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جامعة الملك عبد الله
للعلوم والتقنية
King Abdullah University of
Science and Technology

Charge-Storage Mechanism of Aluminum-Sulfur Batteries

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Primary energy consumption; world

Investment in renewable energy, world

Sustainability

Electric vehicles

Renewable energy

Energy storage

Introduction

1. Passivating surface

2. Cathode

- Reversible and stable reaction with Al^{3+} ions
- High and stable energy density
- Abundant

3. Electrolyte

- Removes/modifies Al passivating layer
- Efficient Al electrodeposition with Al^{3+} ions
- Large and stable electrochemical window
- No side reactions

State of the game

$AlCl_3$: $[EMIM]Cl$ Electrolyte

For molar ratio greater than unity

Al electrodeposition

Aluminum-sulfur battery

Al-S operation

- Energy density of **1371 Wh kg⁻¹** and 2742 Wh L⁻¹
- **Conversion** reaction for charge storage

$$\text{Capacity} = \frac{nF}{M} = \mathbf{1071 \text{ mAh g}^{-1}}$$

ICP-OES

Elements	As-received	Purified
Co	0.7 wt%	0.1 wt%
Mo	4 wt%	0.7 wt%

	Carbonaceous component	Metal impurities*
Ref. 1	Carbon black	N/A
Ref. 2	Activated carbon cloth	N/A
Ref. 3	Carbon nanofibers, SWCNT	<15 % Fe
This work	Carbon black, SWCNT	<0.8 % Co, Mo

* These are metal impurities present in the carbonaceous materials used in the cathodes

1. J. Maultzsch, H. Telg, S. Reich and C. Thomsen, *Physical Review B*, 2005, **72**, 205438.
2. G. Cohn, L. Ma and L. A. Archer, *Journal of Power Sources*, 2015, **283**, 416-422.
3. T. Gao, X. Li, X. Wang, J. Hu, F. Han, X. Fan, L. Suo, A. J. Pearse, S. B. Lee, G. W. Rubloff, K. J. Gaskell, M. Noked and C. Wang, *Angewandte Chemie International Edition*, 2016, **55**, 9898-9901.

Electrochemical impedance

Post mortem analysis

- Carbon additives can improve the cycling stability of an Al-S battery
- Capacity fade cannot be fully reversed
- Buildup of insoluble and poorly conductive discharge products, consequence of electrolyte-sulfur interaction
- New electrolytes are needed for future Al-S batteries

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- KAUST

- KAUST Core Labs

- Laboratory for Carbon Nanostructures

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