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1.Introduction

Radioactive impurities such as U/Th/Ra are one of the serious background sources in low-BG experiments such as KamLAND and Super-K.

➡ **Purification** to remove RIs in advance is extremely important.

Issues related to purification

- Presence of dissolved U in Gd water at SK.
- Reduction in LS light yield by distillation at KamLAND.
- Dissolved Fe in Gd water at XENONnT.

We have been developing chelate filter for U/Th/Ra adsorption.

Features of Chelate Filters

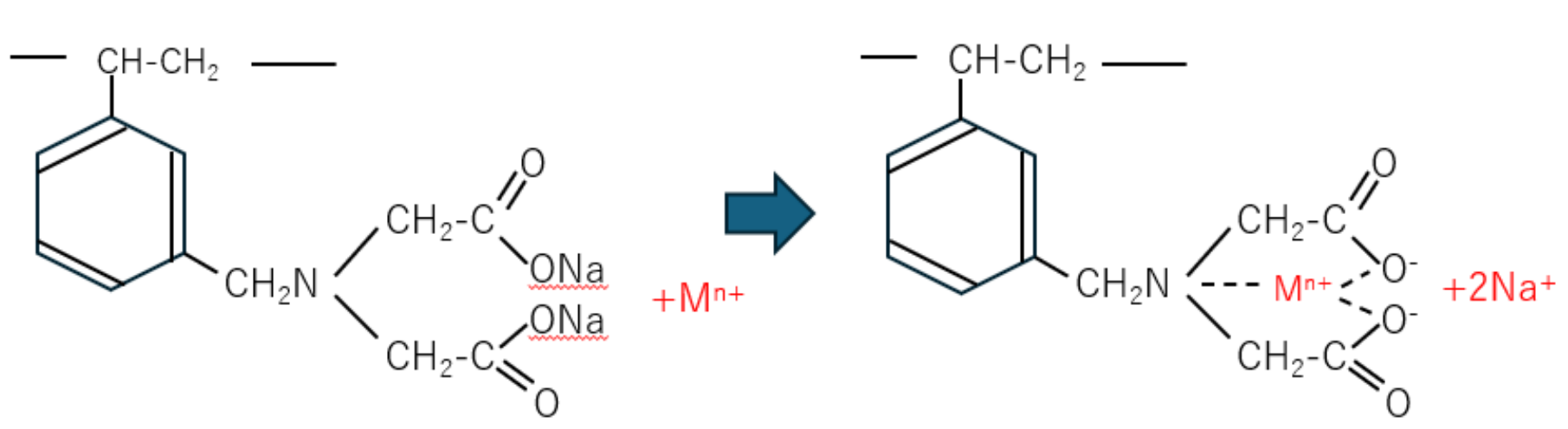
- Easy purification compared with distillation and liquid–liquid extraction.
- High selectivity for specific metal ions compared with ion-exchange resins.

Strong Binding

A functional group that strongly binds specific metal ions by forming complexes.

Example: Iminodiacetic acid

<https://ionexchange-info.com/type/chelate/>



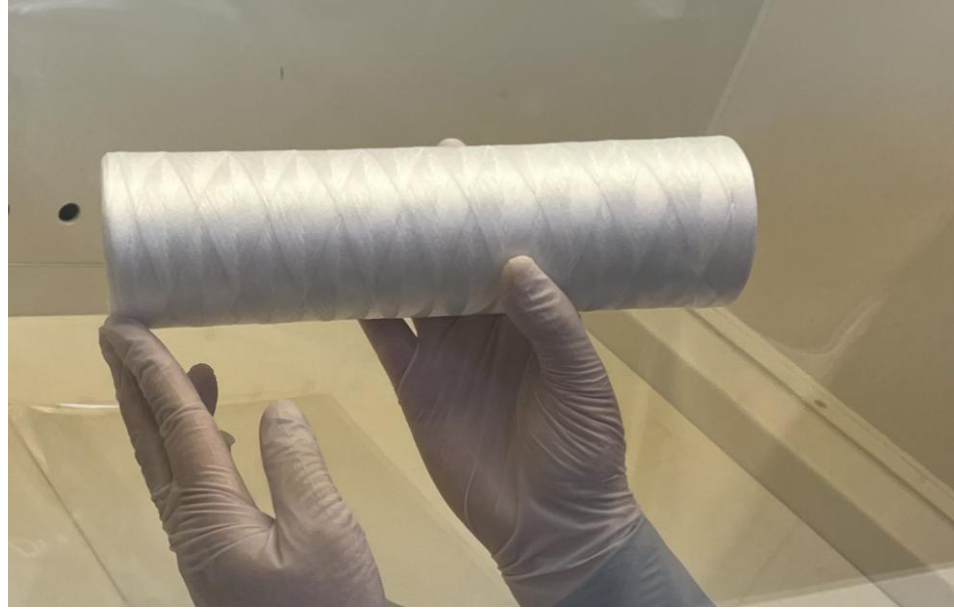
2. Chelating group

3. Chelating Filters and Our Target

- Created by attaching chelating exchange groups to a nylon filter
- Used for removing radium at Ningyo-toge and Cesium Fukushima Nuclear Power Plant.
- Used for U adsorption even in seawater.

Oil (Liquid Scintillator)

A simple and inexpensive purification method that does not require large-scale purification systems



Our Target

Ultrapure Water

Development of a U/Th Adsorption Filter with Higher Selectivity than Ion-Exchange Resins

Water Solution (Gd Water)

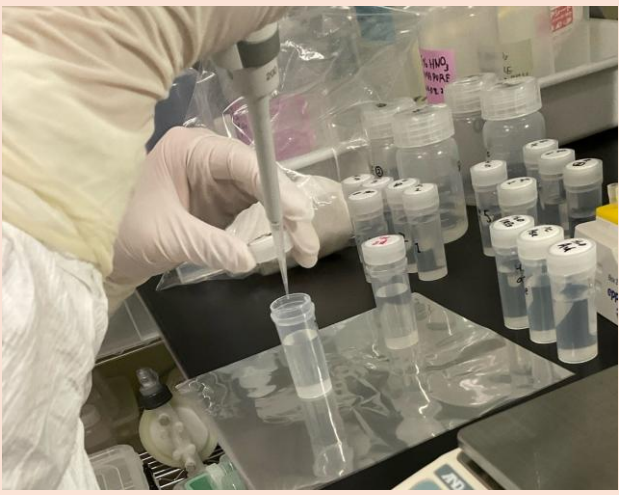
Selective adsorption of a specific metal from a solution

4. Evaluation of Filter Performance

Performance Evaluation of U Adsorption in Ultrapure Water

1. Preparation of U Standard Solutions

- Prepare a 10 ppt U,Th standard solution (XSTC-331).
- Take a sample before treatment.



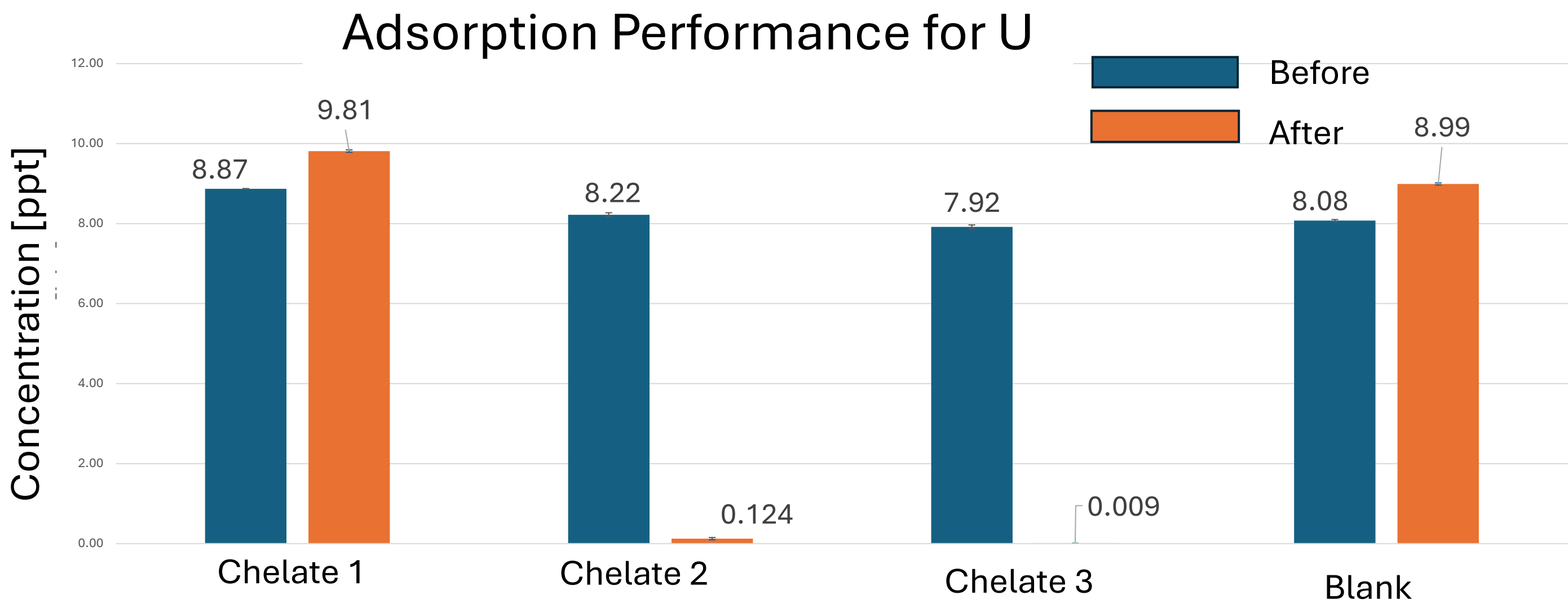
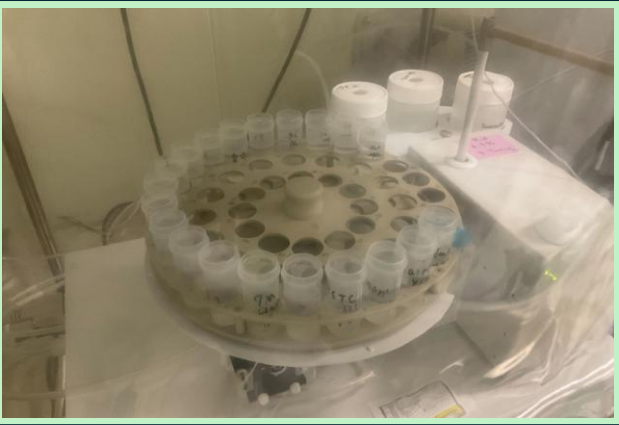
2. Filter-soaking

- Soak ~0.1 g of fiber in 100 mL of standard solution.
- Measure the solution pH before and after soaking filters.
- Stir overnight with a magnetic stirrer.
- Collect sample solutions before and after soaking.



3. ICP-MS Measurement

- Add 68% HNO₃ to the samples to be 2% HNO₃
- Measure U and Th concentrations in the samples.



- Chelate 3 showed the best performance, **reducing U from 7.92 ppt to ~9 ppq**. In this time, the samples pH was 2.5~3.0. Adsorption of chelating filters has pH-dependence. Adjusting the pH toward 7 should be done.

Development of Oil-based Standard Solutions

Water-based Standard solutions

Commercially available

(XSTC-331)

Oil-based Standard solutions

Commercially not available

If you have any idea, please let me know!!!

We need to develop Oil-based Standard Solutions by ourselves !!!

Nitrogen bubbling

- XSTC-331(100ppb) 1 mL : PC 99 mL
- Bubble nitrogen gas through the solution overnight while stirring.

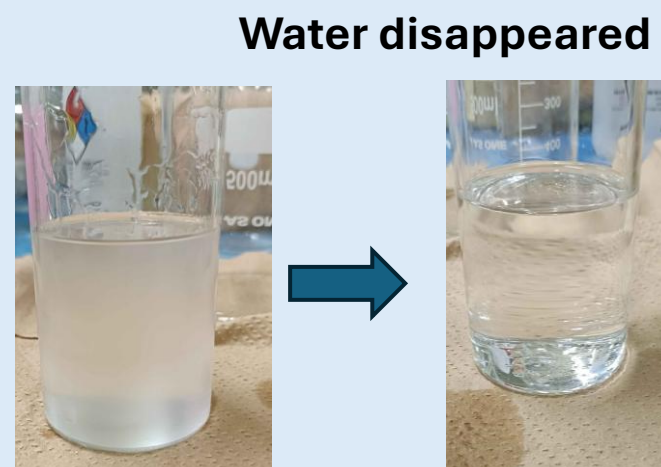


Adding Acetone

- XSTC-331(100ppb) 10 μL : PC 95 mL : Aceton 5mL

- Use a **organic solvent** to facilitate mixing of PC and water-based standard solution.

- A more concentrated XSTC solution will be used to minimize the amount of acetone.



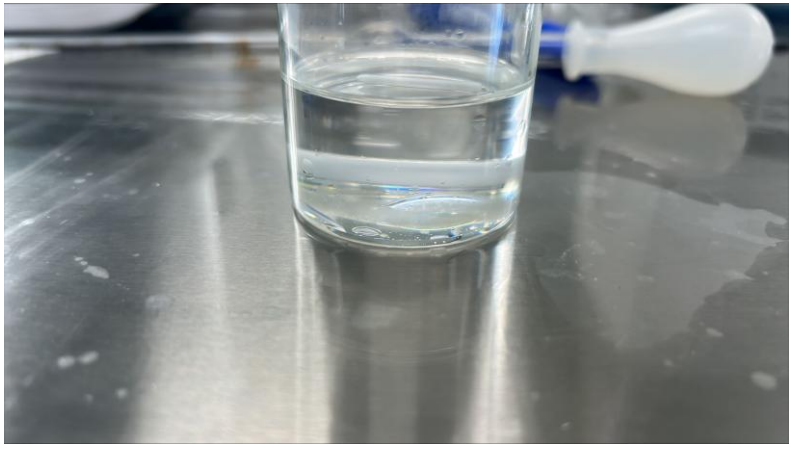
Mixing with acetone After mixing

First trial...

Mixing pseudocumene (PC) with water-based standard solution.



Stir overnight



The standard solution settled at the bottom and **did not mix with the PC at all**.
→ A different mixing method is required.

	Th Conc. [ppt]	U Conc. [ppt]
Stirring Target concentration:1000 ppt (Dissolution ratio)	0.49 ± 0.03 (0.049 %)	0.43 ± 0.02 (0.043 %)
Nitrogen bubbling Target concentration:1000 ppt (Dissolution ratio)	257 ± 3 (25.7 %)	123 ± 1 (12.3 %)
Acetone Target concentration:10 ppt (Dissolution ratio)	7.83 ± 0.08 (78.3 %)	4.65 ± 0.03 (46.5 %)

- A solution containing a certain amount of U and Th was successfully developed.
- In terms of Dissolution Ratio, **the acetone method is most effective**.
- The concentration of the solution itself needs to be measured each time it is used.

5 .Summary

- **Developing the Chelating Fibers to address purification issues**
- **Features of chelating groups**
 - **Strong binding** through complex formation with metal ions
 - **High selectivity** for specific metal ions
- **Performance Evaluation of Chelating Fibers**
 - Three types of chelating fibers have been tested.
 - Confirmed U adsorption down to **9 ppq** with chelate 3
- **Development of Oil-based Standard Solutions**
 - Confirmed that acetone is an effective method

Future Prospect

Understanding pH Dependence

Measuring the pH dependence of chelating groups.
We plan to use **NH₃** to adjust the pH.

Stability Check of Oil-Based Standard Solutions

Long-term stability of the standard solution needs to be evaluated.



Applications to Oils Using Oil-Based Standard Solutions

Conduct an adsorption tests using self-developed oil-based standard solution.

Applications of Gd Water

Selective U and Th adsorption from Gd water without removing Gd.

