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Estimation of Dispersal Rate in Strontium-82 Extraction Process from Rubidium Chloride Target Irradiated with 100-MeV Proton Beam

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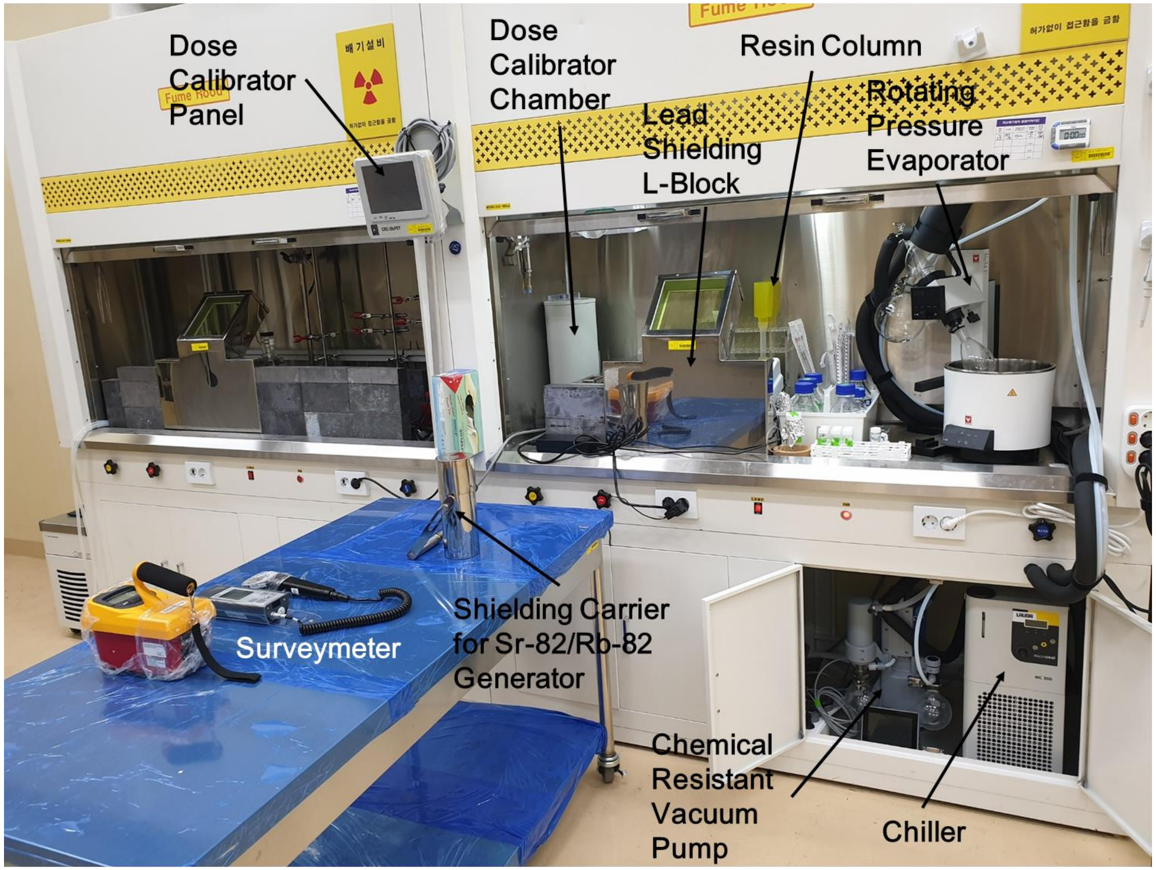
Introduction: RI facility

- KAERI is preparing a facility based on a 100 MeV proton linear accelerator for the production of various RIs.
- Using this facility, ^{82}Sr production is being prepared first.
- RI production facilities should be prepared for RI contamination through various routes.



RI experimental setup inside RI hood

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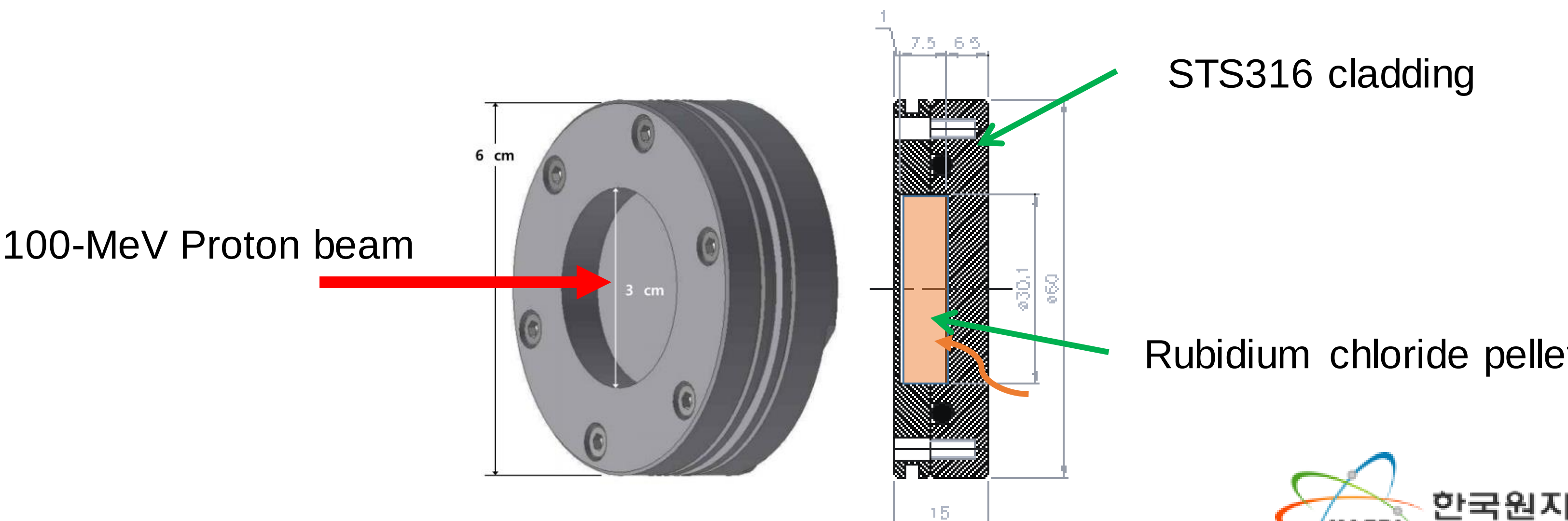
Introduction: RI dispersion

- Among them, dispersion generated while handling RI is very difficult to estimate, so in general, facilities are designed very conservatively.
- In the case of the KOMAC's RI production facility, it is assumed that 1/10,000 of the maximum amount of RI used per day is dispersed for the design of exhaust facilities, etc.
- However, in the case of actual RI works, the dispersal rate may be different depending on the nuclide, physical state, chemical state, and how to handle.

➢ **Therefore, it is necessary to estimate a more realistic dispersal rate for the ^{82}Sr production process under development.**

^{82}Sr Production Process: Target

- Rubidium chloride powder is compressed into pellets, and a metal cladding is placed on it to produce a target.
- When the target is irradiated with a 100-MeV proton beam, a radioactive isotope, ^{82}Sr, is produced by $^{85}Rb(p,4n)^{82}Sr$.
- The irradiated target is transferred to hot cell or RI hood to start the ^{82}Sr separation process.
- RI contamination is not a concern as it remains sealed until transferred to hot cell or RI hood unless the target is accidentally damaged.



^{82}Sr Production Process: Pellet

- Dispersion begins as soon as the rubidium chloride pellets (containing a small amount of ^{82}Sr and other RIs) are exposed to air by removing the cladding in the hot cell.
- This pellet is dissolved in a buffer solution to convert it to an aqueous solution, and it goes through several processes to remove unnecessary elements and extract ^{82}Sr.

Nuclide	^{82}Sr (alkaline earth element) and other metals
Chemical state	Inorganic compound (chloride) and aqueous solution
Physical state	Lump (pellet) and liquid (aqueous solution)
Handling process	Machining (lump) and drying (Aqueous solution)

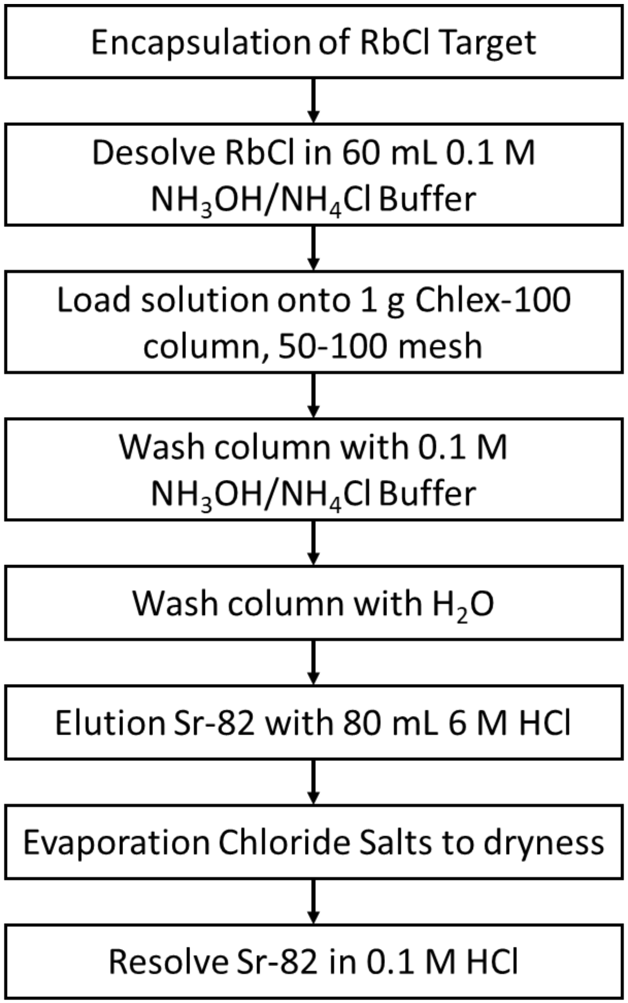


Fig. 1. ^{82}Sr extraction procedure

Daily Dispersal Rate [4]

Dairy dispersal rate by nuclide

Nuclide	Dispersal Rate per Day
^{3}H, ^{14}C, ^{35}S, ^{75}Se	10^{-3}
^{131}I, ^{137}Cs, ^{197}Hg, etc.	10^{-4}
Most other metals	10^{-7}

Coefficient by shape

Shape	Coefficient
Powder	× 10
Liquid	× 1
Lump	× 0.1

Coefficient by handling process

Handling process	Coefficient
Heating (drying, etc.)	× 100
Chemical reaction, mechanical machining, animal experiment, etc.	× 10
General manipulation	× 1
No manipulation	× 0.1

Total dispersal rate per day =
Σ (Daily dispersal rate per day by nuclide × Shape coeff. × Handling coeff.)

Dispersal Rate for ^{82}Sr Production Process

It is assumed that RI dispersion = 0 in the target state.

^{82}Sr extraction process from the irradiated pellet includes

1) machining to remove metal cladding
2) chemical reaction to dissolve chloride to make an aqueous solution
3) general manipulation of aqueous solution
4) evaporation of aqueous solution

1) ^{82}Sr chloride, lump, machining: $10^{-7} \times 0.1 \times 10 = 10^{-7}$
2) ^{82}Sr chloride, lump, chemical reaction: $10^{-7} \times 0.1 \times 10 = 10^{-7}$
3) ^{82}Sr aqueous solution, liquid, manipulation: $10^{-7} \times 1 \times 10 = 10^{-6}$
4) ^{82}Sr aqueous solution, liquid, evaporation: $10^{-7} \times 1 \times 100 = 10^{-5}$

$\sum$ all dairy dispersal rates in the process (1+2+3+4) = 1.12×10^{-5}

Conclusions

- The daily dispersal rate of the process for extracting ^{82}Sr from irradiated target is estimated to be about 10^{-5}. Since this is lower than 10^{-4} originally used in the design of the RI production facility, it can be confirmed that this facility has a sufficient safety margin for the ^{82}Sr separation & purification process.

- The process that accounts for a large portion of the dispersal rate is the drying process. Therefore, it will be helpful to prevent contamination by RIs if the experimental equipment is configured to minimize dispersion in this drying process and the experiment is conducted with more caution compared to other processes. In this sense, vacuum drying currently used for the ^{82}Sr extraction process development is a very appropriate method.

- The same dispersal rate will be estimated for other metal RIs generated in the ^{82}Sr production process and for most other metal RI production process that undergo a similar procedure.

Acknowledgement & Reference

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[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., Status and Plans of Sr-82 Development Using a High Energy Proton Accelerator, Transactions of the Korean Nuclear Society Spring Meeting, Jeju, Korea, May 18-19, 2017.

[3] Yeong Su Ha, et al., Comparative Study of 82Sr Separation/Purification Methods Used at Brookhaven National Laboratory and ARRONAX, Journal of Radio-pharmaceuticals and Molecular Probes Vol. 5, No.2, 2019.

[4] Shigeru Takada, et al., An Estimation for the Dispersal Rates of Radioactive Materials under Various Handling, Radioisotopes, Vol. 32, 1983.

[5] 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.

Thank you.

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