Fast electrochemical deposition of Bismuth

H. Hummrich, J.V. Kratz
Institut für Kernchemie, Johannes Gutenberg-Universität Mainz, Germany

Fast electrochemical deposition is a promising method for the aqueous chemistry of the superheavy elements [1]. To perform electrodeposition experiments, the knowledge of basic electrochemical parameters like deposition potentials and the deposition velocity is necessary. To prepare experiments with element 115, its homolog Bi was investigated.

Experiments were performed with carrier free ^{212}Bi ($t_{1/2}$ = 60 min, E_γ = 727 keV). 1 ml of a solution of ^{212}Pb in 0.5 M HCl was obtained via the emanation method [2]. The solution was passed through a column (d = 8 mm, l = 15 mm) filled with the cation exchanger Dowex 50x8 (100 - 200 mesh). Under the given conditions ^{212}Pb is retained, whereas ^{212}Bi forms an anionic chloro complex and passes the column. A total elution volume of 2 ml was sufficient to elute 90 % of the activity. The eluate was evaporated to dryness and dissolved in 1 ml 0.1 M HCl.

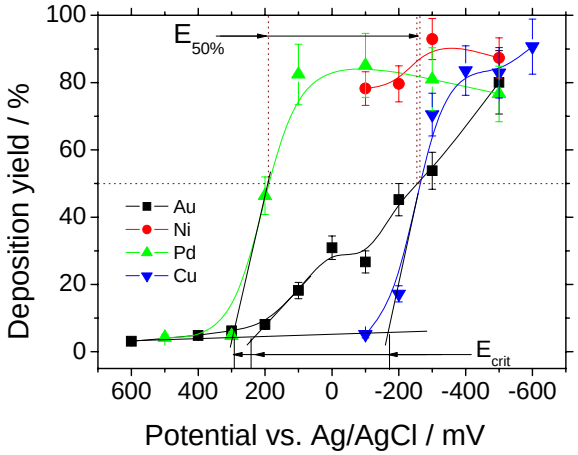

Figure 1: Potential curve for the electrochemical deposition of ^{212}Bi on various electrodes from 0.1 M HCl.

Electrochemical deposition experiments were performed using a potentiostatic setup with an electrochemical cell for fast electrochemical depositions [3]. The electrolyte was 0.1 M HCl, the working electrode material was varied. 1 ml electrolyte containing ^{212}Bi was electrolysed for 10 min, starting at the electrode rest potential which is obtained without applying external current. The deposited activity was measured for 1 min by γ-spectrometry and then electrolysis was resumed at a more negative potential etc.

Table 1: E_{crit} and $E_{50\%}$ values for the deposition of Bi from 0.1 M HCl on various electrode materials

Electrode	E_{crit}	$E_{50\%}$
Au	+250	-240
Pd	+290	+180
Cu	-180	-260
Ni	spontaneous deposition	

Potential curves for the deposition of Bi on Au, Ni, Pd, and Cu are shown in Fig. 1. The critical potential (E_{crit}), at which a significant deposition sets in, and the potential for the deposition of 50 % of the atoms in solution ($E_{50\%}$), are indicated. Numbers are given in Table 1. In agreement with literature [4], a nearly complete deposition of Bi on Ni is already observed at the rest potential (spontaneous deposition). For the deposition on Cu and Pd, s-shaped curves are obtained. The corresponding E_{crit} and $E_{50\%}$ values for the deposition on Pd and Cu differ more than 400 mV, meaning that the interaction of Bi and Pd is much stronger than the interaction of Bi with Cu. The deposition yield for the deposition on Au increases only slowly with decreasing potentials, resulting in a big difference in E_{crit} and $E_{50\%}$. This can be taken as is a sign for a hindrance in the electrodeposition process.

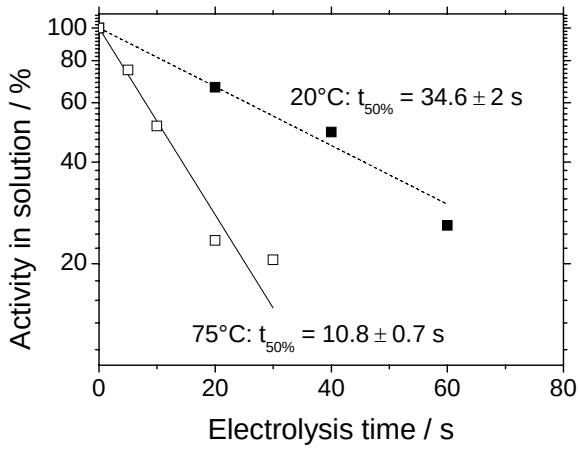

Figure 2: Electrodeposition velocity for the spontaneous electrodeposition of ^{212}Bi on Ni from 0.1 M HCl at room temperature (filled squares) and at 75 °C (open squares).

The electrodeposition velocity was determined for the spontaneous deposition of ^{212}Bi on Ni. Electrolysis was performed for a certain time and the deposited activity was measured. The time for the deposition of 50 % of the atoms in solution ($t_{50\%}$) was 35 s at room temeperature. This value could be lowered to 11 s by increasing the electrolyte temperature to 75 °C.

If isotopes of element 115 with a half-live in the range of 10 s were available, electrodeposition experiments should be performed with Ni or Pd electrodes.

References

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[4] S.C. Ehinger, R.A. Pacer, F.L. Romines, J. Radioanal. Nucl. Chem. Articles 98, 39 (1986)