Non-aqueous separation process for the purification of the lutetium-177 medical radioisotope

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Introduction

Lutetium-177 is becoming one of the most important radionuclides because of its high theranostic potential and convenient production logistics.[1] The most efficient production method of lutetium-177 is through neutron irradiation of ytterbium-176 targets. However, this method requires separation of the ytterbium and lutetium.[2] Classical extraction techniques require multiple steps as separation factors are low and only a low concentration of lutetium is present.[3]

The novel method relies on electrochemical reduction of ytterbium(III) to ytterbium(II), changing its chemical behavior significantly, improving the separation factor. This reduction is possible as ytterbium is one of the few lanthanides showing a stable divalent state. Unfortunately divalent ytterbium reacts readily with water, requiring additional precautions to be taken.

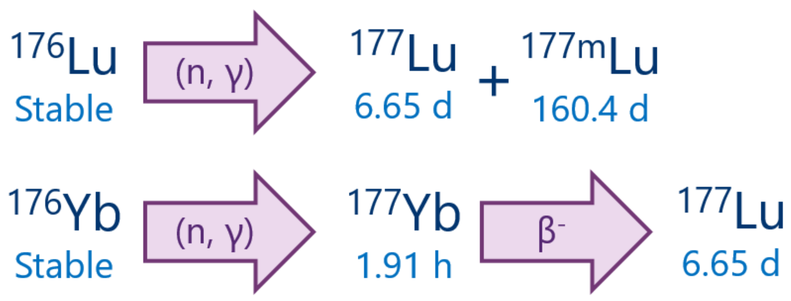

Figure 1: Production of lutetium-177[1]

Objectives

- **Reduce Yb^{3+}**
- **Stabilize divalent species**
- **Develop a suitable extraction system for the Yb^{2+}/Lu^{3+} separation**

Setup

Experiments are performed in a glovebox as moisture has shown to be a major obstacle. For electrochemical experiments a potentiostat is connected to a small volume cell containing following electrodes:

- Working electrode (glassy carbon or platinum)
- Counter electrode (platinum)
- Quasi-reference electrode (Ag/Ag^{+})

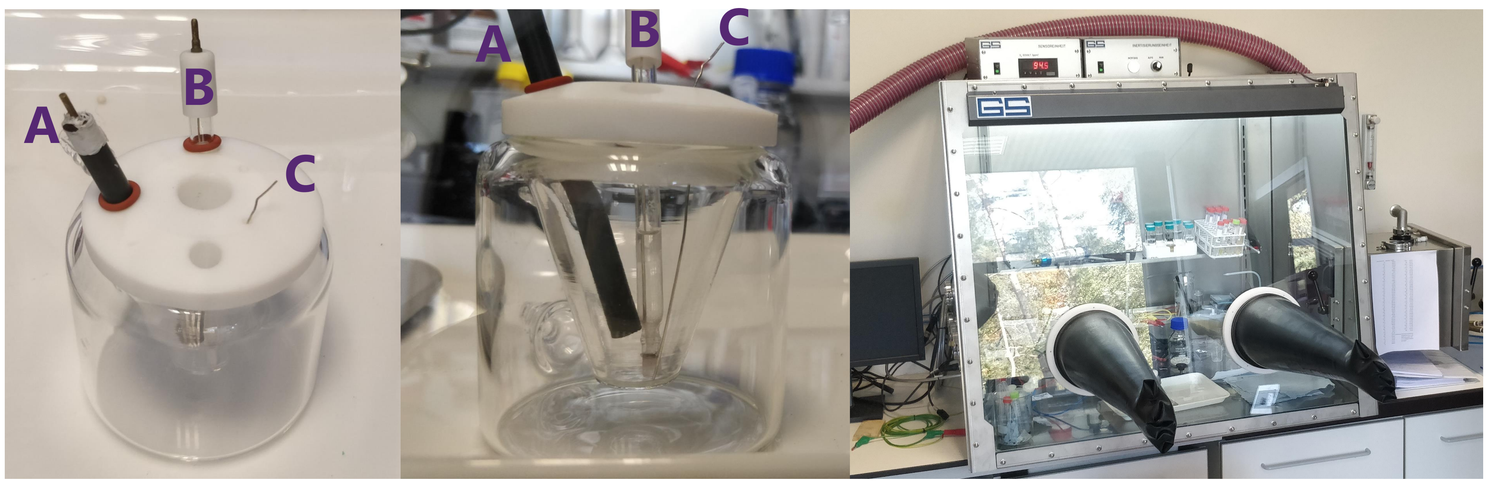

Figure 2: Experimental setup: A Working electrode, B Quasi-reference electrode, C Counter electrode

Results & Discussion

Coulometric Karl Fischer titration

- Initial experiments: working under argon flow
- Insufficient to prevent water uptake
- Solvents are very hygroscopic

Electronic Impedance spectroscopy

- Organic solvents show a high uncompensated resistance
- Up to 5000 Ω in ethylene glycol and tetrahydrofuran

Voltammetry

- Linear relation between peak current and concentration
- Moisture negatively impacts the shape of the peak
- Solvent choice impacts peak shape and potential

Spectroscopy

- UV/Vis spectra were measured in various solvents

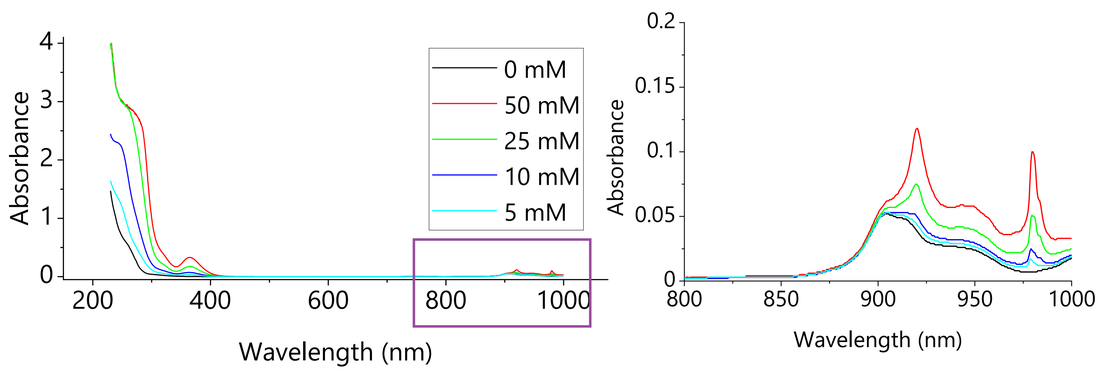

Figure 4: UV/Vis spectrum of $YbCl_3$ in tetrahydrofuran

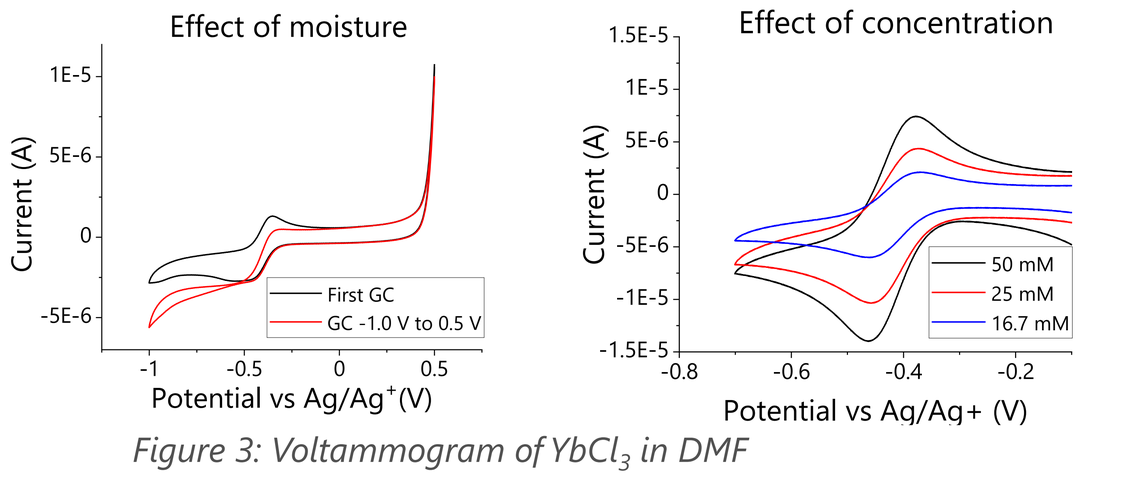

Figure 3: Voltammogram of $YbCl_3$ in DMF

Outlook

- Perform electrolysis experiments and quantify the amount of Yb^{2+} formed
- Investigate stabilization of Yb^{2+} by comparing different supporting electrolytes and additives
- Develop an extraction system compatible with the conditions of the reduction

References

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(2) Van de Voorde, M., Van Hecke, K., Cardinaels, T. & Binnemans, K. Radiochemical processing of nuclear-reactor-produced radiolanthanides for medical applications. Coord. Chem. Rev. 382, 103–125 (2019)
(3) Dash, A., Chakravarty, Rubel Knapp, F. & Pillai, A. Indirect Production of No Carrier Added (NCA) 177Lu from Irradiation of Enriched 176Yb: Options for Ytterbium/Lutetium Separation. Curr. Radiopharm. 8, 107–118 (2015).

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