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Development of the Innovative Nuclide Separation System for High-Level Radioactive Waste using Microchannel Chip

—Extraction Behavior of Metal Ions from Aqueous Phase to Organic Phase in Microchannel—

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Background

To reduce the quantity of high-level radioactive liquid wastes (HLLW) and to prevent discharge of radioactive materials into the environment…

Development of innovative separation technologies for actinides or long-lived radionuclides in radioactive wastes has been required.

We have examined applicability of extraction using microchannel chip to nuclide separation.

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Reactions in microscopic space
(*e.g.* microchannel)

- large specific interface area
- short diffusion distance
- small heat capacity

→ **Chemical reactions in microchannel will make possible to hatch the innovative separation technologies with high-selectivity to nuclides.**

Thermal Lens Microscope (TLM)

- high-sensitivity
- wide dynamic range
- *in-situ* analysis in microscopic space

→ **TLM is advantageous technique for direct determining concentrations of metal ions in microscopic space.**

The microchannel extraction system equipped with TLM will give us useful information on the extraction behaviors of metal ions in microchannel chip.

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Objective

To develop the innovative nuclide separation system using microchannel chip.

Subject

Extraction behavior of U(VI) from aqueous phase to tri-*n*-butylphosphate (TBP) one in microchannel.

- TLM measurements of U(VI) in aqueous and TBP samples.
- Microchannel extraction experiment of U(VI) in 3M HNO_3-TBP system.

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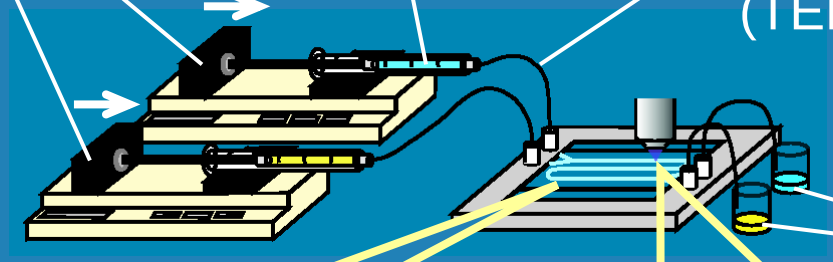
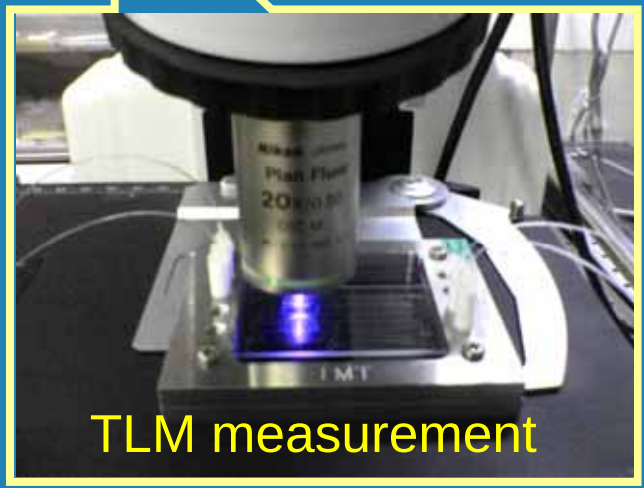
Experimental setup for extraction experiment using microchannel chip




Microchannel Chip
(PYREX glass)


TLM measurement

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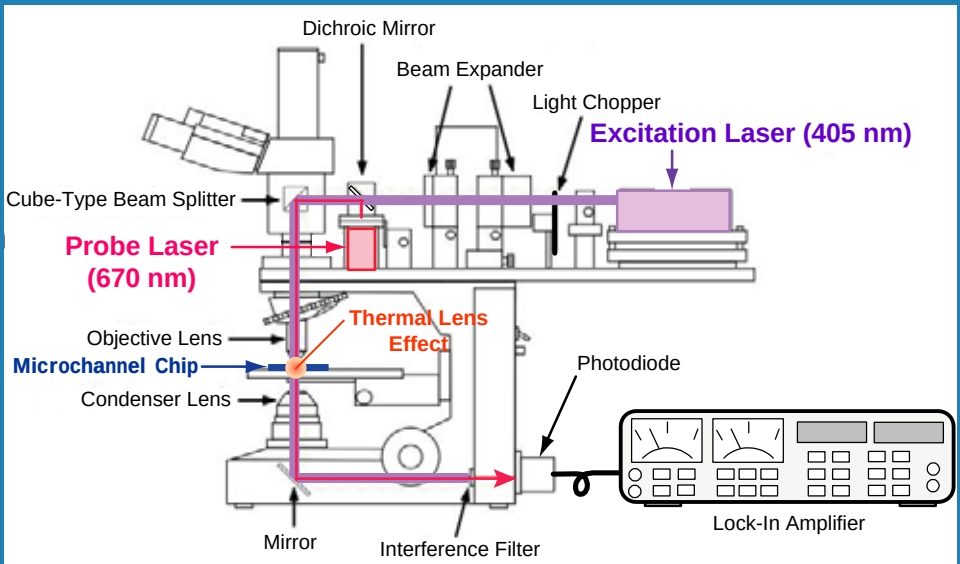
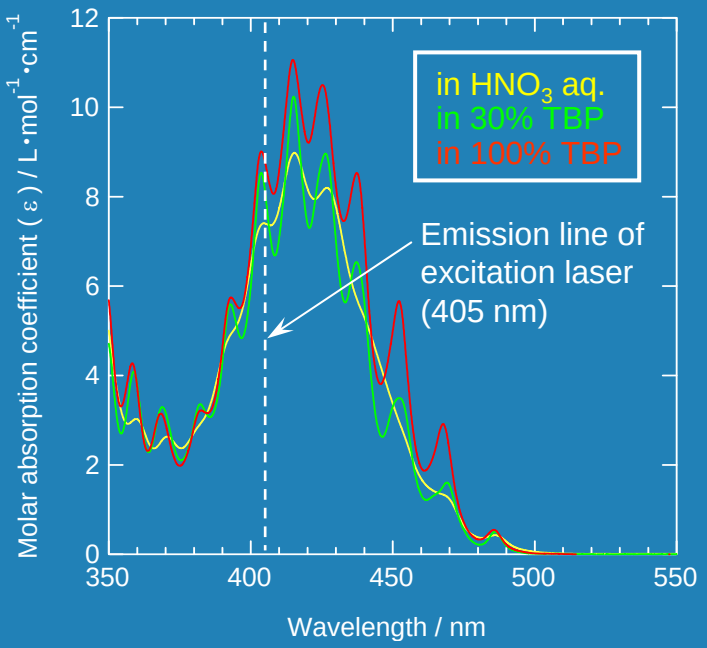
TLM measurement system



TLM measurement system



UV-Vis absorption spectra of U(VI) in aqueous and TBP solutions

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Concentration dependence of thermal lens (TL) signal of U(VI) in aqueous and TBP phases

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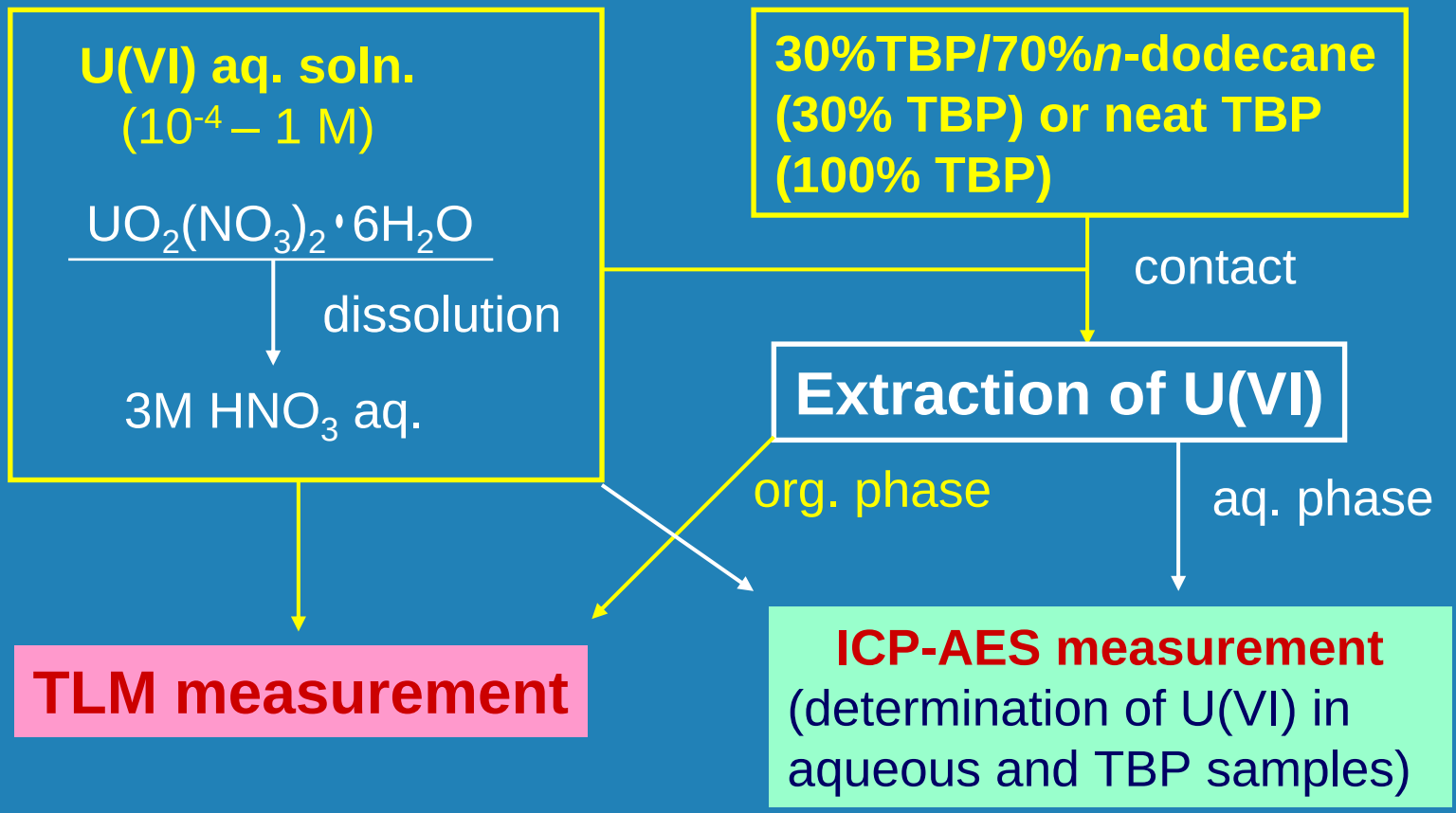
Experimental procedure



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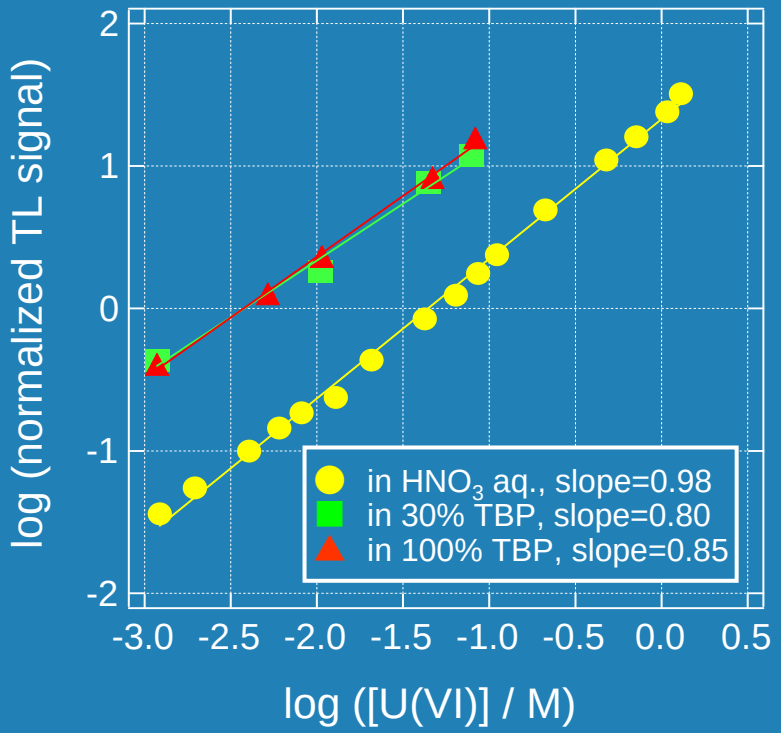
Results



TLM measurements

Limit of detection (LOD) values of TLM and UV-Vis absorption measurements of U(VI) in aqueous and organic solutions (M)

	in 3M HNO_3 aq.	in 30% TBP	in 100% TBP
UV-Vis	3.8×10^{-5}	6.8×10^{-5}	1.8×10^{-5}
TLM	1.8×10^{-4}	1.2×10^{-4}	1.4×10^{-4}

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Extraction behavior of U(VI) from aqueous phase to TBP one in microchannel

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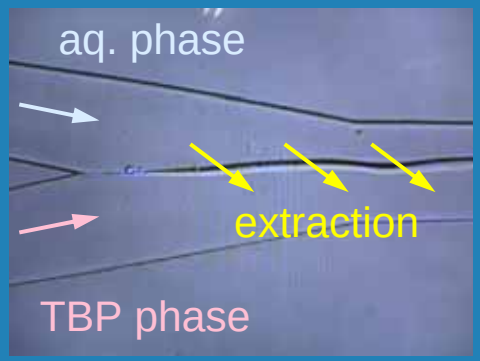
Experimental procedure

aq. phase
U(VI)-3M HNO_3 aq.
U(VI) conc.：0.11 M
flow rate：3μl/min.

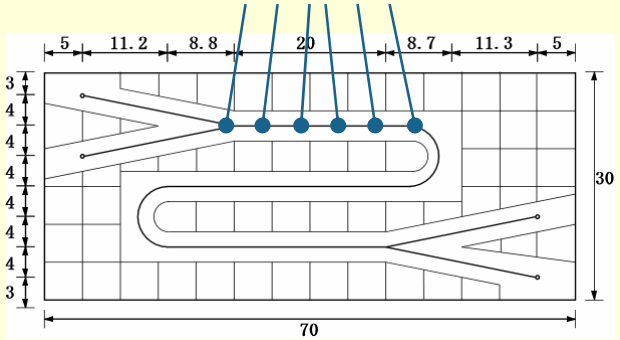
TBP phase
30% TBP (4.3μl/min.)
100% TBP (2.2μl/min.)

Contact in microchannel
channel width：100.5μm
channel depth：43.5μm



TLM measurement

Measurement points
(every 5 mm)



Contact time dependence of U(VI) concentration in aqueous and TBP phases

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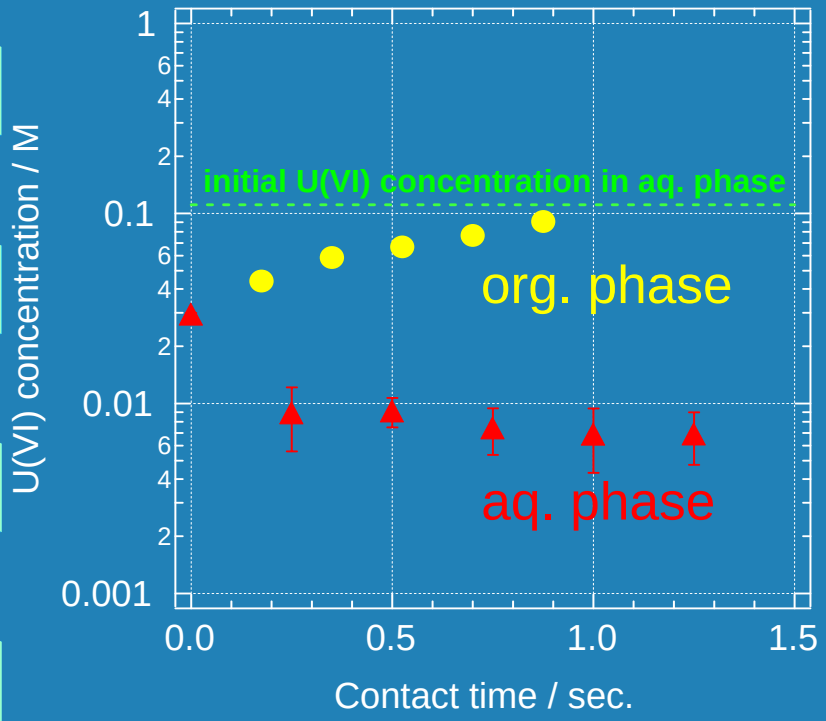
Results
- extraction to 30% TBP phase -



Contact time dependences of U(VI) concentration in 3 M HNO_3 and 30% TBP phases

In aq. phase:
Concentration of U(VI) approaches to constant value of approximately 6.8×10^{-3} M after 1 s.

In 30% TBP phase:
Concentration of U(VI) reaches approximately 9.1×10^{-2} M after 0.9 s.

Extraction equilibrium was achieved in approximately 1 s.

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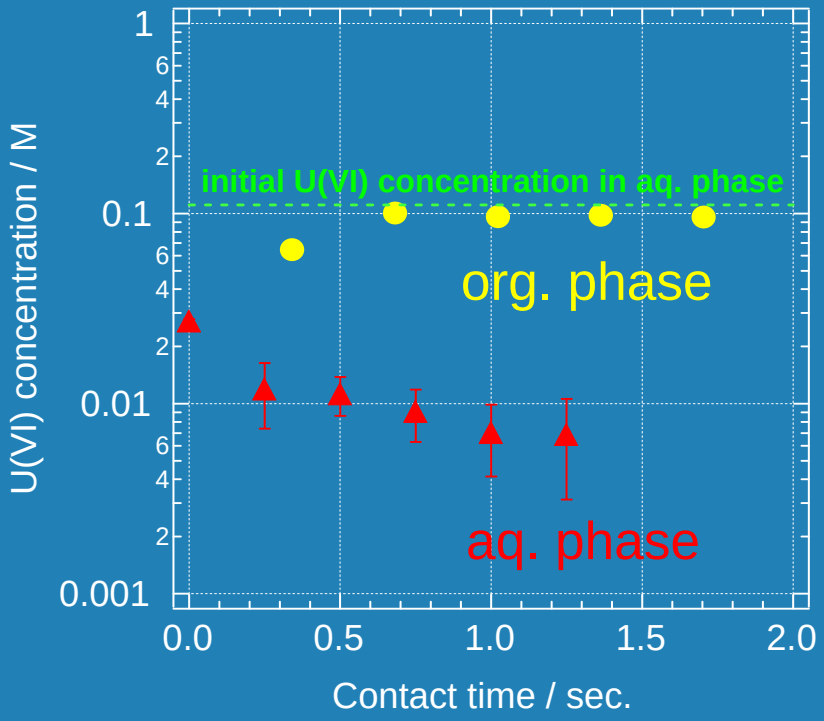
Results
- extraction to 100% TBP phase -



Contact time dependences of U(VI) concentration in 3 M HNO_3 and 100% TBP phases

In aq. phase:
Concentration of U(VI) approaches to constant value of approximately 7.0×10^{-3} M after 1 s.

In 100% TBP phase:
Concentration of U(VI) reaches approximately 0.1 M after 0.7 s.

Extraction equilibrium was achieved in approximately 0.7 s.

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Results - extractabilities -

Extractabilities of U(VI) in 3M HNO_3-TBP systems (%)

	microchannel extraction	bulk extraction
30% TBP	93.8	96.1
100% TBP	93.8	–

Extractability of U(VI) from 3 M HNO_3 phase to TBP one in microchannel is almost same as that in bulk liquid-liquid extraction.

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Summary

- Extraction of U(VI) from HNO_3 phase to TBP one in microchannel chip can be performed in approximately 1 s with good extractability in both systems of 30% and 100% TBP.
- Extraction of U(VI) using microchannel chip can be carried out with higher extraction efficiency than in bulk extraction.
- In microchannel, extraction of U(VI) from aqueous phase to TBP one in microchannel can be achieved without adding diluents, *e.g.*, *n*-dodecane.
- By applying microchannel chip to nuclide separation system, it is expected that the separation of nuclides can be performed more selectively, efficiently, and finely than conventional separation methods.

Thank you very much for your attention.

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