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On the fast release of tracer elements from metallic hosts –a step towards vacuum chromatography

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The most common way to chemically investigate transactinides since almost 50 years is by using a gas based transport setup. The "gas-jet" method has proved to be very useful as a fast transport medium, allowing investigations of nuclei with half-lives down to about a second. However, for sub-second nuclei gas-jet type transport has quite poor efficiency due to decay losses. Transport in vacuum is much faster and could therefore be a solution to this problem. Vacuum chromatography [1] is an intenisvely discussed and promissing method that may be applied in the near future to investigate some of the heaviest elements known. In a gas-jet system the evaporation residues (EVRs) are stopped in the carrier gas itself. This is of course not possible in a vacuum system. Therefore it is mandatory to find a new method for stopping the EVRs after their production in nuclear fusion reactions. One possible solution would be to use a very thin metal foil or a stack of metal foils where the EVRs are implanted. However, in order not to loose the speed advantage a vacuum based setup, it is necessary that the subsequent thermal release of the EVR from the metal foil is very fast. We have conducted initial experiments, using the lighter group 13 and 14 homologues of E113 and Fl (E114) to determine suiteable catchermaterials and the best methods to achieve fast release.
The model about the heat of mixing from A.R. Miedema [2] was used to determine the potential catchermaterials Ni, Y, Zr, Nb, Mo, Hf, W, and Re. The experiments took place at the Philips cyclotron at Paul Scherrer Institute in Switzerland. Tracer-doped host materials were produced by the implantation of the fusion products from a Zn, Cd, Hg targets that was irradiated with 80-MeV 4He2+. Otherwise, proton induced reactions were used to produce tracers within the catcher materials. Diffusion constants and activation energies could be determined for the various tracer-host material combinations. Using the principles from Crank [3], Borg, and Dienes [4] it was possible to deduce release rates at various annealing temperatures and for different foil thicknesses. A first on-line experiment was performed at the Oslo Cyclotron Laboratory of the University of Oslo using fission products from proton induced fission of uranium.
Using a model applied for the first time by Bakker [5] it was possible to extrapolate diffusion values from the model experiment and from values from literature to predict corresponding properties for transactinides. For a certain set of experimental parameters, such as catcher material thickness, temperature, and time, it is possible to calculate release rates of superheavy elements from the investigated host materials, assuming that the desorption time of the segregated tracer nuclide is not the time determining factor of the release process.
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