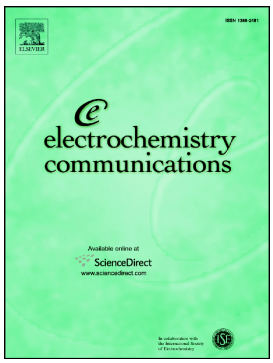

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New formulation for reduction potentials of (Cu, Ni, Al, Zn)–lanthanide alloys – implications for electrolysis-based pyroprocessing of spent nuclear fuel

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Abstract

In this work, the electrochemical behavior of lanthanides (except promethium) on several active cathodes in LiCl–KCl molten salts was investigated. We have discovered that the reduction potentials of lanthanide alloys present a "bimodal effect". A numerical model was established based on the result of multiple linear regression analyses, which indicates that the reduction potentials are correlated with differences in atomic radii and differences in electronegativity. Employing the fitted formulae, which provide a preliminary model of the behavior of these elements in electrolysis-based pyroprocessing, the electrochemistry of both lanthanides and actinides on active metal cathodes could be reasonably estimated.

Keywords: Bimodal Effect; reduction potential; atomic radius difference; electronegativity difference; Hume-Rothery rules

1. Introduction

With the depletion of fossil energy sources and the rising concern about environmental issues, the adoption of alternative clean forms of energy has become a matter of global concern [1, 2]. Nuclear energy, due to its economy and efficiency, is expected to be able to meet human consumption requirements without the carbon emissions produced by burning of fossil fuels [3]. To achieve a closed nuclear fuel cycle and sustainable development of nuclear energy, efficient pyroprocessing of spent fuel becomes a core concern in Generation IV nuclear energy [4]. As a typical neutron poison, lanthanides are detrimental elements in the partitioning and transmutation (P&T) strategy and thus have to be separated from actinides. Molten-salt-based electrolysis is proposed as a possible method for achieving this separation in future pyroprocessing technology [5].