Progress on the Development of (n,γ)^{99}Mo/^{99m}Tc generator, an Alternative of Conventional Generator

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1. Introduction

Even though different types of generators have been developed to extract ^{99m}Tc [1], most of the generators uses ^{99}Mo from the fission products as the mother radionuclide of ^{99m}Tc. Recently, the crisis of ^{99}Mo production becomes one of the international issues as ^{99m}Tc is a dominant diagnostic radionuclide. The shortage of ^{99m}Tc has been predicted in the society for more than 10 years. However, actions to prevent such crisis were slow as the initial investment to construct a new research reactor for the production of ^{99}Mo is high. Currently, it is expected the shortage of ^{99m}Tc will last at least for more than 5 years.

As an alternative to minimize such crisis, a new approach is proposed and studied. In this approach, the mother source of ^{99m}Tc comes not from fission products but from the neutron irradiation of molybdenum oxide. Hence, most of the research reactors, which do not have capability to produce fission molybdenum, (n,f)^{99}Mo can produce ^{99}Mo. The key issue in this approach is the uptake capacity of the generator column for (n, γ)^{99}Mo, which has extremely low specific activity compared to (n,f)^{99}Mo.

Currently, the results from the research activities at Korea Atomic Energy Research Institute have shown such approach has enough potential as an alternative of the conventional generator. Hence, the progress of the research is reported in this paper.

2. Methods and Results

2.1 Generator Material and Column Assembly

The proposed generator is similar to the conventional ^{99m}Tc generator, which has, in general, an adsorption column, a needle assembly, and a shielding container. The major differences between the proposed generator and the conventional generator are the adsorbent and the size of the adsorption column, where ^{99}Mo is adsorbed, and ^{99m}Tc is generated. Also, a second column is attached to the adsorption column to further purify ^{99m}Tc. As some of the conventional generators also have such a tandem column for better quality of ^{99m}Tc, it is not a major issue.

Conventional generator column contains acid alumina or manganese oxide as the adsorbents. Such adsorbents can adsorb tens mg of molybdenum per gram of adsorbent at maximum. Hence, such adsorbents cannot be used for the proposed generator as the column becomes extremely larger to handle. Hence, the proposed generator employs a new adsorbent (ALSUL) that was developed at Korea Atomic Energy Research Institute for new generator systems such as ^{188}W/^{188}Re generator [2].

The main column to generator enough amount of ^{99m}Tc (i.e. 500mCi) by using the (n, γ)^{99}Mo produced from HANARO can contain 4 ~ 5 grams of the adsorbent (see Figure 1). Such amount of the adsorbent can adsorb more than 600mg of molybdenum and can overcome the low specific radioactivity of (n, γ)^{99}Mo.

Figure 1. Generator Main Column Capable to Contain 4 ~ 5g of ALSUL

2.2 Loading and Elution Experiments

The performance of the proposed generator is tested by using the following experimental setting (see Figure 2). 0.2Ci/g·Mo of (n, γ)^{99}Mo was produced by irradiating MoO_3 powder from IP5 hole at HANARO. After the dissolution of the MoO_3 in NaOH solution followed by chemical conditioning the solution, a designated amount of the (n, γ)^{99}Mo was fed into the main column and washed the column by a certain amount of saline solution. After such loading step, a tandem column is either attached or not for ^{99m}Tc elution. The elution of ^{99m}Tc was performed after 24 hours of the loading.

In general, the loading amount of ^{99}Mo for each experiment was more than 1 mCi because the use of μCi quantity were results in significantly low elution efficiency for ^{99m}Tc such as less than 70%. The reason of such low elution efficiency from the column loaded with μCi of ^{99}Mo is probably the adsorption-desorption equilibrium between ^{99m}Tc and the adsorbent.

As shown in Figure 3, the loading efficiency of ALSUL for (n, γ)^{99}Mo is about 90%. The elution efficiencies after 24 hours of the loading process are 90 ~ 97%. These values are satisfactory compared to any other alternative generators ever reported in the literature [3 ~ 4]. The leaching of ^{99}Mo in the ^{99m}Tc solution is high such as more than 10,000 ppm at the first day of elution. This is inevitable as the proposed generator system is based on ^{99}Mo at low specific activity. The leaching can be easily avoided by installing a tandem column in which either small amount of acidic alumina or other adsorbents is packed.

A trial experiment with a tandem column containing an adsorbent (proprietary) was performed to show the possibility of the leaching of ^{99}Mo. From this experiment, the content of ^{99}Mo in the ^{99m}Tc was minimized to meet the requirement in the pharmacopeia.

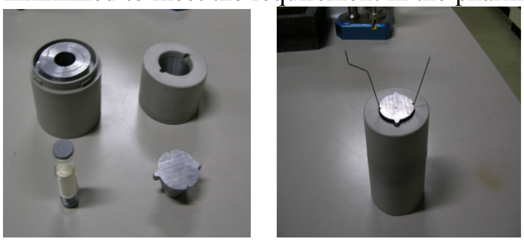

Figure 2. Experimental Generator Setting, ^{99}Mo Loading and ^{99m}Tc Elution either by Peristaltic Pump or Vacuum Vial

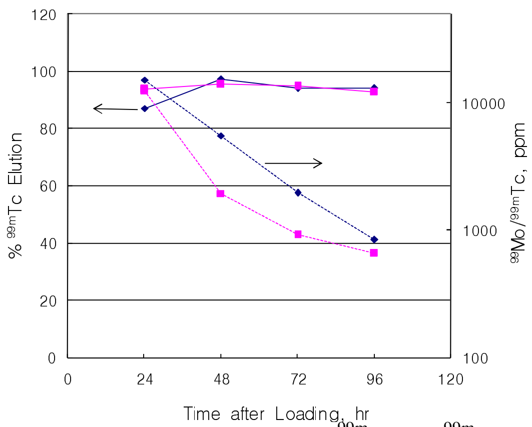

Figure 3. Elution Efficiency of ^{99m}Tc (% ^{99m}Tc Elution) from (n,γ)^{99}Mo Loaded Generators (two demonstration experiments), Amt. of ALSUL/column = 4.0g; Loaded amount/Column = ~ 65mCi (~800mg Mo); Mo Loading Efficiency = ~ 90%; Eluant: 10ml of Saline

2.3 Current Research Progress

Currently the research activities on the development of adsorbents for tandem column, irradiation safety analysis of enriched molybdenum target at HANARO, ^{99m}Tc labeling tests, and design of generator shielding container and generator loading system are undertaken.

It is expected from that the possibility of the proposed generator as an alternative generator will be obvious at the middle of 2010.

3. Conclusions

Alternative ^{99m}Tc generator is proposed and tested experimentally in this study. Currently, the major issues of the efficiencies of (n, γ)^{99}Mo loading on the column and the elution of ^{99m}Tc from the column are satisfactory, which means that the proposed generator has enough potential to be used in real applications. After finishing the safety analysis for the irradiation of enriched molybdenum at HANARO and the labeling tests, it will be determined whether to apply the production license to KFDA for the local supply.

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