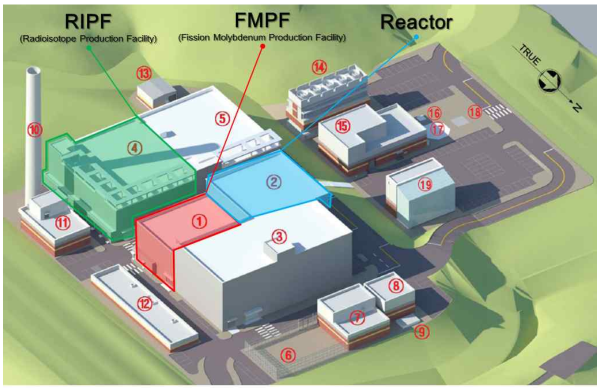

Fig. 1. Building layout of Fission Mo-99 Production Facility (1), Kijang New Research Reactor (2) and, Radioisotope Production Facility (4)

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.

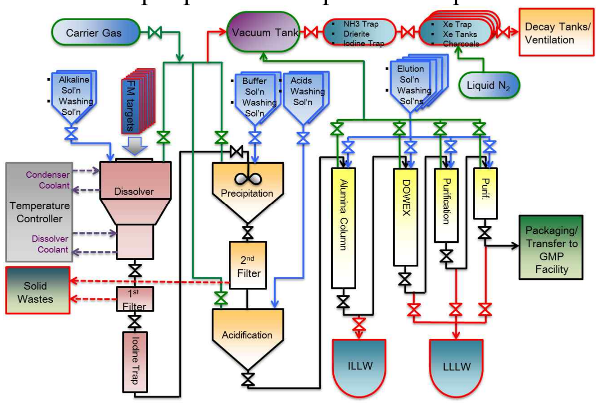

Fig. 2. Scheme for the KAERI's fission Mo-99 process

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 post-irradiation tests are undergoing. For the fission Mo production process development, cold-experiments with performed. Through 2015 and 2016, hot experiments with irradiated or non-irradiated 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 2019.

3. Conclusions

Planned weekly productivity of 2000 Ci fission ^{99} Mo from the Kijang new research reactor will cover 100% domestic demand of Korea as well as about 20% of international market.

REFERENCES

[1] International Atomic Energy Agency, "Non-HEU Production Technologies for Molybdenum-99 and Technetium-99m", IAEA Nuclear Energy Series No. NF-T-5.4, 2013.
[2] International Atomic Energy Agency "Fission Molybdenum for Medical Use", IAEA-TECDOC-515, 1989.
[3] International Atomic Energy Agency , "Management of Radioactive Waste from ^{99} Mo Production", IAEA-TECDOC-1051, 1998.
[4] M. V. Wilkinson, A. V. Mondino, A. C. Manzini, J. Radionanl. Nucl. Chem., Vol. 256, p. 413, 2003.
[5] R. Muenze, G. J. Beyer, R. Ross, G. Wagner, D. Novotny, E. Franke, M. Jehangir, S. Pervez, A. Mushtaq, Sci. and Tech. of Nuclear Installations, 932546, p. 9, 2013.
[6] S. Dittrich, Sci. and Tech. of Nuclear Installations, 514894, p. 9, 2013.