Status and Prospect on the Development of the Fission ^{99}Mo Production Technology Using LEU

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1. Introduction

A study on the technology development for producing fission product ^{99}Mo, a parent of the medical radioisotope ^{99m}Tc, by using highly enriched uranium (HEU) has been conducted since 1997 [1]. However, the import of a HEU became impossible due to a strong nuclear nonproliferation policy in the world. Thus, the project was changed into the use of low enriched uranium (LEU) instead of HEU as a target material [2]. In this paper, the current status for the technology for producing fission ^{99}Mo by using LEU is briefly explained and its prospect in the future is surveyed.

2. Current Status

There are two main research areas in the fission ^{99}Mo production technology by using LEU – uranium target manufacture and ^{99}Mo separation from the irradiated target. The KAERI research was focused firstly on the development of a LEU target and after its development the separation technology will follow.

2.1 LEU Target

The main disadvantages on the use of a LEU target are a low specific ^{99}Mo activity, a large production of ^{239}Pu and a generation of a significant amount of radioactive waste when compared to the use of a HEU target. ANL in USA has developed an annular type of a LEU target by using uranium metal foil. A very thin uranium foil is wrapped by a nickel foil of about 20 micron in thickness, and then it is inserted between inner and outer aluminum tubes. The LEU foil target became a promising substitute for a HEU target that could solve the handicap of a low ^{99}Mo activity and a large amount of liquid waste. However, a high cost in uranium foil fabrication was an Achilles heel to commercialize the LEU foil target.

In the meantime, KAERI has developed a novel technology of fabricating a uranium metal foil. The cooling roll casting method invented by KAERI can produce a foil of 120~150 micron in thickness in several meters at a time [4]. This technology basically solved a high cost in the foil fabrication, and thus an economic weakness involved in the LEU target manufacture can be resolved. The LEU foil target appropriate to the outer core in HANARO was designed to be able to meet a domestic demand of ^{99}Mo [5].

A sample manufacture of an annular target was successfully done by using a copper foil instead of a uranium foil. Further studies on an enlargement of an aluminum tube and a welding of both ends of the inner and outer tubes are still under development.

2.2 ^{99}Mo Separation

Several successive chemical processes are usually adopted to separate ^{99}Mo from an irradiated target. Major commercial suppliers of ^{99}Mo such as as MDS Nordion(Canada), IRE(Belgium), NTP(South Africa) have their own chemical process.

We decided to apply the LEU-modified Cintichem process [6] which was developed by the USA and could be utilized freely. The current status on the development of the ^{99}Mo separation technology is at a basic stage. because it is not easy to use the existing separation facility for an irradiated target including fission materials.

3. Prospect

According to a nuclear nonproliferation, LEU will be substituted for HEU as a target material in the end. USA has made many efforts on the use of a LEU target through the RERTR program in both target development and chemical process development for a LEU. However, major suppliers of ^{99}Mo are reluctant to develop the ^{99}Mo production technology for a LEU until the technology is commercially verified.

From this point of view, the prospects for a fission ^{99}Mo production by using LEU are evaluated by taking not only an international environment on fission ^{99}Mo production but also a domestic necessity into account.

3.1 Can the LEU Foil Target be Commercially Utilized?

At the end of last year, the IAEA launched a project on the development of small scale ^{99}Mo production technology [7]. USA released the documents from its experiences related with the LEU target and LEU-modified Cintichem process. Five countries will test a LEU target irradiation and a ^{99}Mo separation. Also a feasibility study on a fission ^{99}Mo production was performed by MURR in order to determine the possibility of a demonstration trial of an irradiation and ^{99}Mo separation and to ascertain MURR's capability [8].

Considering the above efforts, the technology on the fission ^{99}Mo production by using a LEU foil target is believed to be developed to a commercial level. The LEU foil target instead of a HEU target will be commercially irradiated in some countries.

3.2 Necessity of the Irradiation and Separation Technology for the LEU Foil Target in Korea

^{99m}Tc is a main radioisotope for a medical diagnosis. The domestic demand for ^{99}Mo is steadily increasing. Its stable supply thus will contribute to the improvement of public welfare because of an increased life expectancy and public interest in their health.

Since ^{99}Mo has a half life of only 66 hours, its stable supply is very important. It is totally imported as a type of ^{99}Mo solution or ^{99m}Tc generator. However, an increasing terror threat in recent years, heavy snow and a volcanic eruption may disturb its stable import unexpectedly. For example, air transportation of it may one day be stopped suddenly. Any difficulty in its import may bring about an instability of its cost.

On the other hand, KAERI has developed the foil fabrication technology. LEU foil and/or target may be exported if the ^{99}Mo production technology using a LEU foil target is developed. Thus, a test of an irradiation and separation of a LEU foil target is needed in order to prepare a qualified technology for an export in the future. The quality of the ^{99}Mo product will depend on how many experimental tests are performed.

Having fission ^{99}Mo production technology may be helpful to overcome a halted supply or a raise in price by a major foreign supplier in an emergency case.

A commercial production of ^{99}Mo for only a supply of a domestic demand isn't economical. However, if the potential demands in China and Japan are considered, it can be economical.

3.3 How Can the Test of Target Irradiation and ^{99}Mo Separation Be Performed?

An alpha hot cell is required in order to extract ^{99}Mo from a target. The irradiated target is separated into the foil and cladding. Next, the foil is dissolved inside the specially prepared dissolver. ^{99}Mo is then separated by using a LEU-modified Cintichem process.

There is no alpha hot cell for ^{99}Mo separation in Korea. Even though a hot cell for a post irradiation examination of a power plant fuel exists, it is not easy to put equipments and materials inside it, and pull them out later, etc. because it is prepared appropriately for the irradiated fuel of a power plant. Also, an additional license for a ^{99}Mo separation is required in order to use the present hot cell.

An on-power loading facility is not installed in HANARO. Only 5~7 days' irradiation is enough for the ^{99}Mo target, but HANARO operates continuously for 4 weeks. For a couple of irradiation tests, a capsule may be utilized.

Considering the above, a test of an irradiation and separation is recommended in a foreign research reactor having an alpha hot cell via an international cooperation program.

It is expected that HANARO's capability will be saturated in the near future. A consensus on the construction of a new research reactor might be reached. The construction of an alpha hot cell for fission ^{99}Mo production is preferable to be included in a new research reactor project if it is launched. Because an independent drive to construct an alpha hot cell requires a big budget, a long licensing period and public acceptance is hard to get.

4. Conclusion

The LEU foil target developed by ANL is promising as a substitute for a HEU target for a fission ^{99}Mo production. The key material of the LEU foil target is a uranium foil. KAERI has developed the continuous fabrication technology of a uranium foil. It provides a solution to the low economy for the use of a LEU target. Researches on the technology development of a fission ^{99}Mo production by using a LEU foil target are being actively undertaken. It is expected that the LEU foil target will be commercially utilized for a small scale fission ^{99}Mo production in the near future.

A test of an irradiation of the LEU foil target made by KAERI and a ^{99}Mo separation is needed in order to develop the technology for a fission ^{99}Mo production and to prepare for the possibility of exporting the foil. The irradiation and ^{99}Mo separation results will be important data for a decision on the future policy about a domestic production of ^{99}Mo.

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