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Cobalt leaching from lithium cobalt oxide in microbial electrolysis cells

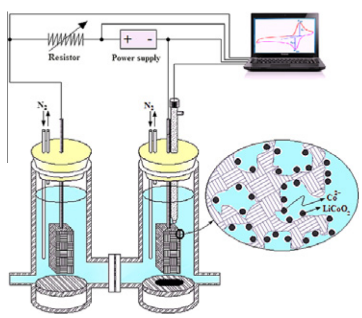
Liping Huang [a,*], Rui Guo [a], Linjie Jiang [a], Xie Quan [a,*], Yuliang Sun [a], Guohua Chen [b]

[a] Key Laboratory of Industrial Ecology and Environmental Engineering, Ministry of Education (MOE), School of Environmental Science and Technology, Dalian University of Technology, Dalian 116024, China
[b] Department of Chemical and Biomolecular Engineering, Kowloon, Hong Kong University of Science and Technology, Hong Kong, China

HIGHLIGHTS

- ▶ Cobalt leaching from particulate $LiCoO_2$ was efficiently achieved in MECs.
- ▶ Higher applied voltage and more acidic pH enhanced cobalt leaching.
- ▶ A synergetic interaction in MECs was observed, leading to more rapid cobalt leaching.
- ▶ The E_a of 16.6 kJ/mol obtained in MECs was much lower than the series of controls.

GRAPHICAL ABSTRACT



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ABSTRACT

More energy-efficient and cost-effective methods for cobalt leaching from wastes are attracting increased interest due to the limited resource and the requirement of sustainable society. Two chamber microbial electrolysis cells (MECs) were examined here for the effectiveness and energy efficiency for cobalt leaching from particulate lithium cobalt oxide, one main cathodic component in spent Li-ion batteries. Cobalt leaching of 57.0 ± 0.7% and energy efficiency of 134.0 ± 5.6% were achieved at an applied voltage of 0.2 V and pH 2.0. Higher applied voltage (0.4–1.0 V) and more acidic pH (1.0) enhanced cobalt leaching, but decreased energy efficiency. A synergetic interaction in MECs was observed, leading to more rapid cobalt leaching at a rate 1.9–16.8 times the sum of rates by conventional chemical processes and no-acid MEC controls. While solution conductivity and temperature were positively correlated with cobalt leaching, both a high solution conductivity of 17.6 mS/cm and temperature 35 °C led to lower energy efficiencies. The apparent activation energy (E_a) obtained in MECs was 16.6 kJ/mol, much lower than 30.8–54.6 kJ/mol in controls of electrolysis cells with membrane (ECs + membrane), electrolysis cells (ECs), open circuit conditions (OCCs), and no-acid MECs. These results show that cobalt leaching using MECs may be a promising process for cobalt recovery and recycle of spent Li-ion batteries, and the evidence of influence factors including applied voltage, solution conductivity, pH, and temperature can contribute to improving understanding of and optimizing cobalt leaching in MECs.

1. Introduction

The increased future valuable metals demand, together with the decline of valuable metal resources gives an impetus for increased metal recovery from wastes such as fly ash, sewage sludge, spent batteries and electronic scrap materials, as well as the hydroprocessing catalysts [1]. $LiCoO_2$ is extensively used as the cathode material for Li-ion batteries and cobalt recovered from $LiCoO_2$ thus becomes attractive due to the annual increase of spent batteries in astonishing quantities [1]. Moreover, the higher contents of 5–15% cobalt in these batteries than those found in natural ores or even concentrated natural ores makes recovery of this metal from spent

* Corresponding authors. Tel./fax: +86 411 84708546 (L. Huang), +86 411 84706140 (X. Quan).
E-mail addresses: lphuang2008@gmail.com (L. Huang), quanxie@dlut.edu.cn (X. Quan).

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