

aluminum plating/stripping in non-corrosive Al(OTf)₃-based electrolyte

Mahla Talari^a, Angelina Sarapulova^{a,b,c}, Eugen

Zemlyanushin^a, Noha Sabi^{a,d},

Andreas Hofmann^a, Sonia Dsoke^{a,b,c}

^a Institute for Applied Materials (IAM), Karlsruhe Institute of Technology (KIT), Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen, Germany
^b Albert-Ludwigs-Universität Freiburg, Department of Sustainable Systems Engineering (INATECH), Emmy-Noether-Straße 279110, Freiburg, Germany
^c Fraunhofer Institute for Solar Energy Systems, Dep. Electrical Energy Storage, Heidenhofstr. 2, 79110 Freiburg, Germany
^d High Throughput Multidisciplinary Research (HTMR), Mohammed VI Polytechnic University, Lot 660 Hay Moulay Rachid, Ben Guerir, 43150, Morocco

Introduction

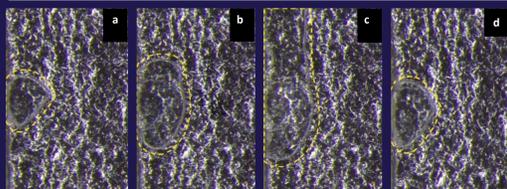
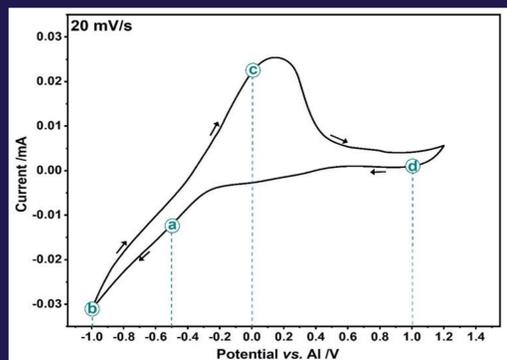
Aluminum (Al) batteries are promising candidates due to the abundance and high volumetric capacity[1]. While Chloroaluminate-based electrolytes enable reversible plating/stripping of Al, their corrosivity is a drawback[1]. Addressing this, an alternative electrolyte was proposed, consisting of aluminum trifluoromethanesulfonate Al(OTf)₃, N-methylacetamide (NMA), and urea [2]. The physicochemical properties and dissolution/dissociation mechanism of Al(OTf)₃ are well established [2,3].

Motivation and Strategy

Al plating from Al(OTf)₃/NMA/urea electrolyte is not proved yet. Answering the research question **“is the presence of AlCl₃ fundamental for Aluminum plating/stripping?”**

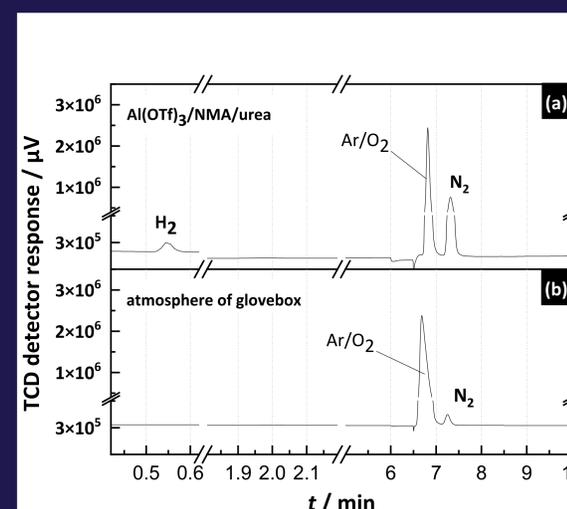
Bibliography

- [1] H. Yang et al., Angew.Chem. Int. Ed., 11978-11996, 2019.
 [2] T. Mandai, P. Johansson, J Mater Chem A., 12230-12239, 2015.
 [3] W. Peters et al., Phys Chem., 21923-21933, 2021.

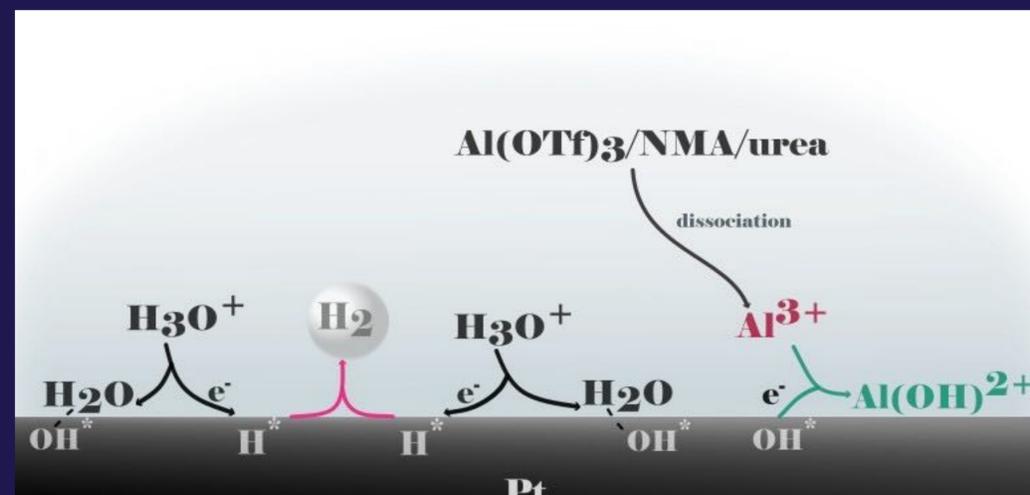


The Optical microscopy images of the Pt electrode in the electrolyte during CV measurement a) -0.5 V vs. Al b) -1 V vs. Al c) 0 V vs. Al d) 1 V vs. Al.

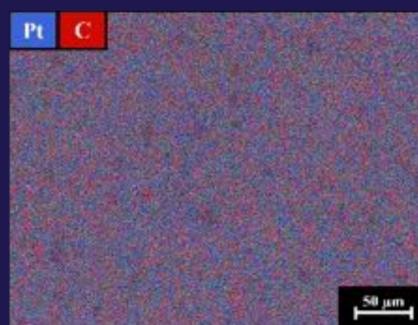
➤ Formation of hydrogen and nitrogen gas



(a) GC spectrum of the collected gas after polarization of the Pt working electrode at -1 V vs. Al for 30 min in the electrolyte. (b) GC spectrum of the collected gas from the atmosphere of the glovebox

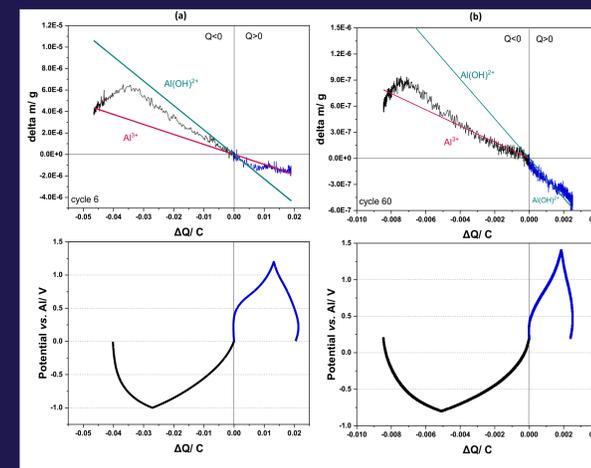


Mechanism of Surface Reactions on the Pt in Al(OTf)₃/NMA/urea (0.05/0.76/0.19 in mole ratio) electrolyte



The Pt electrode polarized at -1 V vs. Al for 2 hours

- Plated Al cannot be detected
 ➤ Adsorption of Al(OH)₂⁺ and Al³⁺



Electrode mass change vs. charge and potential vs. charge for CV measurement on Pt-coated quartz crystal in the electrolyte for cycles (a) 6th (b) 60th.

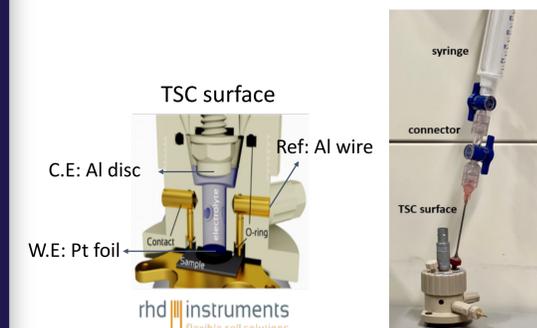
Electrochemical cell setup



C.E: Al foil
 Ref: Al foil
 W.E: Pt foil

EL-CELL
 electrochemical test equipment

Operando Optical microscopy Cell



Gas Chromatography Cell



C.E: Al wire
 Ref: Al wire
 W.E: Pt coated quartz crystal

Electrochemical Quartz Crystal Microbalance (EQCM) Cell

Electrolyte:
 Al(OTf)₃/NMA/urea=0.05/0.76/0.19 (mole ratio)

Conclusions

Al was not plated from the electrolyte and the reductive/oxidative currents are correlated to hydrogen evolution reaction. A mixed ion adsorption/desorption of Al(OH)₂⁺ and Al³⁺ hindered successful Al plating and stripping, as SEM analysis did not confirm the electrodeposition of Al from this electrolyte.

Acknowledgment

This work, contributes to the research performed at CELEST (Center for Electrochemical Energy Storage Ulm-Karlsruhe) and was funded by the German Research Foundation (DFG) under Project ID 390874152 (POLIS Cluster of Excellence).



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