

Indium recovery from secondary sources by electrowinning

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INTRODUCTION

The increasing amount of electronics, such as consumer products and green technologies (e.g. solar PV cells) increases the demand of metals such as indium. Indium is identified as critical raw material [1], but currently not recycled from secondary sources such as flat panel displays (FPDs) and Copper Indium Gallium Selenide (CIGS) photovoltaic modules. Solutions to recover indium would therefore contribute to closing the materials cycle, reducing Europe's dependency on primary resources and thereby contributing to a circular economy.

OBJECTIVE

Purification of indium is done by solvent extraction (SX) resulting in concentrated hydrochloric acid solutions containing indium [2]. Electrowinning of indium from such solutions is feasible using stainless steel as cathode [3-5], the corrosive nature of hydrochloric acid however limits the technical applicability [5]. The objective of this research is to determine the optimal conditions for indium electrowinning from concentrated hydrochloric acid using graphite cathodes.

RESULTS

The electrochemical system is characterised by cyclic voltammetry for 10 g/l indium in 1 M HCl and 6 M HCl (Figure 1). Electrowinning of indium was performed in 1 M HCl and 6 M HCl under potentiostatic conditions at -0.8 V vs. SCE in a divided cell and showed similar current densities (CD) and current efficiencies (CE). Stabilisation of the current was reached within 1 min. in 1 M HCl and 20 min. in 6 M HCl. Electrowinning experiments were conducted in 6 M HCl (used as strip liquor in SX) and loaded strip liquors.

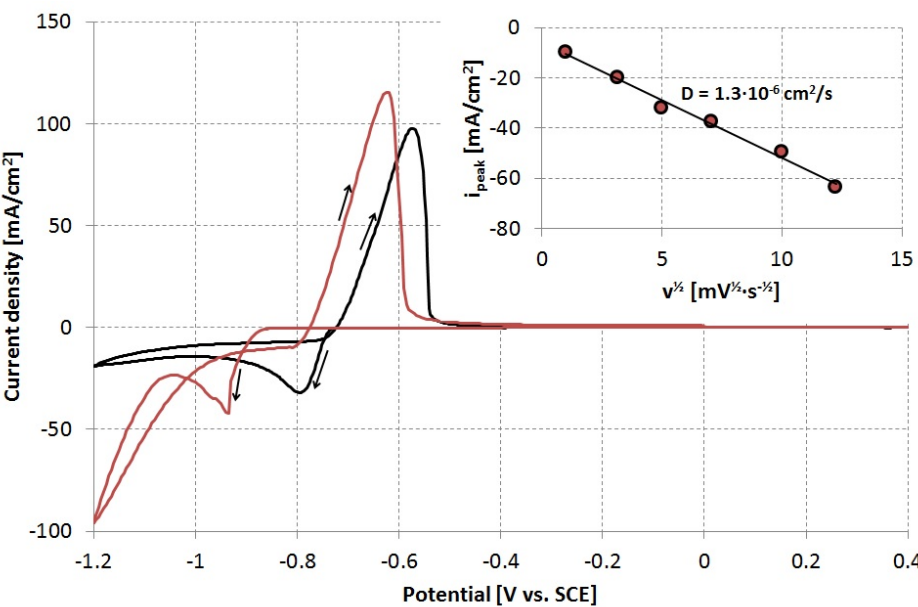


Figure 1: Cyclic voltammograms, obtained at 25 mV/s for 10 g/l indium in 1 M HCl (black line) and 6 M HCl (red line), the insert shows the peak current vs. the square root of the scan rate in 1 M HCl.

Table 1: Conditions and results of electrowinning experiments

Catholyte	Potential [V vs. SCE]	Temp. [°C]	Indium		CD [mA/cm²]	CE [%]
			Initial [g/l]	End [g/l]		
Synthetic	-0.8	20	25.8	7.6	76	84%
Synthetic	-0.8	20	9.8	0.32	41	86%
Synthetic	-0.8	20	4.8	0.13	21	86%
Synthetic	-0.9	20	10.2	0.16	49	91%
Synthetic	-0.8	40	9.3	5.7	47	42%
Strip liquor ¹	-0.8	20	17.3	12.1	25	81%
Strip liquor ²	-0.8	20	8.6	2.0	20	99%
Strip liquor ³	-0.8	20	17.7	13.6	19	93%

¹ obtained after SX of 0.3 g/l indium solution

² obtained after SX of FPD leach solution (pre-treatment A)

³ obtained after SX of FPD leach solution (pre-treatment B)

The results of the electrowinning experiments are shown in Table 1. Electrowinning of indium from concentrated hydrochloric acid was done efficiently in a wide indium concentration range (0.13 - 25.8 g/l). The morphology of the formed deposits appears rough and microporous (Figure 2) and exists of coarse indium particles with a grain size of 50 - 200 µm (Figure 3A). Lowering the potential to -0.9 V vs. SCE resulted in dendritic shaped deposits. Electrowinning at 40 °C exhibited gas formation and as result a lower current efficiency. Large holes in the microporous structure were observed when using the strip liquor of the solvent extraction process (Figure 3B). Similar results were obtained with pre-treatment A of FPD material (Figure 3C), pre-treatment B had a significant influence on the deposit morphology (Figure 3D). The current efficiency remained in all cases high, although at lower current densities.

The purity of the indium deposit obtained from strip liquors is ≥99% (EDX analysis). Arsenic, vanadium and zinc impurities, 3, 7 and 43 mg/l respectively, were not deposited.

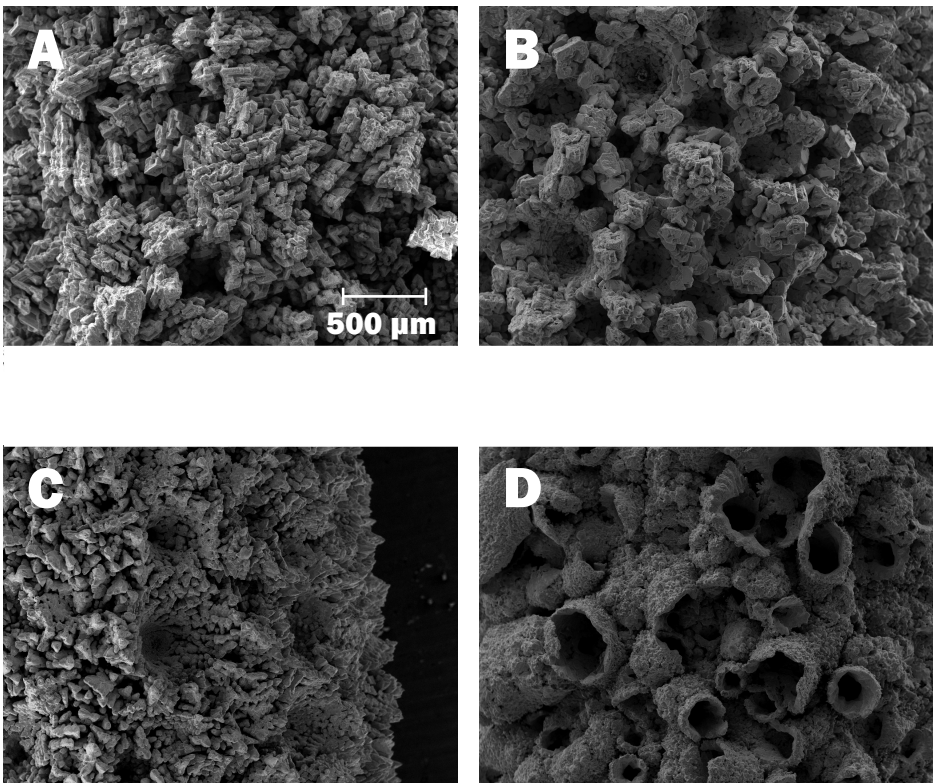


Figure 3: SEM pictures of electrodeposited indium from A: synthetic (10 g/l); B: strip liquor 1; C: strip liquor 2; D: strip liquor 3

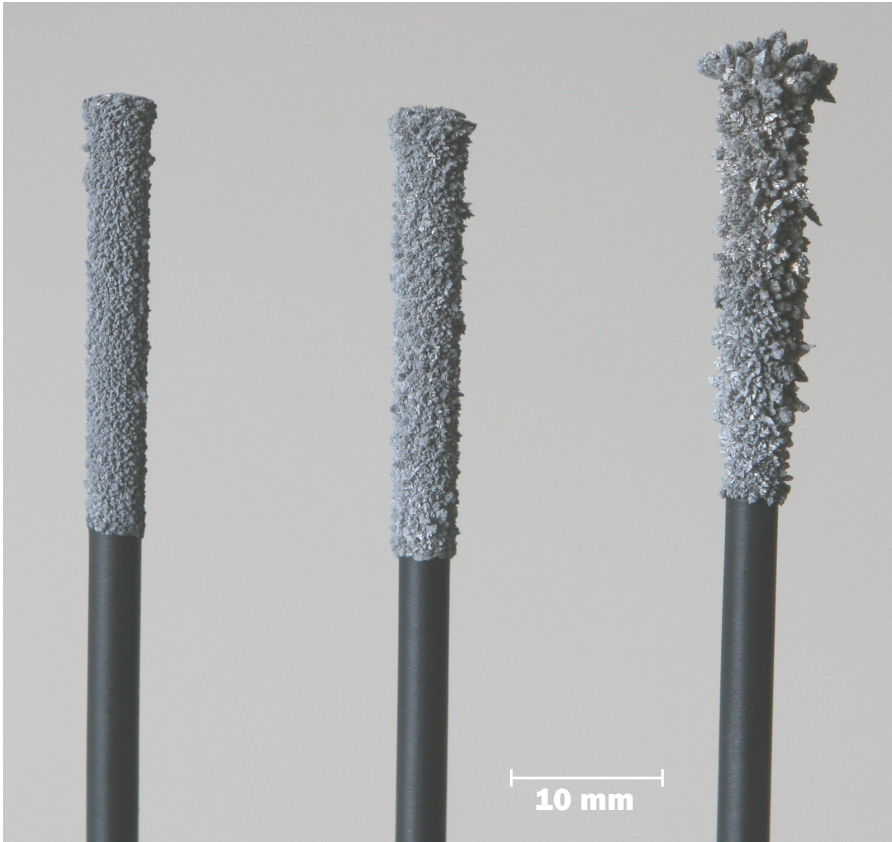


Figure 2: Deposited indium on graphite rods from solutions containing 4.8, 9.8 and 25.8 g/l indium; left, middle and right respectively.

CONCLUSION & OUTLOOK

Electrowinning of indium from concentrated hydrochloric acid solutions can be performed efficiently at -0.8 V vs. SCE at 20 °C. Impurities present in the strip liquor are retained in solution thus obtaining high purity indium.

Demonstration of indium recovery from secondary sources (FPD and CIGS material) on pilot scale, including electrowinning, is planned for 2016.

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