14-8 Innovative Method to Produce ^{99}Mo for Medical Diagnosis without Uranium

− Development of ^{99}Mo Production Technique with Molybdate Solution −

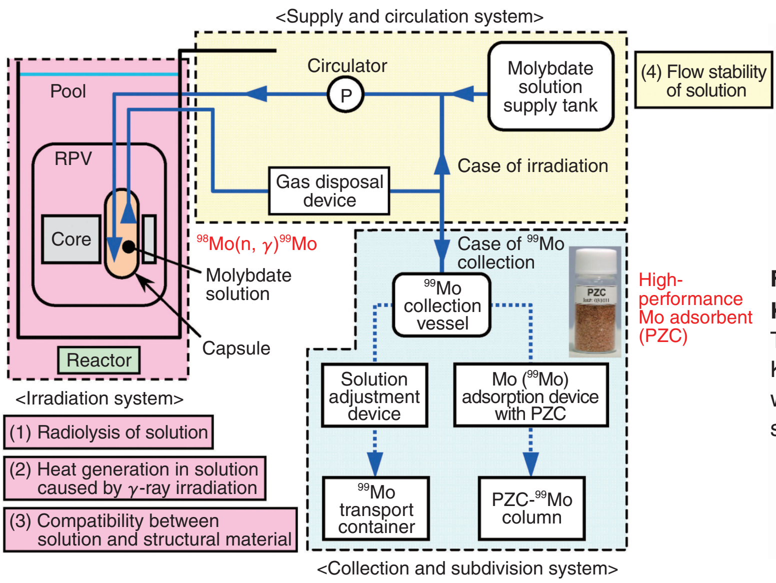

Fig.14-17 Outline of systems for ^{99}Mo production by solution irradiation method, and evaluation items

In the irradiation system, a molybdate solution in a capsule installed in a reactor core is irradiated with neutrons, and ^{99}Mo is generated. In the supply and circulation system, this solution is supplied to the capsule, and then circulated back. In the collection and subdivision system, the solution including generated ^{99}Mo is collected from the capsule, and this solution is purified and put into transport vessels. (1) to (4) are evaluation items for two of these systems.

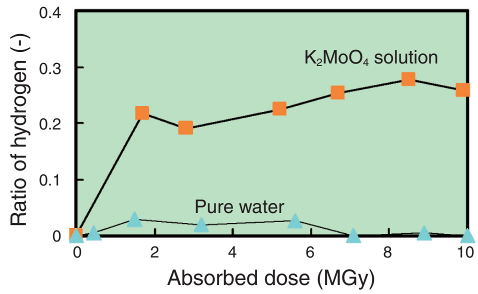

Fig.14-18 Relationship between absorbed dose of K_2MoO_4 solution and ratio of hydrogen in generated gas

The ratio of hydrogen in the radiolysis gas generated from K_2MoO_4 solution (concentration: 58wt%, temperature: 80°C) was investigated. As a result, it was found that this solution generates more hydrogen than pure water does.

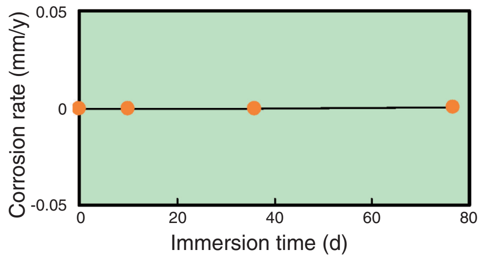

Fig.14-19 Relationship between immersion time and corrosion rate of SS304

SS304 was immersed in a K_2MoO_4 solution (the concentration: 58wt%, the temperature: 80°C), and the compatibility between SS304 and the solution was investigated. As a result, it was found that SS304 has no corrosion after 80 days of immersion.

Technetium-99m (^{99m}Tc) is the most widely used radiopharmaceutical for medical diagnosis. The raw material of ^{99m}Tc is molybdenum-99 (^{99}Mo), and all ^{99}Mo used in Japan is imported from foreign countries. However, a problem has emerged that the supply of ^{99}Mo is unstable due to aging production facilities. Therefore, the stable supply and production of ^{99}Mo is needed in Japan.

^{99}Mo has been produced mainly by the fission method using highly enriched uranium. In Japan, ^{99}Mo production by the fission method is difficult because of nuclear nonproliferation requirements and radioactive waste. Therefore, taking a hint from the shipment form of ^{99}Mo, the solution irradiation method was invented (Fig.14-17). In this method, a solution of molybdate that has high solubility is irradiated with neutrons in a nuclear reactor. ^{99}Mo is thus produced by the ^{98}Mo (n, γ) ^{99}Mo reaction and is collected with the high-performance Mo adsorbent PZC. This method has three advantages: ^{99}Mo production rate can be increased simply by increasing the volume of the irradiation target, the processes required to produce a shipment are simpler, and the amount of radioactive waste is much smaller than that of the fission method.

As the molybdate solution used in the solution irradiation method, potassium molybdate (K_2MoO_4) solution which has a high concentration of molybdenum was selected to increase the ^{99}Mo production rate. For the investigation of its suitability as the irradiation target, γ-ray irradiation tests of the solution were carried out. The test results indicated: (1) the ratio of hydrogen in the gas generated from the solution is 20 times higher than that from pure water (Fig.14-18); however, this is not a serious problem for the gas disposal device installed into the ^{99}Mo production system, (2) the increase in calorific value of the solution upon γ-ray irradiation is about the same as that of pure water, (3) the compatibility (nonreactivity) between the solution and stainless steel material of the capsule is very good (Fig.14-19), (4) the solution flows stably in a pipe 4mm in inner diameter and 30m in length without precipitation.

From the above results, it is clear that the K_2MoO_4 solution is suitable as the irradiation target for the ^{99}Mo production system by the solution irradiation method. In addition, it is evaluated that over 20% of the domestic demand for ^{99}Mo (88.8TBq/week) can be provided by this system using JMTR. Based on this obtained data, plans for the practical application of this system are to be considered.

Reference

Inaba, Y. et al., Development of ^{99}Mo Production Technique by Solution Irradiation Method; Characterization of Aqueous Molybdate Solutions, Nippon Genshiryoku Gakkai Wabun Ronbunshi, vol.8, no.2, 2009, p.142-153 (in Japanese).