《シンポジウム》

Radionuclide Production

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Neutron-deficient radionuclides can be produced carrier-free by cyclotron bombardment, and some of them are used effectively in nuclear medicine. Radionuclide production usually consists of the steps of (1) the bombardment of the target and (2) chemical treatment of the product radioisotope. As for the bombardment, its conditions (i.e., nuclear reaction, incident particle energy and beam flux, nuclidic state—enriched isotope or not—of the target, its chemical and physical state and size and thickness, its cooling, and bombardment duration) should be selected on the basis of the following factors: (1) characteristics of the available cyclotron, (2) excitation functions for the possible production reactions and their side reactions, (3) availablity of an enriched target substance, as well as (4) methods in the succeeding chemical steps and required radionuclidic purity of the final product. These factors are mutually dependent, and when one of them is set at its ideal condition, hard tasks are imposed on the others and thus a poor over-all result is often obtained. The selection of the bombardment conditions is exemplified by our study of ^{77}Br production.

Commercially available cyclotron-made radioisotopes (e.g., ^{67}Ga, ^{111}In, ^{123}I and ^{201}Tl) are mostly produced by the (p, 2n) or (p, 3n) reaction. The bombardment with a compact cyclotron (E_p= 25—30 MeV) is often used together with well-established chemical steps, giving efficiently the product in satisfactory purity. Usually proton or deuteron induced reactions give much higher yields than ^{3}He or α-particle reactions owing mainly to the difference in range among the incident particles.

An in-house cyclotron is needed for the production of radioisotopes with their lives too short for their transportation. These isotopes include ^{11}C (20 m), ^{13}N (10 m), ^{15}O (2 m) and ^{18}F (110 m), which are all positron emitters and can be introduced into organic molecules. For the production of these low Z radioisotopes, the socalled Baby Cyclotron is one of the most suitable types. Now, a device is attached to this machine to offer automatically pure ^{11}Co and $^{11}Co_2$, and $^{13}NH_3$, $^{13}N_2$, $^{15}O_2$, $H_2{}^{15}O_2$, and aqueous solution of $H^{18}F$ can be obtained easily by the well-known techniques. Automatic synthesizers for ^{11}C-labelling precursors, such as $^{11}CH_3I$, $H^{11}CN$, $^{11}CH_2O$ and $COCl_2$ have almost been developed. Photosyntheses and enzymatic methods are utilized for the preparation of ^{11}C sugars and ^{11}C and ^{13}N amino acids. Efforts are being made in various ^{18}F-labelling methods, especially for the elevation of the specific activity of the product. In general, further development of rapid syntheses without carrier addition is first required for full use of an in-house cyclotron, and convenient automation or at least remote operation of these synthetic procedures is then needed.

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For efficient production of ^{52}Fe, ^{73}Se, ^{75}Br, ^{77}Br, and ^{124}I-free ^{123}I, an accelerator with higher energies ($E_p \geq 40$ MeV) is necessary. Such an accelerator will also become useful for the production of some positron-emitter generators. Except in the use of an in-house cyclotron, the importane of rapid transportation systems for medical radioisotopes should always be kept in mind.

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