APPLICATION OF CYCLOTRON TO NUCLEAR MEDICINE

Tatsuo Ido
National Institute of Radiological Sciences

The cyclotron produced nuclides which are emitting low energy r-ray with the short physical half-life are very useful for clinical diagnosis in nuclear medicine because their application results in a low radiation-absorbed dose to a patient and a high resolution of a diagnostic image. The nuclides, gallium-67, rubidium-81, indium-111, iodine-123 and thallium-201 are supplied commercially and widely used to the nuclear medicine diagnosis as tumor, thyroid, kidney, adrenal glands and myocardial imaging.

The application of the positron emitting nuclides to this field with a recently developed positron camera or positron tomograph is able to give us the 4 dimentional diagnostic image with the dynamic informations. This method will be the major diagnosis tool and will contribute in the preventology.

The positron emitting isotopes, carbon-11, nitrogen-13, oxygen-15 and fluorine-18 are particularly useful nuclides for labeling to the compounds of biological importance. However, the very short half-lives of these nuclides limit their use to facilities which have a cyclotron on site.

Some comments for the preparation of labeled compounds with these nuclides and the investigation of the radiopharmaceuticals are discussed here.

NUCLIDES

At NIRS, carbon-11, nitrogen-13, fluorine-18, iron-52 and iodine-123 are produced routinly and supplied to medical use. And also titanium-45, manganese-52m, zinc-62, xenon-123 and -125 are prepared for the investigation of radiopharmaceuticals.[1)]

NUCLEAR REACTION

The low Z nuclides carbon-11, nitrogen-13, oxygen-15 and fluorine-18 were produced by the (p,n), (p,a), (d,n), (d,a) reactions. And the high Z nuclides iron-52, kripton-77 and iodine-123 were produced by the (p,4n), (p,3n) and (p,5n) reactions with the good quality.

TARGETRY

The target state and form which gave the good production yield depended on the beem shape and current.

Gas target: The beem penetration effects were observed. The target should be prepared with the about twice of the thickness than the calculated beem range.2)

Liquid target: If the irradiation is carried out under the currents more than 25uA, the bubble effect will deduce yield. The high flow circulation is effectable to cancel this phenomenon.

Solid target: The partial melting and the making celamic are observed on the focused beem. A defocused beem or a scaned beem is required.

SYNTHESIS OF LABELED COMPOUNDS

Generally, the traditional chemical synthesis is useful for the preparation of labeled compounds with carbon-11 and fluorine-18. The nuclides bromine-77 and iodine-123 can be labeled by the isotope-exchange reaction. The enzyme reaction is also useful for labeling of ^{11}C-sugar and ^{13}N-amino acid. The hot atom reaction and radiochemical reaction are efectable for the symple compounds as the precurcer of further synthesis such as H^{11}CN,3) ^{11}C-cyanamide, ^{11}C-guanidine.4)

SPECIFIC ACTIVITY

The strong bioactive compounds such as neurorepitic and hormone should be labeled with the high specific activity almost carrier free. However,it is very difficult to prepare ^{11}C-compounds with the real carrier free state because of the contamination of carbonatom from atmosphere. Only the no carrier added state is available.

RADIOPHARMACEUTICLS AND CLINICAL USE

^{11}C-CO,CO_2 ; blood flow and lung function
fig.1 shows the positrogram after ^{11}CO inhalation.

^{11}C-octylamine ; lung-liver function determination of MAO act.

11C-methyonine ; pancreas ,brain

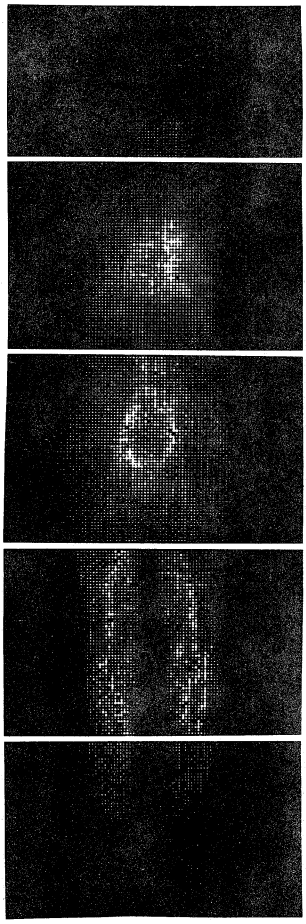
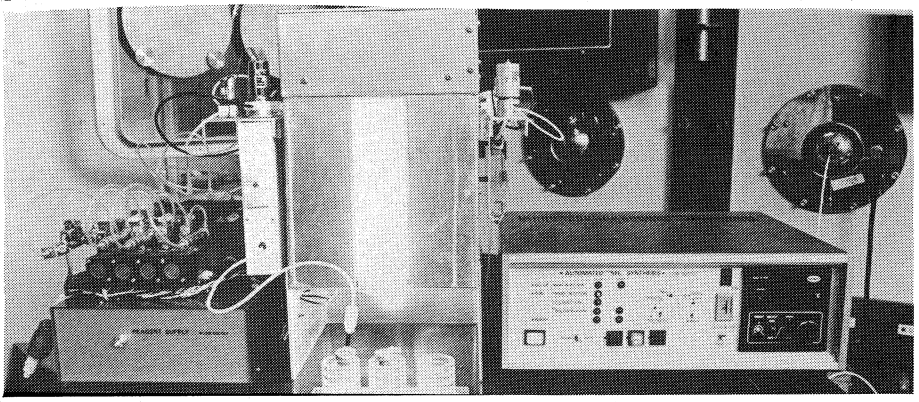


Fig.1 ^{11}CO

^{11}C-etorphine ; opiate receptor (brain)
^{11}C-palmitate ; myocadial scanning
^{13}N-ammonia ; brain,myocardial,liver
^{13}N-glutamate ; brain myocardial,liver
^{18}F-fluorouridine ; tumore
^{18}F-fluorodeoxyglucose ; brain,myocardial glucose metabolism
^{52}Fe-citrate ; bone marrow
^{123}I-sodium iodide ; thyroid
^{123}I-6-iodomethyl-19-norcholesterol ; adrenal glands
^{123}I-hipprun ; kidney

AUTOMATED SYNTHESIS SYSTEM

The development of the fully automated synthesis system of radio pharmaceuticals is the most important subject for the routine clinical diagnosis systems which are connected with in-house cyclotrons and the positron tomographic devices.
An ideal system(so called a chemical black box) should be the one where the whole synthetic process is controlled automatically by a defined program and a radioparmaceutical is available by only a few buttons.
The fig.2 shows the ^{13}N-ammonia synthesis system which is recently developed. 5) The systems for ^{11}C-methyl iodide and ^{11}C-palmitate are under investigation.



1) T.Ido Radioisotopes,28, 648-657 (1979)
2) B.W.Wielandetal 3rd Int.Symp.Radiopharm.Chem.,27-29(1980)
3) D.R.Christman etal J.Appl.Radiat.isotopes,26,435(1975)
4) R.Iwata,T.Ido etal 3rd Int.Symp.Radiopharm.Chem.,187-188
5) T.Ido,R.Iwata 3rd Int. Symp.Radiopharm.Chem.,244-246(1980)