



HAL
open science

Electrochemical Regeneration of LiAlH₄

Elijah Eric Ugaddan, Parviz Hajiyev, Thibault Charpentier, Umit Bilge Demirci

► **To cite this version:**

Elijah Eric Ugaddan, Parviz Hajiyev, Thibault Charpentier, Umit Bilge Demirci. Electrochemical Regeneration of LiAlH₄. Metal-Hydrogen Systems 2024, May 2024, Saint-Malo, France. 2024. hal-04566815

HAL Id: hal-04566815

<https://hal.science/hal-04566815>

Submitted on 2 May 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License

Electrochemical Regeneration of LiAlH₄

E. Ugaddan^{1,3,*}, P. Hajjiev¹, T. Charpentier² and U. Demirci³

¹LITEN, CEA, Grenoble Alpes University, 38000 Grenoble, France

²NIMBE, CEA, University of Paris-Saclay, 91191, Gif-sur-Yvette, France

³IEM, CNRS, University of Montpellier, 34090, Montpellier, France

*elijah-eric.ugaddan@cea.fr

Hydrogen, a promising clean energy vector, surpasses traditional fuels in energy content (140 MJ/kg) but faces storage challenges. Aluminum-based complex metal hydrides like LiAlH₄ offer solutions with high volumetric (>80g H₂/L) and gravimetric (>8 wt %) energy densities, along with low decomposition temperatures (<423 K). However, their synthesis involves costly organometallic reactions and high hydrogenation pressures (>1 kbar). Consequently, a significant interest is in cost-effective approaches for regenerating LiAlH₄ from its spent (hydrogen-depleted) material and H₂.

Graetz^[1] proposed its first chemical regeneration, examining dehydrogenated LiH and Al with a Ti catalyst in THF under high H₂ pressure (50 bar). Humphries^[2] explored sub-ambient regeneration (<0°C) using Me₂O and 95 bar H₂. However, their practicality is hindered by reliance on high H₂ pressure. Our research group investigates the viability of an electrochemical approach for its regeneration and potential elimination on the use of high H₂ pressure, a novel concept not previously reported in the literature..

Electrochemical properties were studied in THF-based electrolyte and Ar atmosphere at RT. Figure 1 shows a cyclic voltammogram of 1M LiAlH₄ in THF to which we identified essential reactions, including Li and Al deposition, and irreversible anodic polarization of [AlH₄⁻] associated with H₂ release^[3]. Applying a constant reduction potential (-3.10 V vs. standard hydrogen electrode) resulted in dehydrogenated LiAlH₄ (Li-Al alloy formation) and H₂ release, demonstrating room-temperature electrochemical dehydrogenation with a Faradaic efficiency of 69%. We explore the effect of H₂ pressure on these electrochemical reactions using our custom electrochemical pressure cell. The next step involves regenerating the deposited Li-Al alloy under moderate H₂ pressures (<10 bar) and applying oxidative potentials to induce [AlH₄⁻] reformation using Pd, Pt, Ti, or Ni electrocatalysts. Reformed LiAlH₄ is quantified using ²⁷Al NMR coupled with ICP-MS. Fundamental parameters will be investigated, including its kinetics, diffusion coefficients, and regeneration mechanisms, using various electroanalytical techniques like chronoamperometry, voltammetry, rotating disk electrode, and electrochemical-impedance spectroscopy.

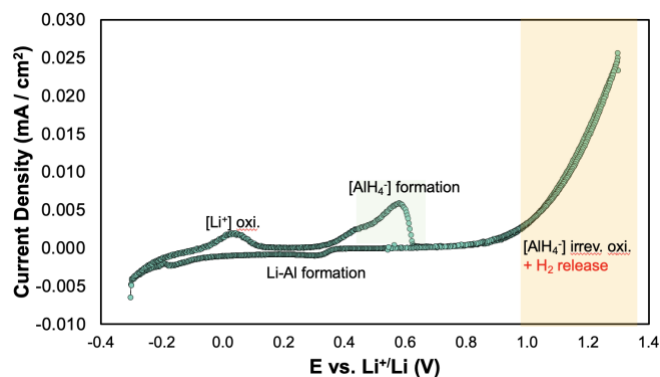


Figure 1. CV of a 1M LiAlH₄ – THF solution under 7 bar of Ar with a scan rate of 20 mV/s.

References

[1] J. Graetz, J. Wegrzyn, J. Reilly, J. American Chemical Society, 130.52 (2008): 17790-17794

[2] T. Humphries, D. Birkmire, S. McGrady, B. Hauback, C. Jensen, J. Alloys and Compds, 723 (2017): 1150-1154

[3] H. Senoh, T. Kiyobayashi, N. Kuriyama, K. Tatsumi, J. Power Sources, 164.1 (2007): 94-99