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Evaluation of the new EURO-GANEX process resistance by gamma irradiation test loop

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The reprocessing of spent nuclear fuel is currently moving towards advanced cycles that contemplate the recycling of minor actinides (MAs: Am, Cm, Np), as a strategy to minimise the radiotoxicity of the waste that must be stored [1]. One of the constraining points for the development of extraction processes from the point of view of safety is their resistance to the highly radioactive field and acid concentration where they must be used. For that, resistance studies of extraction systems are very useful to know and predict the long-term behaviour during a normal or mal-operation in a future reprocessing plant.

Within the homogeneous strategy, which addresses the recycling of U and the transuranic elements (TRU= Np, Pu, Am, Cm) contained within a single fuel type and distributed homogeneously throughout the reactor core, GANEX (Group ActiNide EXtraction) is the most promising process to recover all of them. In the GANEX concept, bulk uranium is removed in the first cycle, followed by the co-extraction of all actinides in a second cycle. Three options exist for this second cycle CEA-GANEX, EURO-GANEX and CHALMEX processes [1]. EURO-GANEX process was tested by an irradiation loop [2] and successfully demonstrated with high plutonium content in centrifugal contactors for the first time [3], obtaining excellent results. However, EURO-GANEX also has various drawbacks: one of them is that the sulphonated BTP reagent employed in the aqueous phase does not accomplish the “CHON principle” increasing the waste volume; another one is that the combination of two extractants in the organic phase (TODGA and DMDOHEMA) complicates solvent formulation, clean up and the process itself. Therefore, the process needs to be further optimized to meet the above mentioned criteria.

Improvements made to EURO-GANEX system have resulted in the emergence of the so-called New EURO-GANEX process, where the composition of the solvent has been modified by replacing TODGA and DMDOHEMA with cis-mTDDGA in the organic phase and SO₃-Ph-BTP with PyTri-Diol in the aqueous phase [4].

In this work, the Náyade irradiation loop has been configured to simulate the two main steps of the new EURO-GANEX process, i.e. An + Ln co-extraction and TRU stripping steps, under an interinstitutional study between CEA, INL and CIEMAT. For that, a high accumulated dose over the organic solvent in contact with nitric acid was supplied, simulating the recycling of the organic phase; but a relatively low dose over the aqueous phase containing PTD was supplied since it is not expected to be recycled. The performance and changes in the composition have been analysed along the irradiation experiment by different techniques: gamma spectrometry and ICP-MS for the extraction and corrosion behaviour of the full system, and HPLC-MS to determine the degradation of the organic and aqueous solvent.

[1] Lyseid Authen, Thea, et al. Separation Science and Technology (2021): 1-21.

[2] Sánchez-García, Iván., et al. Nuclear Engineering and Technology (2021).

[3] Malmbeck, Rikard, et al. Radiochimica acta 107.9-11 (2019): 917-929.

[4] Macerata, Elena, et al. Journal of the American Chemical Society 138.23 (2016): 7232-7235.

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