7-10 Production of Medical RIs Using Accelerator Neutrons
—Development of an Innovative RI Production Method—

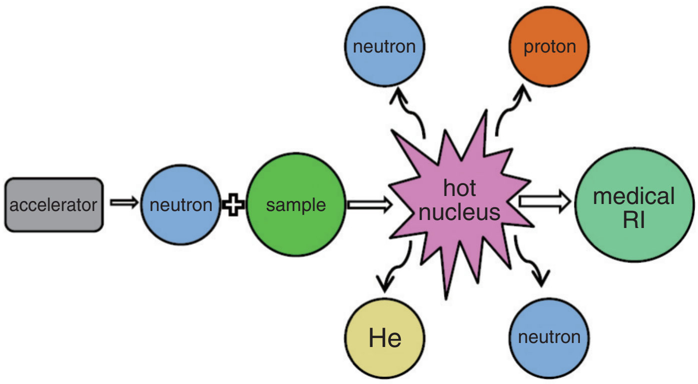

Fig.7-25 Production of medical RIs by using accelerator neutrons
The temperature of sample nuclei irradiated by accelerator neutrons becomes so high that various particles, such as protons, neutrons, and He, are emitted. Consequently, high-quality RIs can be obtained by separating the produced RIs from the sample materials by a chemical or physical process.

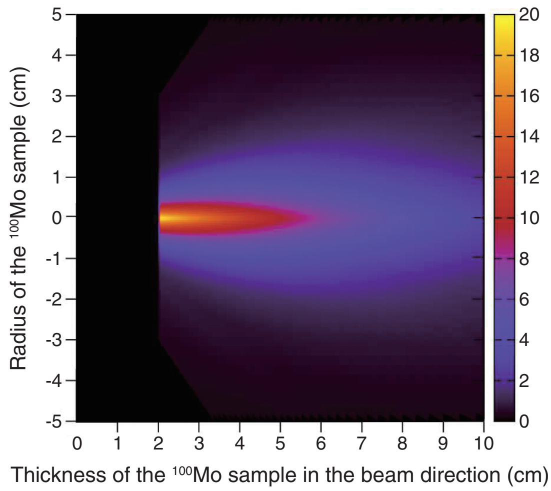

Fig.7-26 Calculated yield distribution of ^{99}Mo
^{100}Mo yield distribution in terms of the radius and thickness of the ^{100}Mo sample. ^{99}Mo is produced by the ^{100}Mo(n,2n)^{99}Mo reaction using accelerator neutrons from the ^{nat}C(d,n) reaction. On the ^{99}Mo intensity scale, red indicates a higher intensity than purple does.

A radioisotope (RI) with a half-life ($T_{1/2}$) of less than several days plays an important role in nuclear medicine. The daughter nuclide of ^{99}Mo ($T_{1/2}$=66 h), i.e., ^{99m}Tc ($T_{1/2}$=6 h), is used for diagnostics, and ^{90}Y ($T_{1/2}$=64 h) is used for cancer therapy. Most medical RIs, including ^{99}Mo and ^{90}Y, are imported in Japan. An unscheduled shutdown of aging research reactors in which most of the ^{99}Mo nuclide was produced has resulted in a critical shortage of ^{99}Mo worldwide. Therefore, the establishment of a reliable production method for ^{99}Mo is very important to ensure the continued medical applications of ^{99m}Tc.

We have proposed a new route for producing medical RIs using accelerator neutrons, as shown in Fig.7-25. In fact, a variety of medical RIs can be produced using accelerator neutrons as the production cross section of a sample nucleus is large at En=10~15 MeV. For example, the ^{99}Mo production cross section of the ^{100}Mo(n,2n)^{99}Mo reaction is 1.5 b at En≈10~20 MeV, while the ^{97}Zr production cross section of the ^{100}Mo(n, α)^{97}Zr reaction is 0.002 b. Note that ^{97}Zr, a radioactive impurity nucleus, is produced in small amounts. The ^{90}Y production cross section of the ^{90}Zr(n,p)^{90}Y reaction is also large. High-quality ^{99m}Tc and ^{90}Y can be separated from the irradiated Mo and Zr samples by sublimation and ion exchange, respectively. Quasi-mono energetic, high intensity accelerator neutrons (En=10~15 MeV), therefore, are very useful for the production of medical RIs.

Neutrons (about 10^{15} n/s) with an En of about 14 MeV are produced in the ^{nat}C(d,n) reaction using 40 MeV 5 mA deuteron beams provided by an accelerator. Such an accelerator is currently under construction in France.

We evaluated the angular and depth distributions of ^{99}Mo that was produced by using the accelerator neutrons to study the effective use of the neutrons, as shown in Fig.7-26. It is shown that the ^{99}Mo yield is restricted to a narrow region at an extremely forward angle with respect to the deuteron beam direction; this observation assisted us in obtaining high-specific-activity ^{99}Mo.

The present results motivated us to employ this new RI production method to ensure constant and assured supply of medical RIs for domestic use and to open a new frontier in medicine and pharmacy.

Reference

Minato, F., Nagai, Y., Estimation of Production Yield of ^{99}Mo for Medical Use Using Neutrons from ^{nat}C(d,n) at E_d=40 MeV, Journal of the Physical Society of Japan, vol.79, no.9, 2010, p.093201-1-093201-3.