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Selective Polymeric Separators for Alkaline Zn/MnO_2 Batteries

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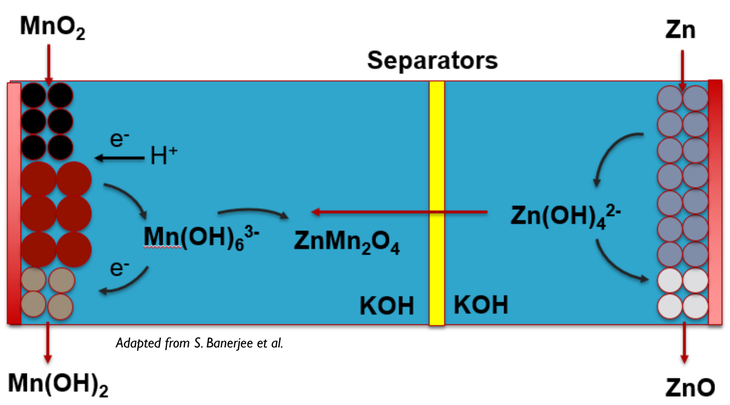
Background and Objectives



Cathode Failure Mechanisms:

- Formation of irreversible Mn_3O_4.
- Formation of irreversible $ZnMn_2O_4$.
- Passivation from an insulating ZnO layer.

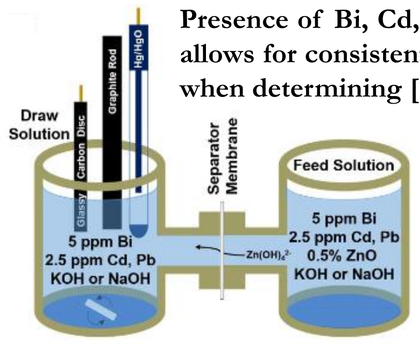
Caused by $Zn(OH)_4^{2-}$ crossover

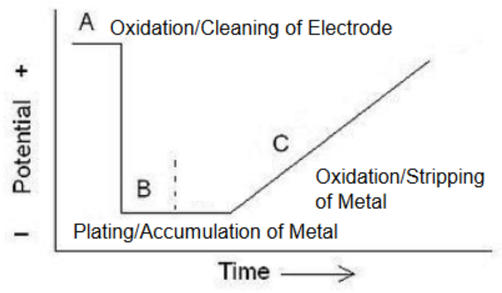
Objectives:

- Prepare polymeric separators selective for blocking zincate, while allowing for crossover of hydroxide
- Cast membranes with thicknesses similar to those of commercial separators and characterize selective properties relevant to application in alkaline batteries
- Implement into prototype cells and demonstrate an improvement in battery performance

Zinc Diffusion Analysis

Presence of Bi, Cd, and Pb allows for consistent results when determining [Zn]





A. J. Bard, L. R. Faulkner, Electrochemical Methods, (2001) 458–466.

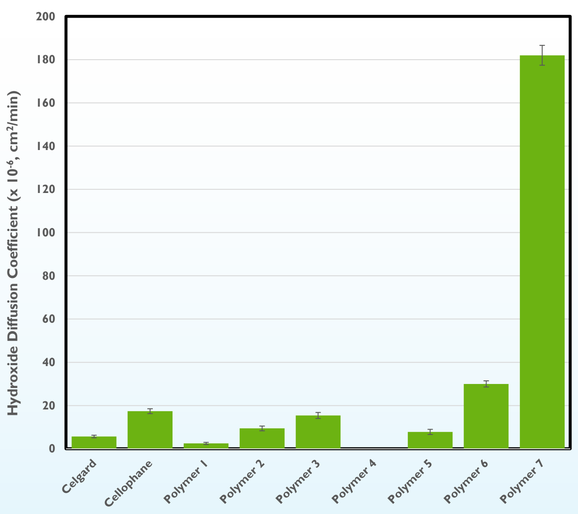
Anodic stripping voltammetry (ASV) allows for much faster screening of separators compared to ICP-MS, with similar limits of detection.

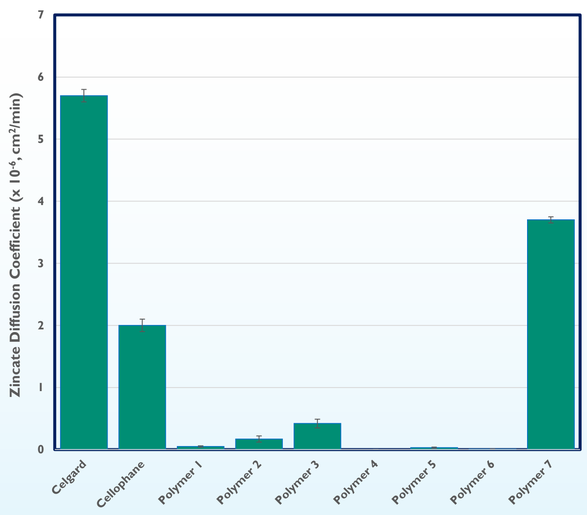
ASV Analysis of Zn performed for the first time in alkaline conditions.

J. Duay, T.N. Lambert, R. Aidun, *Electroanalysis,* 29 (2017) 1-8.

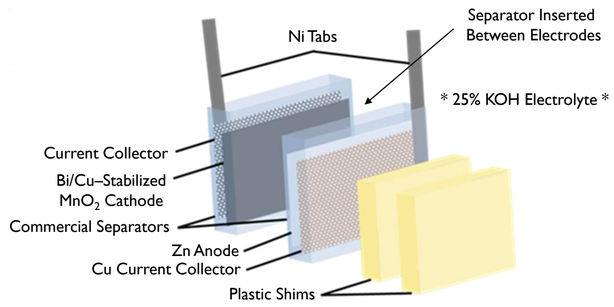
Polymeric Separators

Separator	Hydroxide Diffusion (cm^2/min) *10^{-6}	Zincate Diffusion (cm^2/min) *10^{-6}	Selectivity	Water Uptake (%)	Thickness (µm)	Conductivity (mS/cm)
Celgard 3501	6.74	5.7	1.18	68	25	12.2
Cellophane 350P00	17.4	2.0	8.70	96	25	13.8
Polymer 1	2.48	0.049	50.6	11	30	5.83
Polymer 2	9.43	0.17	55.5	17	30	7.19
Polymer 3	15.4	0.42	36.7	47	30	8.79
Polymer 4	0 (No Crossover)	–	–	5	69	4.7
Polymer 5	7.79	0.030	257	–	25	–
Polymer 6	30	0.074	405	33	44	12
Polymer 7	182	3.7	49	72	36	39





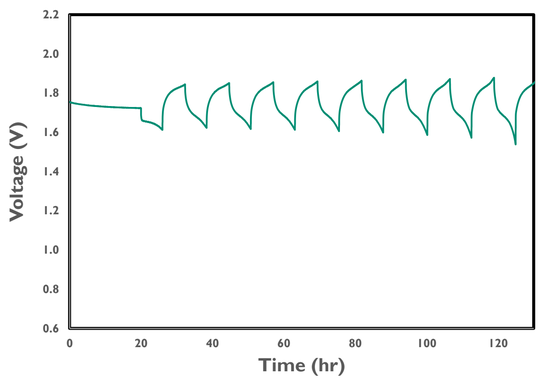
Battery Assembly and Cycling

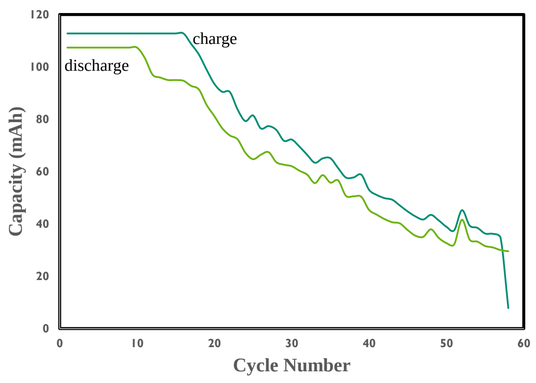


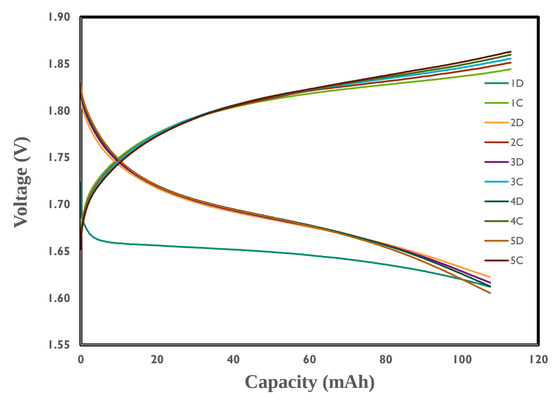
Adapted from Journal of Power Sources, 395 (**2018**) 430-438

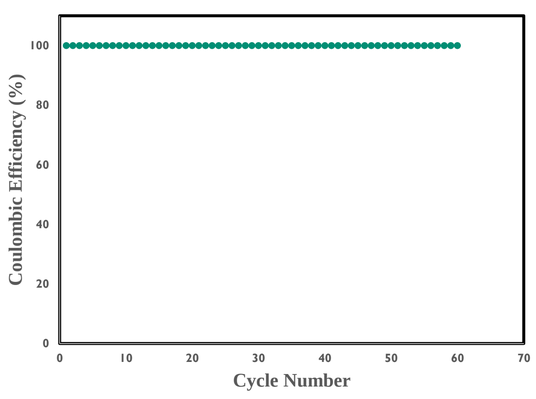
Control cells are assembled by wrapping both the anode and cathode in 3 layers of Cellophane, while the cells containing Polymer 6 are assembled by wrapping only the anode in 3 layers of Cellophane, inserting Polymer 6 between the electrodes (as shown to the left) and using the cathode as received from CUNY-EI, with no additional wrapping.

Polymer 6: C/20 Cycling; 30% Zn DOD Cycling; 0.8 V – 1.95 V; no V hold









Conclusions and Research Output

- Prepared flexible polymeric membranes that limit zincate crossover, while maintaining hydroxide permeability on par with commercial separators.
- Initial data - Zn–MnO_2 cells with 30% Zn DOD fail early but shows cycling at C/20, rates that are on par with cells using commercial separators.
- Zn-Ni and Zn-MnO_2 cell builds are underway and will be reported in due time.

Publications

- Kolesnichenko, I. V.; Arnot, D. A.; Lim, M. B.; Yadav, G. G.; Nyce, M.; Huang, J.; Banerjee, S. Lambert, T. N. "Zincate-Blocking Functionalized Polysulfone Separators for Secondary Zn-MnO2 Batteries" *ACS Applied Materials and Interfaces*, **2020**, *12*, 50406-50417.

Acknowledgements

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