

## Development of Microfluidic Devices for Highly Efficient Separation and Detection of Selenium Ion

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This research developed a novel microfluidic system for high speed selenium separation and detection. Formation of selenium complex and microscale extraction of the complex in a hydrophobic-hydrophilic patterned microfluidic chip were achieved.

**Keywords:** Selenium-79, microfluidic device, solvent extraction, surface modification

Selenium-79 (Se-79) is a  $\beta$ -emitted and a kind of long-lived fission products (LLFPs) and is essential for waste management in decommissioning sites and for geological disposal. However, since trace amounts of Se-79, about 5g/MTU[1] are included in the fission products, separation and analysis of 79-Se are often difficult by means of conventional techniques. On the other hand, microfluidic technologies should be suitable analysis tool due to unique features such as microliter solution volumes, large surface to volume ratios, and highly efficient mass transfer. Several researches on analysis of actinide and lanthanide ions using micro/nano fluidics have been already performed [2]. Therefore, in this work, we aim to realize high speed separation and online determination of Se ion by combination of microfluidic flows and fluorescence detection.

The chelating agent DAN (2,3-diaminonaphthalene) has good chelating ability with Se(IV), resulting in fluorescent Se complex. A novel microfluidic chip was fabricated by photolithography and wet-etching techniques on a fused-silica substrate. A toluene solution containing octadecyltrichlorosilane (ODS) was introduced into the microchannel, converting the channel surface from hydrophilic to hydrophobic. Additionally, the outlet area of the channel was hydrophilically patterned using 0.1 M sodium hydroxide. An aqueous solution containing Se(IV) and DAN and a cyclohexane solution were simultaneously introduced into the microchannel. Two phase parallel flow was formed and microextraction of Se complex into the cyclohexane phase occurs along the length of the channel. The cyclohexane phase was completely separated from aqueous phase at the hydrophilic/hydrophobic patterned outlet area. The extracted Se complex was *in-situ* detected using a fluorescence microscope.

The microscale results showed that there was almost 100% Se complex extraction into the cyclohexane phase at a contact time of 0.4 sec compared to bulk scale of 3 min. In addition the cyclohexane phase from the aqueous phase could be completely separated. Further improvement to these results involve development of plug flow droplets which is currently in progress.

### References

[1] S. Asai *et al.*, *J. Nucl. Sci. Technol.*, 48, 851–854, **2011**. [2] T. Tsukahara, *Rad. Inter. Mat. Technol.*, 65-66, **2014**.

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