Radiochemical separation and identification of neutron-rich isotopes of heavy and superheavy elements

Project in nuclear physics for INTEREST online programme at JINR University Centre

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Brief description

The aim of this research is the development of a method for radiochemical separation of heavy elements by high-performance liquid chromatography for the correction of nuclear data and search for new neutron-rich isotopes of actinides produced in multinucleon transfer reactions or as a decay product of superheavy elements
The theoretical approximation of experimental curves will allow to develop model and determine separation parameters in non-equilibrium processes at one-atom-at-a-time level. As a result we will describe our experimental data using the stochastic theory of chromatography and show the possibility of transition to liquid phase chromatography of one atom at a statistically significant level.

Research activity

Flerov laboratory of nuclear reactions is a world leading laboratory in synthesis of superheavy elements and study its nuclear chemistry. In the field of liquid phase single-atom chemistry the ongoing research is focused on the development of a model that could predict the position of the peaks of unknown elements at tracer level at the chromatogram. Production of orders of magnitude different amounts of radionuclides of actinides and their short half-lives force us to consider novel theoretical approach for describing the chromatography process. The method of theoretical plates is used for the development of the theory of mass transfer to predict the position of peaks and determine the separation parameters of the three elements americium, curium and californium in the classical system for the identification of actinides cation exchanger (Aminex A5-α - HIB) in the concentration range 0.2-0.5 mol/l. This will be followed by optimization of the selected system on-line with light homologues and construction of setup for fast preparation of spectrometric samples detection of rare events of short-lived actinide isotopes. As a result, we expect that developed model and methods will allow separation of single atoms of heavy elements and thus extend research to low level cross-section region.
Novel methods for An(II) and An(III) separations will be developed for the studies of hard-to-reach Md, No and Lr which can be produced only in heavy ion reactions. The obtained data will also be used for development for actinide cyclotron targets manufacturing and recycling.

Plan of the project at the current stage

The work schedule is drawn up for 6 weeks in period 08 February - 19 March, 2021 and is agreed with the student including discussion of the short literature review, analysis of the experimental data, calculations, results and final report

- Theoretical investigation of actinides chromatography
- Optimisation of actinides separation using the theory of plates and chromatography model development based on the obtained results
- Calculation of linear gradient system to separate actinides and experiments on HPLC
- Selection of systems prospective for An(II) / An(III) separation
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Required skills

- Basic knowledge of nuclear chemistry and physics (gamma-spectrometry)
- Motivation
- English speaking skills (B2 level)
- Basic IT knowledge (Matlab)

Acquired skills and experience

- Understanding the mechanisms of the heavy and superheavy elements production in nuclear reactions
- Understanding the chromatographic theory concepts and its application in heavy elements separation
- Processing experimental chromatograms and gamma-spectra

Recommended literature

M. Schädel, D. Shaugnessy (editors), The Chemistry of Superheavy Elements, 2nd Ed., Springer, 2014.