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Ion Selective Separators for Rechargeable Alkaline Zn/MnO_2 Batteries

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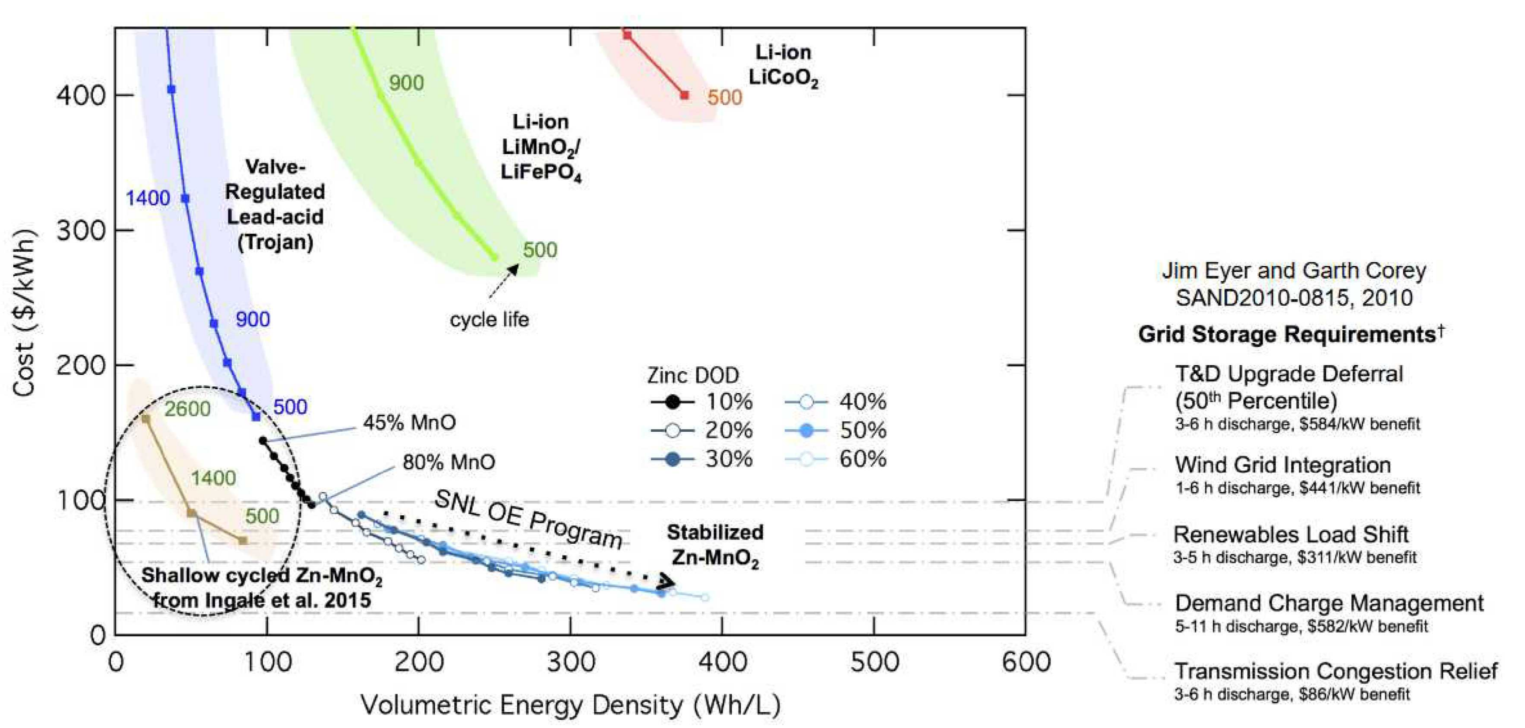
Abstract

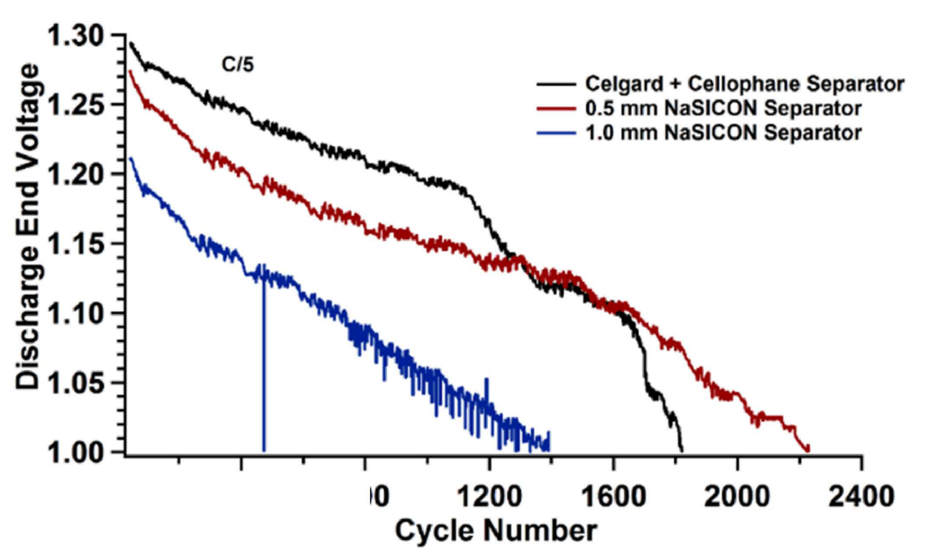
Rechargeable alkaline Zn/MnO_2 batteries are a good candidate for grid-level energy storage due to their low cost, theoretically high energy density, and environmental compatibility. However, performance has been hindered by the formation of electrochemically inactive $ZnMn_2O_4$ phases at the cathode. Previous experimentation from our group showed that a commercial ceramic sodium ion conductor (NaSICON) separator which is impervious to zincate, increased battery cycle life by over 22%. Here, an ion selective polymeric separator which prevents the transport of zincate [$Zn(OH^-)_4^{2-}$] from anode to cathode is presented.

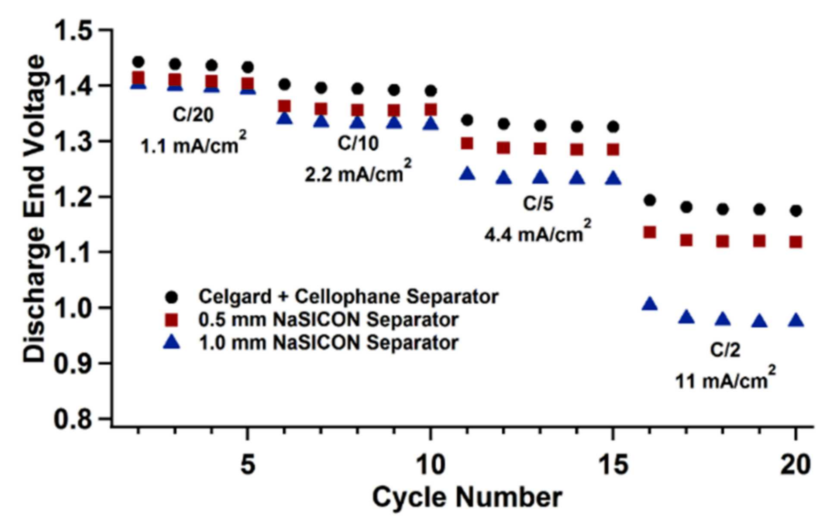
Potential for Zn/MnO_2 Batteries



NaSICON Separator

Discharge end voltage versus cycle number for cells discharged at a C/5 rate at 5% DOD for commercial separators and NaSICON of varying thickness.





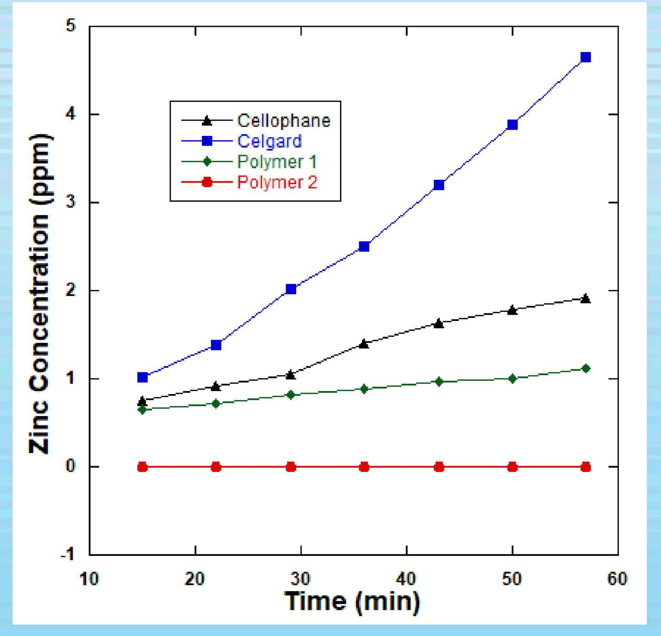
Initial rate testing shows that the resistance of the separator has a more pronounced effect at faster cycling rates.

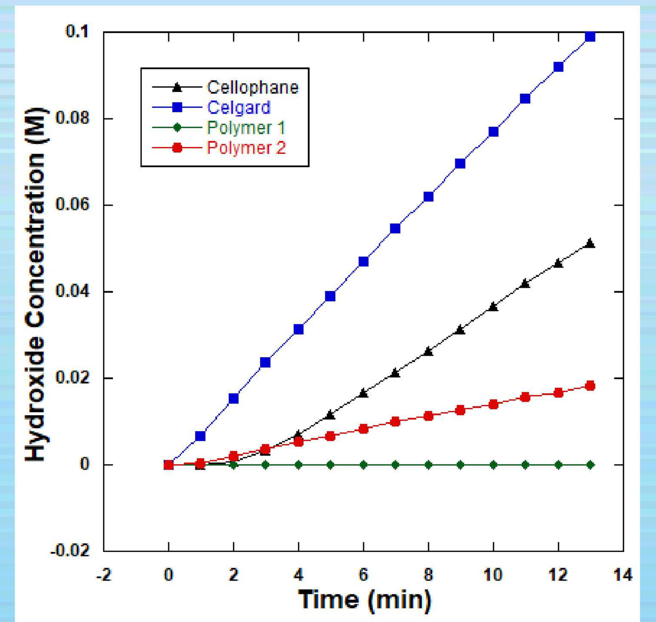
J. Duay, M. Kelly, T.N. Lambert, *J. Power Sources* 395 (2018) 430-438.

Polymeric Separators

	Thickness (mm)	Resistance (Ω)
Celgard 3501	0.025	0.1
Cellophane 350PO O	0.025	0.2
NaSICON	0.5	9.8
Polymer 2	0.025	2.7

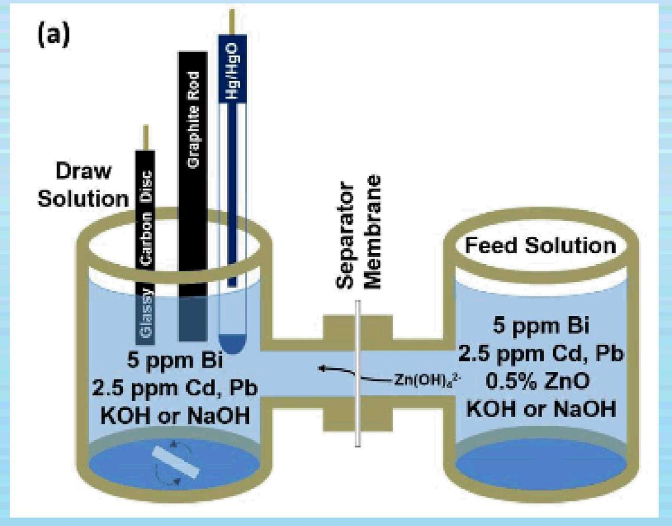
Polymer separators offer lower thickness and less resistance compared to ceramic NaSICON separators.

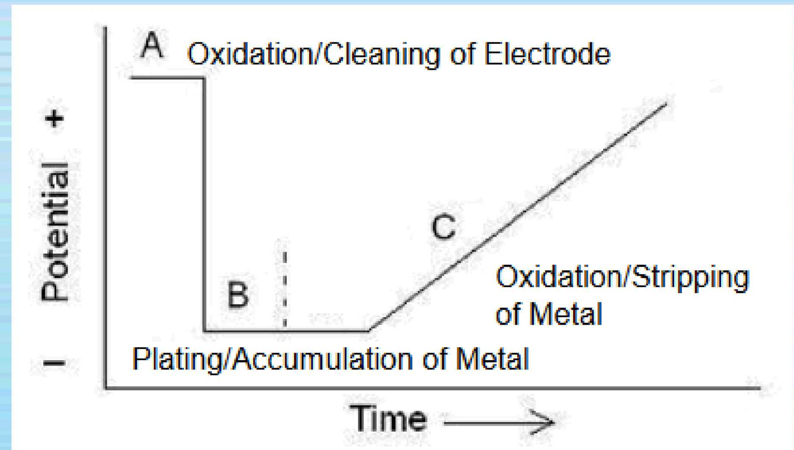




Polymer 2 was chosen to be tested in batteries based on nearly complete zincate blocking after a period of three weeks with only minor effects on hydroxide diffusion rates.

Zinc Diffusion Analysis





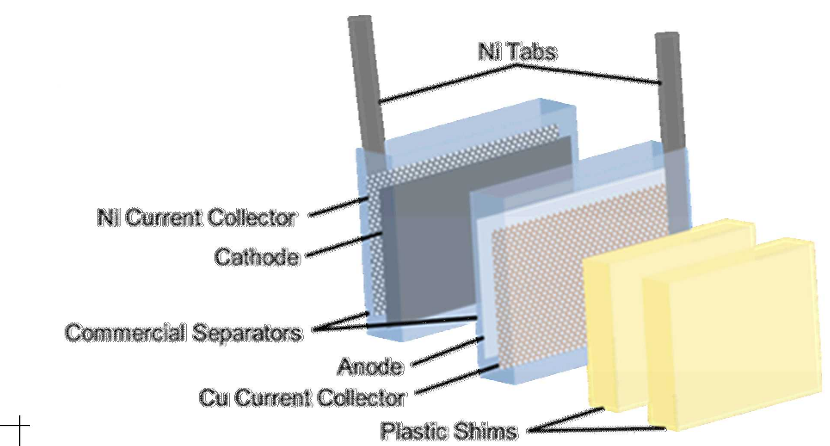
A. J. Bard, L. R. Faulkner, Electrochemical Methods, (2001) 458–466.

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

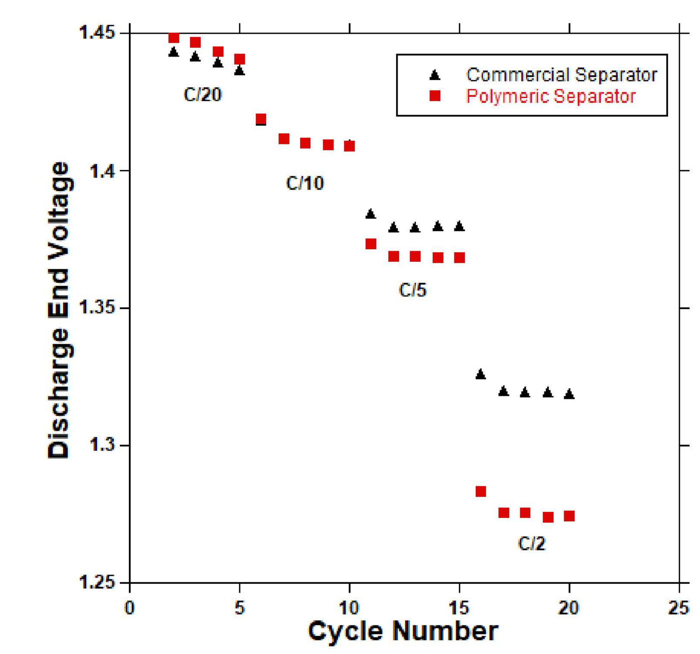
J. Duay, T.N. Lambert, R. Aidun, *Electroanalysis* 29 (2017) 1-8.

Battery Assembly and Testing

Batteries are assembled as shown and placed inside a sealed prismatic polysulfone case.



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



Cells cycled at 5% DOD relative to 1e⁻ MnO_2 discharge and varying rates with commercial and polymeric separators show smaller differences in discharge end voltage than those with ceramic NaSICON separators.

Conclusion

Accelerating the integration of intermittent renewable power sources is an important part of reducing our dependence on carbon-burning sources of energy. Rechargeable Zn/MnO_2 batteries represent an exciting grid-level energy storage solution. In this work, flexible polymeric separators were evaluated and displayed favorable diffusion properties. Zincate diffusion across the separator was slowed down to an immeasurable rate with more moderate effects on conductivity and hydroxide transport. In the future, these polymeric separators will be improved further through new fabrication techniques and decreases in thickness. Lowering the resistance of the separators will allow for higher rates and depths of discharge to be obtained, increasing power output and volumetric energy density.

Acknowledgements

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