Improvement of Large-Scale Production System and Automation Program for Lu-177

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1. Introduction

Lutetium-177 (177Lu, $t1/2$ = 6.7 d) is increasing in demand as an important therapeutic radionuclide for targeted radiotherapy in nuclear medicine because of its high theranostic potential. 177Lu emits β- particles ($E\beta$,max = 498 keV) with a soft tissue penetration range of less than 3 mm and γ-rays ($E\gamma$ = 208 keV (11.0%) and 113 keV (6.4%)) suitable for imaging with a detector.

177Lu can be produced in high yield by the 176Lu(n,γ)177Lu reaction. However, this production method has a limitation in that carrier 176Lu are mixed and by-products 177mLu with a long half-life ($t1/2$ = 160 d) are produced. In this respect, no-carrier added (nca) 177Lu has high specific activity and high radionuclide purity without long-lived radionuclide impurity, making them particularly useful for radioimmunotherpy. The nca 177Lu can be produced by the 176Yb(n,γ)177Yb → 177Lu reaction by irradiating neutrons to an enriched 176Yb2O3 target. The critical process is the radiochemical separation of nca 177Lu from macroscopic amount of Yb target with adjacent atomic number.

As the demand of lanthanide nuclides (including 177Lu) increases, numerous researchers have devoted themselves to developing faster and more efficient separation techniques. In particular, the separation technology based on ion exchange to improve selectivity have been developed. In ion exchange technology, generally, α-HIBA and NH4+ is used as a complexing agent and a separating ion, respectively. However, P.S. Balasubramanian reported that 177Lu was separated from neutron-irradiated ytterbium using a cation exchange resin (Dowex-50X8, 200-400 mesh) with α-HIBA and Zn2+ ion as a separating ion.

At KAERI, a large-scale production system for Lu-177 was designed and manufactured, and the automation program was improved accordingly.

2. Configuration of the Lu-177 Production System

2.1 Configuration of the Lu-177 Production Device

An automated system for separation, purification, and recovery of Lu-177 is under development. The equipment was designed to enable rapid processing for n.c.a Lu-177 while ensuring operator safety. The overall configuration of the system is shown in Fig. 1.

The large-scale production system consists of five parts : Part A(pump and control), Part B(separation and detector), Part C(valve and recovery), Part D (purification) and Part E(control panel). Part A controls the separation process and supplies the separation eluents; it is installed outside the hot cell. Part B is shielded with acrylic (β-ray shielding) and lead (γ-ray shielding) to allow accurate radioactivity measurement. Part C includes a switching valve, a selection valve, a syringe pump, and a structural support frame. Part D consists of a peristaltic pump, a three-way valve, a concentration column, and a media bottle, and operates according to signals from the detector.

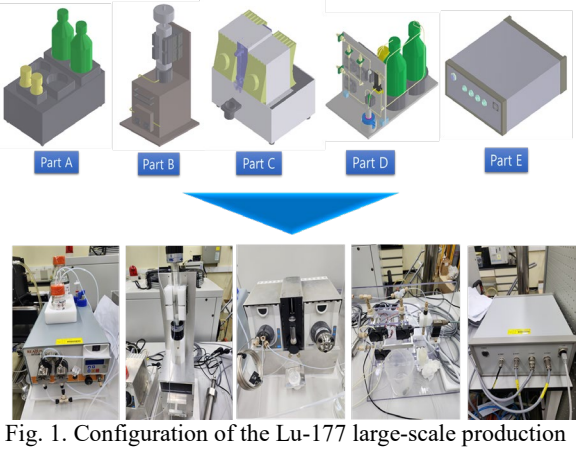

Fig. 1. Configuration of the Lu-177 large-scale production system

2.2 Configuration of the Lu-177 Automation Program

The system control program was developed using LabVIEW 2021. The main interface consists of Auto Test, Manual Control, Sequence Editor, Easy Sequence, and Viewer modules.

3. Improvements to the Lu-177 Production System

Experimental operation identified several areas requiring improvement in both the production device and the automation program. In the production device, leakage from the check valve was corrected, overheating of the three-way valve was resolved, and the controller power switch system was modified. In the automation program, the “Easy Sequence” mode was reorganized into a step-by-step configuration. An “INIT” button was added to allow initialization before operation, and a stop button was implemented for use

during Easy Sequence operation. The detailed improvements are shown in Fig. 2.

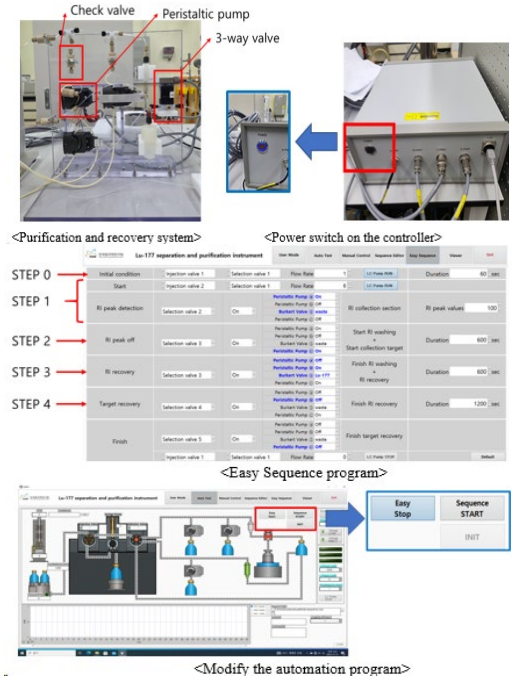

Fig. 2. Improved production device and programs

4. Conclusions

A large-scale production system for ^{177}Lu has been developed and is currently under testing. All processes are being evaluated using stable isotopes in preparation for production exceeding 1 Ci and are continuously being improved. The automated system is expected to reduce radiation exposure to operators and enhance the safety and reliability of RI production. In the future, Lu-177 production will be carried out using the improved system.

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