

Development of a chromatographic microsystem for the separation of actinides prior to mass spectrometric measurements

The development of processes in the field of spent nuclear fuel recycling requires continuous analytical control. In this sense, numerous samples are characterized from the point of view of their isotopic and elemental composition, in particular uranium, plutonium, minor actinides and fission products. These analyses are carried out by thermoionization mass spectrometry (TIMS) or inductively coupled plasma mass spectrometry (ICP MS). Most radionuclide analyses need chemical separations prior to mass spectrometric measurements, to eliminate biases or interferences. These separations are generally performed by chromatography on ion exchange resins, in acidic media, and the different fractions containing the isolated and purified elements are collected before being analyzed off-line by mass spectrometry. These resins are typically enclosed in cartridges to perform chemical separations in the classical analytical format. In order to reduce the drawbacks related to radioactive sample handling, reagent consumption and effluent volumes generated by these separation steps, the aim of this project is to downscale the sample purification protocols preceding the analysis by mass spectrometry.

The strategy is based on the synthesis and *in situ* anchoring of a monolith in the channel of a microsystem, followed by its impregnation with the complexing agents used in conventional separations. This development will be supported by the production of prototypes using microfabrication techniques, to validate the design of the microsystems with representative samples. Based on previous work done in the laboratory, this postdoctoral project will be carried out according to the following steps:

- 1°) Choice of material well-suited to working in the very acidic conditions of the samples, design and manufacturing of a microsystem.
- 2°) *In situ* synthesis and impregnation of the monolith, in the channels of the microsystem.
Characterization of the impregnated monolith
- 3°) Optimization of the separation conditions in conventional laboratory, using Eu, Th and U as simulants.
- 4°) Transposition of the separation and analysis of U and Pu solutions as real samples.
- 5°) Micro-machining and replication of microsystems for analytical monitoring as support for nuclear facilities and implementation of spent nuclear fuel treatment processes.

This project will be led by DPC/SEARS/LANIE at the CEA site in Saclay, where the candidate will benefit from the team's skills and equipments for the fabrication of microfluidic devices, the synthesis of monoliths in microsystems and mass spectrometry measurements (TIMS and ICP MS), in a conventional laboratory but also in a controlled area dedicated to the handling of radioactive samples. This project will also be developed in cooperation with another CEA laboratory at the Marcoule site (DMRC/SASP/L2AT) concerning the applications.

The knowledge and experience acquired in microfluidics and analytical chemistry by the candidate during this postdoctoral project will be an asset for his professional project.

Required profile:

Candidates will be required to hold a PhD in microfluidics and analytical chemistry, with solid skills in microsystem functionalization and polymer synthesis. Experience in mass spectrometry and chromatography would be desirable.

The candidate will be in charge of the management of the project, including the design, fabrication and functionalization of chromatographic microsystems, their application to chemical separations and performing mass spectrometry measurements. He/she will work in collaboration with the Marcoule laboratory. The work will be reported under communication, publication or patent format. The candidate must be autonomous and show a proactive attitude, as well as excellent team working and communication skills, both in-house and in interaction with the partners.

Key words: microfluidics, chromatography, monolith, isotopic analysis, mass spectrometry

Host laboratory:

Commissariat à l'Energie Atomique et aux Energies Alternatives - Direction des Energies
Département de Physico-Chimie - Service d'Etudes Analytiques et de Réactivité des Surfaces
Laboratoire de développement Analytique Nucléaire, Isotopique et Élémentaire (LANIE)
Centre de Saclay, 91191 Gif-sur-Yvette Cedex, 20 km from Paris.

Duration: 12 months from October 2021, possibility of renewal.

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