



PHYSICAL CHEMISTRY 2006

Proceedings

*of the 8th International Conference
on Fundamental and Applied Aspects of
Physical Chemistry*

September 26-29,
Belgrade, Serbia

ISBN 86-82139-26-X
Title: Physical Chemistry 2006. (Proceedings)
Editors Prof. dr A. Antić-Jovanović
Published by: The Society of Physical Chemists of Serbia, Studentski trg 12-16, P.O.Box 137, 11001 Belgrade, Serbia
Publisher: Society of Physical Chemists of Serbia
For publisher: Prof. dr S. Anić, president of the Society of Physical Chemists of Serbia
Printed by: "Jovan" Printing and Published Comp;
250 Copies; Number of Pages: x + 442; Format B5;
Printing finished in September 2006.
Text and Layout: Aleksandar Nikolić
250 – copy printing

VOLTAMMETRIC DETERMINATION OF LUTETIUM

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Abstract

Half wave potential of lutetium was determined by anodic stripping voltammetry using various electrolyte solutions at the mercury electrode. The influence of electrolyte pH on the value of peak current was also observed. The results show that the choice of the supporting electrolyte and the electrolyte pH strongly influence the voltammetric behaviour of lutetium.

Introduction

Various voltammetric techniques, especially stripping voltammetry, are effectively used in analytical determination of very low metal concentrations. These techniques can be applied to wide variety of metals, e.g. in environmental analysis for qualitative and quantitative determination of heavy metals in natural waters [1]. High sensitivity and selectivity of stripping voltammetry are based on the fact that the analyte is accumulated before it is determined.

Anodic stripping voltammetry (ASV) with mercury as the working electrode can be used to determine all metals which are soluble in mercury with the formation of amalgams. The first step is reduction of the metal ions and formation of an amalgam, while in the second step (determination) re-oxidation occurs [2].

Our recent work was orientated towards membrane extraction of radionuclide $^{177}\text{Lu(III)}$ from aqueous solutions at very low concentrations [3]. In order to investigate the physicochemical parameters of transport of Lu(III) across supported liquid membrane, one needs a suitable analytical method which would enable us to determine low concentration of non-radioactive $^{176}\text{Lu(III)}$. ASV potentially offers the possibility to determine trace quantities of Lu(III).

To our best knowledge there is no published information related to voltammetric determination of lutetium yet. Thus, the aim of this study was to find a suitable supporting electrolyte for the determination of Lu(III) and to define its half wave potential using the most appropriate electrolyte.

Results and Discussion

A 797 VA Computrace analyser (Metrohm, Switzerland) was used for all voltammetric measurements. The analyser consists of a 797 VA Computrace Stand and is fully controlled with a 797 VA Computrace software ver. 1.2. The Metrohm Multimode Mercury electrode served as a working electrode, typically in a hanging mercury drop electrode (HMDE) mode, whereas a Pt-wire electrode was used as an auxiliary electrode and an Ag/AgCl ($3 \text{ mol}\cdot\text{dm}^{-3}$ KCl) electrode with ceramic diaphragm was used as a reference electrode. Dissolved oxygen was removed by nitrogen bubbling prior to

measurements. All measurements were carried out at laboratory temperature of 20 ± 2 °C.

The solution of LuCl_3 was prepared by dissolving Lu_2O_3 in hot hydrochloric acid and diluting it with deionised water to a final concentration of $5 \text{ mg}\cdot\text{dm}^{-3}$ Lu(III). Electrolytes used for the determination of Lu by ASV were: $3 \text{ mol}\cdot\text{dm}^{-3}$ potassium chloride, $1 \text{ mol}\cdot\text{dm}^{-3}$ potassium thiocyanate, $0.1 \text{ mol}\cdot\text{dm}^{-3}$ sodium oxalate, $0.1 \text{ mol}\cdot\text{dm}^{-3}$ ethylenediamine tetraacetic acid and $0.5 \text{ mol}\cdot\text{dm}^{-3}$ sodium tartrate. All experiments were performed in the voltammetry cell, containing 10 cm^3 of deionised water, 1 cm^3 of appropriate electrolyte and 0.1 cm^3 of $5 \text{ mg}\cdot\text{dm}^{-3}$ Lu(III). Blank solution was measured before each sample determination. Depending on the supporting electrolyte, the useable potential range was in the interval between 0 and -1.8 V . Method of standard addition was used to verify that the obtained peak originates from Lu(III).

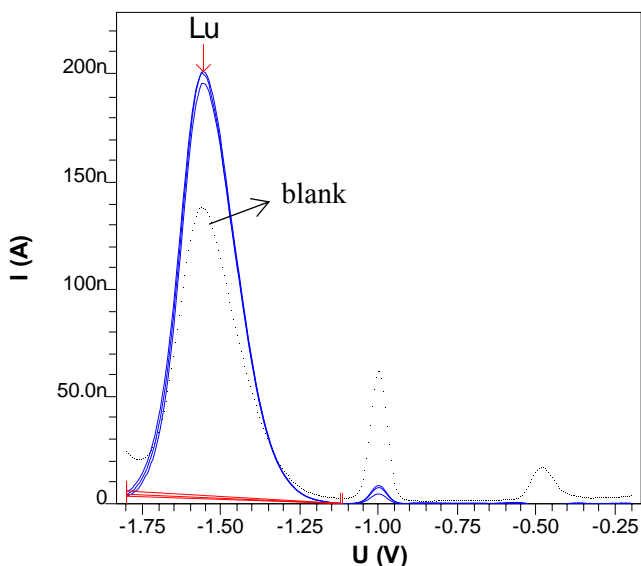


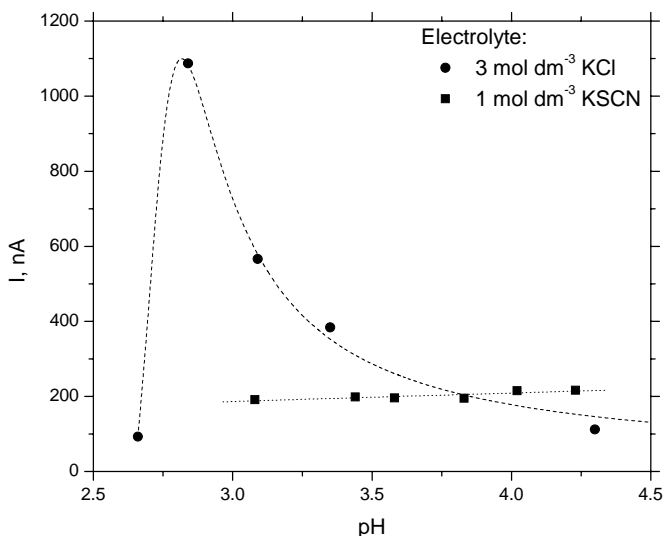
Fig. 1. Voltammogram of Lu(III) using $1 \text{ mol}\cdot\text{dm}^{-3}$ KSCN as supporting electrolyte

Fig. 1 shows a voltammogram of Lu(III) in $1 \text{ mol}\cdot\text{dm}^{-3}$ KSCN as electrolyte which demonstrates a well developed ASV peak with a half wave potential at $-1.55 \pm 0.05 \text{ V}$. The results of other supporting electrolytes mentioned above, are given in Table 1. The dependence of the current maximum on the electrolyte pH, was investigated for KCl and KSCN and given in Fig. 2. It can be seen that the influence of pH of electrolyte on the current maximum of lutetium is much stronger in the case of KCl than in the case of KSCN. Using KSCN, the current maximum of Lu(III) stays approximately constant in the pH interval 3.0 – 4.0.

Table 1. Half wave potentials of Lu^{3+} in various electrolyte solutions

Substance	Electrolyte solution				
	$3 \text{ mol}\cdot\text{dm}^{-3}$ KCl	$1 \text{ mol}\cdot\text{dm}^{-3}$ KSCN	$0.1 \text{ mol}\cdot\text{dm}^{-3}$ $\text{Na}_2\text{-oxalate}$	$0.1 \text{ mol}\cdot\text{dm}^{-3}$ $\text{Na}_2\text{-EDTA}$	$0.5 \text{ mol}\cdot\text{dm}^{-3}$ $\text{Na}_2\text{-tartrate}$
Lu^{3+}	-1.60 cw	-1.55 w	nr	nr	nr

w – very well defined peak; cw – catalytic hydrogen wave; nr – no peak

**Fig. 2.** The influence of electrolyte pH on the current maximum of Lu(III)

Conclusion

The half wave potential of Lu(III) was determined applying the ASV method. The results presented above illustrate that the determination of Lu(III) by ASV is best performed with $1 \text{ mol}\cdot\text{dm}^{-3}$ KSCN as supporting electrolyte. Also, $3 \text{ mol}\cdot\text{dm}^{-3}$ KCl can be applied as electrolyte, but this peak is coupled with catalytic hydrogen wave. The current maximum is influenced by the electrolyte pH and this influence is more pronounced in the case of KCl electrolyte. In the pH interval 3 - 4, which is of interest for our further investigations, the choice of $1 \text{ mol}\cdot\text{dm}^{-3}$ KSCN would be most suitable for the determination of Lu(III).

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