Microfluidic approach dedicated to the screening of chelating molecules for the selective removal of contaminants

Limiting the impact of contaminants coming from the industry sector is of societal concern. Moreover, miniaturising and integrating analytical tools into microfluidic chips are part of environmental approach such as the reduction of sample consumption, solvents, materials and waste production.
In this project, an innovative approach based on microfluidic technology will be developed for the screening of the efficiency of chelating molecules to selectively remove radionuclides (RN) coming from the nuclear energy industry in the event of human contamination. These molecules will be first selected regarding affinity and selectivity criteria towards the RN of interest, particularly uranium (U), caesium (Cs), strontium (Sr) or cobalt (Co). The strategy is based on the use of a separative microsystem previously developed in the LANIE team and for which the proof of concept and gains resulting from the miniaturisation have been demonstrated for the selective capture of uranium target proteins (*Bresson C., Garcia-Cortes M., Vidaud C. & Tran T. 2021 Brevet FR 1910077*). Thus, the *in-situ* synthesis and local anchoring of a functionalised polymeric support have been developed in the microsystem channels, as well as its coupling to inductively coupled plasma mass spectrometry (ICP-MS) to determine the immobilised U amount and measure selective interactions with proteins. The parallel micro-channels offer the possibility to immobilise different metallic ions in each channel, thereby to probe the affinity and the selectivity of candidate molecules for several RN in a single device, precisely and quantitatively.

These conditions will be advantageously applied to develop a versatile and multiplex microsystem, according to three major steps:

1- Evaluating the affinity of chelating molecules towards U

By using protocols of synthesis and coupling to mass spectrometry previously set up, a phosphorylated polymeric support will be synthesised *in-situ* and locally anchored within the microsystem channels, in which uranium will be immobilised and on line quantified. For the screening tests, molecules coming from the family of polyaminocarboxylates, polyphosphonates, catecholates, hydroxypyridinonates… will circulate in the functionalized channels, then a scale of their chelating power towards U will be determined, in connection with the differential affinity of the molecules for this element.

2- Adapting the microsystem in order to immobilize other elements of interest

According the same approach, Cs, Sr and Co will be immobilized in the functionalized micro-channels, each channel being dedicated to a distinct metal. The fixation rate of each element will be measured on line, by ICP-MS. Depending on the performance obtained, it will be possible to functionalize specifically each micro-channel in order to improve the fixation rate of the targeted elements.

3- Determining the affinity and the selectivity of chelating molecules for Cs, Sr and Co

The conditions for retaining and eluting a mixture of chelating molecules will be set up in the micro-channels immobilizing Cs, Sr and Co. The first molecules will be selected based on the literature data, chemical criteria and their availability in the chemical library of a project partner. The affinity scale of the molecules for each metal will then be determined. From this step, it can be possible to fine-tune the structure of the molecules in order to improve their chelating power, if necessary.

The developed miniaturized method should make it possible to accelerate the identification of the most promising chelating molecules, which is a prerequisite for testing molecules of therapeutic interest on *in vitro* and *ex vivo* models, more representative of biological interactions.

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Département de Recherche sur les Matériaux et la Physico-chimie pour les énergies bas carbone
Service de Physico-Chimie

This project will be carried out at the CEA Saclay center (DES/ISAS/DRMP/SPC/LANIE) and in interaction with two other CEA laboratories having expertise in organic chemistry, radiotoxicology and decorporation (DRF/JACOB/IRCM/SREIT/LRT et DRF/JOLIOT/DMTS/SCBM)

Required profile:
PhD in analytical chemistry, with solid skills in microfluidics. Experience in microsystem functionalization and polymer synthesis would be desirable.
The candidate will be in charge of the management of the project, including carrying out the experiments: functionalization of the microsystems, their coupling to mass spectrometry and development of the on line multielemental quantification method. The work will be reported under reports, communication or publication 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.

Host laboratory:
Commissariat à l'Energie Atomique et aux Energies Alternatives - Direction des Energies (DES)
Département de Recherche sur les Matériaux et la Physico-chimie - Service de Physico-Chimie (DRMP – SPC)
Laboratoire de développement Analytique Nucléaire, Isotopique et Elémentaire (LANIE)
Centre de Saclay, 91191 Gif-sur-Yvette Cedex, 20 km from Paris.

Duration: 12 months, possibility of renewal. Starting date: beginning of second 2023 semester

To apply, send your CV and motivation letter to carole.bresson@cea.fr - Tel: +33(1) 69 08 83 48