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Demonstration trials using lab-scale pulsed columns of a new spent nuclear fuel treatment process

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A new spent nuclear fuel treatment process, particularly well-suited to plutonium-rich fuels and based on a N,N-dialkylamide extracting molecule, is under development at CEA. The feasibility of this process has already been established through pilot tests in laboratory scale mixer-settlers on genuine solution [1]. With a view to industrial-scale implementation, the possibility of using this new solvent in pulsed columns must be investigated, both from the hydrodynamic point of view and in terms of transfer efficiency. A first step is to carry out trials in small diameter pulsed columns with uranium feed solutions.

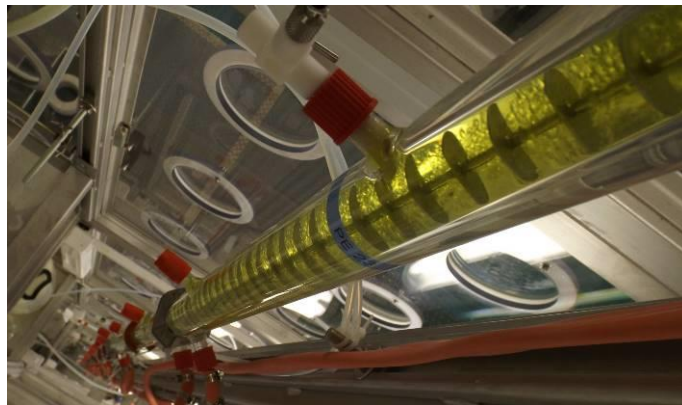
The trials were conducted in three glass columns of 15 mm diameter and 4 meters height, fitted with a packing specifically designed according to the physico-chemical properties of the new solvent. These columns performed the three main steps of the process: extraction, plutonium selective stripping (emulated by the selective stripping of nitric acid) and uranium back-extraction. Several trials were conducted in order to explore a wide range of specific velocities of the phases in the columns.

Due to the viscosity of the new solvent, the hydrodynamic behaviour of the columns (emulsion formation, phases flow) was carefully followed. Despite the low height of the columns, satisfactory performances were obtained:

- in the first column, more than 99.9% of the uranium was extracted from the feed to the solvent,
- in the second column (selective stripping), 91 to 98% of the acid was back-extracted,
- in the third column, more than 99.7% of the uranium was back-extracted.

The height equivalent to a theoretical plate (HETP) was estimated between 0.5 and 1.5 m.

The flowsheet design and the results exploitation were carried out by means of a CEA-developed process simulation software.



Top-view of a 4 metre high laboratory-scale pulsed column during an uranium extraction test

These tests have demonstrated the possibility of implementing the new monoamide-based process in pulsed columns, with a satisfactory transfer efficiency. The development of the process should go on in two directions: on the one hand by pilot tests with a more realistic chemistry (experiments with plutonium) and on the other hand by upscaling toward the industrial size, which will combine hydrodynamic experiments in wider columns and the simulation of hydrodynamics and mass transfer through CFD modelling.

[1] : Demonstration of uranium - plutonium separation and purification from spent nuclear fuel with monoamide solvent, C. Sorel et al., International Nuclear Fuel Cycle Conference GLOBAL 2017, Seoul