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Separation of Fr-221 from Ac-225 using diglycolamide solid extractants

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Diglycolamides are frequently used as extraction agents in many fields of nuclear and separation chemistry including nuclear waste management, nuclear fuel reprocessing, radioanalytical chemistry, radioecology or nuclear medicine. They are tridentate ligands with extraction abilities to extract trivalent ions, mainly lanthanides and actinides [1].

This ability can be beneficial in separation of radionuclides for nuclear medicine. In practise, diglycolamides are used for example in separation of clinical Ra-223 from Ac-227/Th-227/Ra-223 mixtures [2]. Another important medicinal radionuclide of recent years, Ac-225, is separated from its mother radionuclide Ra-226 using diglycolamides as well [3].

Ac-225 is a radionuclide of great potential for targeted alpha particle therapy. Its decay initiates the cascade of 5 alpha decays in total. The second of its decay products, Bi-213, is another radionuclide in the focus of nuclear medicine research at the moment. The separation of Bi-213 cannot be sufficiently performed using diglycolamides because of its chemical properties. However, the first decay product of Ac-225 transmutation is Fr-221 with a half-life of 5 min decaying to Bi-213. As a monovalent ion it could be easily separable from Ac-225.

In this work two most common diglycolamides, TODGA and isoTODGA, were tested for separation of Fr-221 from Ac-225 in preliminary studies. Diglycolamides were immobilised on polyacrylonitrile beads to form solid extractants TODGA-PAN and isoTODGA-PAN. The loading of such solid extractants was 40 %.

Batch sorption experiments with both solid extractants were performed in both hydrochloric and nitric acid media in the concentration range of 0.001-8M. The weight distribution coefficients of Ac-225 were determined. As expected, especially high weight distribution coefficients were achieved for both solid extractants in higher concentrations of nitric acid.

Subsequently, the most promising conditions of Ac-225 sorption were applied in column experiments in order to evaluate Fr-221 elution. The initial activity of Ac-225 was 4.5 MBq and column bed volume was 0.6 ml. The yield of Fr-221 elution was kept over 65 % in 2.5ml of eluate for the whole period of the long-term study. The contamination by Ac-225 was kept under 1.0 % and getting lower during the time of study.

To sum up, the proof of concept has been given in this preliminary study. However, in order to minimize Ac-225 contamination, the parameters of proposed separation system should be optimized.

[1] Ansari S.A. Chemistry of Diglycolamides: Promising Extractants for Actinide Partitioning. Chem Rev. 2012, 112, 1751-1772.

[2] ALGETA AS. Isotope production method. Inventors: Jan R. KARLSON, Peer BØRRETZEN. European patent application. EP2564397 A1. 29.4.2011.

[3] Bruchertseifer F. et al. Targeted alpha therapy with bismuth-213 and actinium-225: Meeting future demand. J Label Compd Radiopharm. 2019, 62, 1-9.

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