Fabrication Plan of Rubidium-82 Infusion System for Basic Experiments

Yong-Sub Cho*, Hyeok-Jung Kwon, Sang-Pil Yoon, Kye-Ryung Kim
Korea Atomic Energy Research Institute, Korea
**Corresponding author: choys@kaeri.re.kr*

1. Introduction

The Korea Atomic Energy Research Institute developed strontium-82/rubidium-82 generators using rubidium chloride targets irradiated with a 100-MeV proton accelerator [1,2], and completed the rubidium-82 elusion experiment [3]. In order to develop a rubidium-82 infusion system with this generator, a manual device capable of basic experiments is planned to be developed.

2. Infusion System

2.1 Configuration

As the requirements for the configuration of this rubidium-82 infusion system, a) it should be installed in one cart, b) a dose measurement should be also installed because frequent calibration is required for initial experiments, and c) solenoid valves should be used to enable automatic control in the future. To satisfy these conditions, the infusion system will be fabricated as shown in Fig. 1.

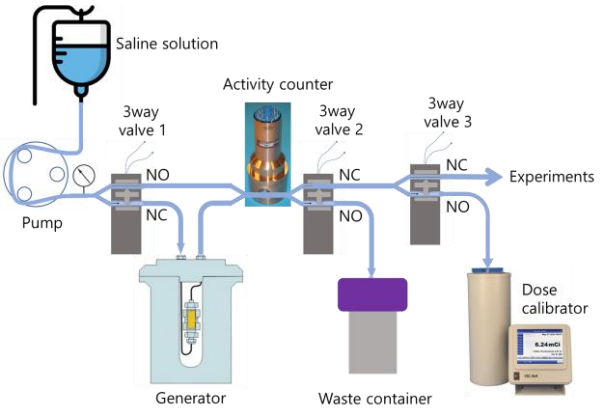

Fig. 1. Configuration of infusion system.

2.2 Operation Method

This system uses three 3-way solenoid valves to sequentially perform a) pump and tube wash, b) generator wash, c) dose measurement, and d) infusion experiments. Fig. 2 shows the 3-way solenoid valve that will be used for and Table I shows the status of the valves for each process. It is designed to run the saline solution by operating a pump and then operate the valves one by one to accomplish the desired process. For safety during the experiment, the valve direction is set so that rubidium-82 will not be eluted when the valve does not operate due to any abnormality in the valve or power supply.

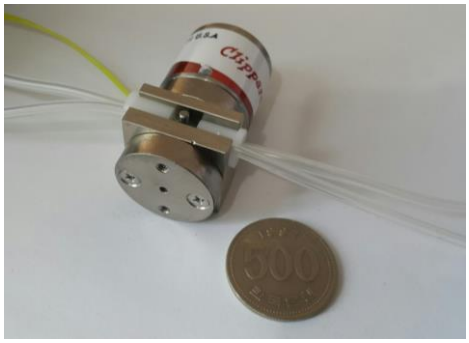

Fig. 2. 3-way solenoid valve.

Table I: Valve Status for Processes

Pump	ON	ON	ON	ON
Valve 1	OFF	ON	ON	ON
Valve 2	OFF	OFF	ON	ON
Valve 3	OFF	OFF	OFF	ON
Process	Pump/tube wash	Generator wash	Measure ment	Infusion

3. Applicability to Small Animal Experiments

3.1 Constraints of Small Animal Experiments

In the case of small animal experiments, a) In consideration of the stress that small animals receive during the experiment, saline infusion should be limited to 0.1ml/min or less, and b) infusion time should be at least 10 seconds for precise control of injection volume.

3.2 Tube Length Constraints for Infusion

Rubidium-82 decays by emitting positrons with a half-life of 75 seconds, as shown in Fig. 3. Therefore, it is necessary to consider radioactive decay while passing the tube connecting the infusion system and the target. Table II shows the amount of rubidium-82 remaining after passing through a 1/16 inch diameter tube for lengths of 2 m, 1 m, and 0.5 m, respectively. When the flow rate is 0.1ml/min, there is no rubidium-82 at a level that can be used in the experiment in any case. In the

case of an actual system, since the tube from the generator to the outlet of the infusion system is at least 30 cm long, it is expected that few rubidium-82 will reach the target animal.

Therefore, in the case of small animal experiments, it is expected that the most suitable method is to place a rubidium-82 infusion system right next to the experimental animal, elute the rubidium-82 at a large flow rate, then put it in a syringe and inject it directly into the target animal.

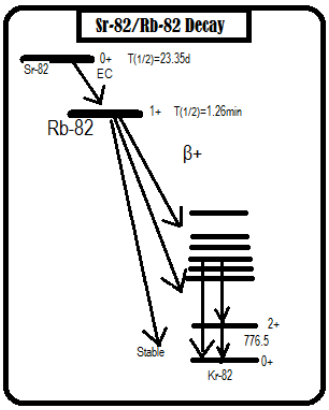

Fig. 3. The decay of rubidium-82, which undergoes positron emission [4].

Table II: Rubidium-82 residual at the outlet of the infusion system as a function of tube length and flow rate.

a) Tube length: 2m		
Flow rate (ml/min)	Time through tube (min)	Residual Rb-82 %
0.1	40	0.0
0.6	6.7	2.6
1	4	11.1
10	0.4	80.3

b) Tube length: 1m		
Flow rate (ml/min)	Time through tube (min)	Residual Rb-82 %
0.1	20	0.0
0.6	3.3	15.9
1	2	33.2
10	0.2	89.6

c) Tube length: 0.5m		
Flow rate (ml/min)	Time through tube (min)	Residual Rb-82 %
0.1	10	0.4
0.6	1.7	39.2
1	4	57.7
10	0.4	94.6

4. Conclusions

The configuration of the rubidium-82 injector was derived to enable basic experiments. Each process such as wash, dose measurement, and infusion experiment is performed sequentially using three solenoid valves. It will be supplemented by procuring and configuring actual parts and conducting experiments. In the case of a radioactivity counter, it may be difficult to procure commercial products, so a separate development plan should be established.

Based on this manual infusion system, it is expected that basic experience and data for future automatic infusion system fabrication will be prepared.

When the infusion rate is low, such as in small animal experiments, in order to maximize the use of rubidium-82, which has a very short half-life, it is desirable to elute rubidium-82 at a large flow rate right next to the experimental animal, put it in a syringe, and inject it into the target animal.

ACKNOWLEDGEMENT

This work was supported by MSIT (Ministry of Science and ICT) and by the National Research Foundation of Korea (NRF) under Grant number NRF-2017M2A2A2A05016601

REFERENCES

[1] Kye-Ryung Kim, et al., Medical RI Development Plan of KOMAC, Journal of the Korean Physical Society, Vol. 71, 2017.
[2] Kye-Ryung Kim, et al., The 1st Radioisotope Separation Experiment for the Sr-82 Production in KOMAC, Transactions of the Korean Nuclear Society Autumn Meeting, Changwon, Korea, October 21-22, 2021.
[3] Kye-Ryung Kim, et al., Development of an exclusive column method for ^{82}Sr/^{82}Rb generator using a 100-MeV proton linear accelerator of KOMAC, Journal of Radiopharmaceuticals and Molecular Probes, Vol. 7, No. 2, 2021.
[4] https://en.wikipedia.org/wiki/Rubidium-82