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Advanced separation strategies for spent nuclear fuel reprocessing studied at Politecnico di Milano Radiochemistry Lab within European Projects

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Actinide recycling by the so-called Partitioning & Transmutation (P&T) strategy is considered worldwide, and particularly in several European countries, as one of the most promising strategies to reduce the inventory of radioactive waste and optimise the use of natural resources. In Europe, the research programs dedicated to hydrometallurgical separation of MA have been supported mostly by the European Commission (EC).

Most of the partitioning strategies rely on a three step approach: i) separation of U (and sometimes also Pu) from spent fuel dissolution liquors; ii) An(III) + Ln(III) co-extraction; iii) An(III)/Ln(III) separation. In fact, Ln are characterised by high neutron-capture cross-section and they must be removed in order to achieve an efficient MA transmutation. Unfortunately, the similar chemical behaviour of 4f and 5f elements together with the unfavourable mass ratio are major difficulties to be dealt with. The processes developed around the world differ from the extracting systems involved in these different steps and the possibility to merge them into a single one. Initially, a two steps approach based on two extraction cycles was proposed. A first step, called DIAMEX (DIAMide EXtraction), was dedicated to the separation of trivalent MA and Ln from other fission products contained in the PUREX raffinate. A second step, named SANEX (Selective ActiNide EXtraction), was aimed at separating trivalent MA from Ln. In the following joint research projects, the improvement of the DIAMEX process and of the MA separation by selective extraction in a SANEX-type process were the main goals.

Within the last projects, special attention has been devoted to process safety issues. Furthermore, the researchers' efforts have been focused on developing more compact and simplified separation strategies for the An recycling by reducing the number of cycles. With this aim, three novel heterogeneous approaches have been outlined: innovative-SANEX, 1cycle-SANEX and EXAm (EXtraction of Americium). Moreover, an innovative homogeneous concept has been introduced with the GANEX (Grouped ActiNide EXtraction) process, with the aim of recovering all TRU in a single solution thus enhancing the proliferation resistance.

At Politecnico di Milano, the Radiochemistry Group has been involved in the study and characterization of different organic extractants suitable for application in the abovementioned processes. Examples of such studies are presented and discussed.

Author: OSSOLA, Annalisa (Politecnico di Milano)

Co-authors: MACERATA, Elena (Politecnico di Milano); MOSSINI, Eros (Politecnico di Milano); FOLGADO DE LUCENA, Ana Filipa (Politecnico di Milano); GALLUCCIO, Francesco (Politecnico di Milano); GIOLA, Marco (Politecnico di Milano); MARIANI, Mario (Politecnico di Milano)

Presenter: FOLGADO DE LUCENA, Ana Filipa (Politecnico di Milano)

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