Modelling the Influence of Membrane Characteristica on the Performance of Secondary Alkaline Zinc-based Batteries

Noah Lettner[1,2], Felix Schwab[1,2], and Birger Horstmann[1,2,3]

[1]German Aerospace Center (DLR), Wilhelm-Runge-Str. 10, 89081 Ulm, Germany
[2]Helmholtz Institute Ulm (HIU), Helmholtzstr. 11, 89081 Ulm, Germany
[3]Ulm University, Albert-Einstein-Allee 11, 89069 Ulm, Germany

Secondary alkaline zinc-based batteries are promising alternatives to lithium-based batteries for certain applications such as stationary energy storage due to their relatively low cost, resource availabilty and high theoretic specific capacity [1]. However, their development is still facing major challenges, especially in terms of cyclability and shelf life.

Interestingly, the crossover of multivalent ions through the separator has shown to be the main degradation mechanism in relevant zinc-based batteries - namely $Zn(OH)_4^{-2}$ in zinc-manganese oxide cells *(degrading the cathode)* and CO_3^{2-} in zinc-air cells *(lowering the alkalinity)* [2]. Hence, a promising approach for cell optimization is the incorporation of a membrane that reduces the crossover of multivalent ions while maintaining a high ionic conductivity for the functionally relevant exchange of OH^-.

Various membranes (such as AEM, CEM, NF, ...) have been investigated experimentally in zinc-based cells [3], but the mechanisms underlying their effect on cycle-life and performance are often not fully understood. Thus, our research aims to analyze the influence of the transport in membranes on the overall cell performance to identify the optimization parameters for future membrane development. This involves the implementation of various existing membrane models such as DSPM-DE [4] and the low-T* model [5], as well as the development of a thermodynamically consistent, widely applicable membrane model.

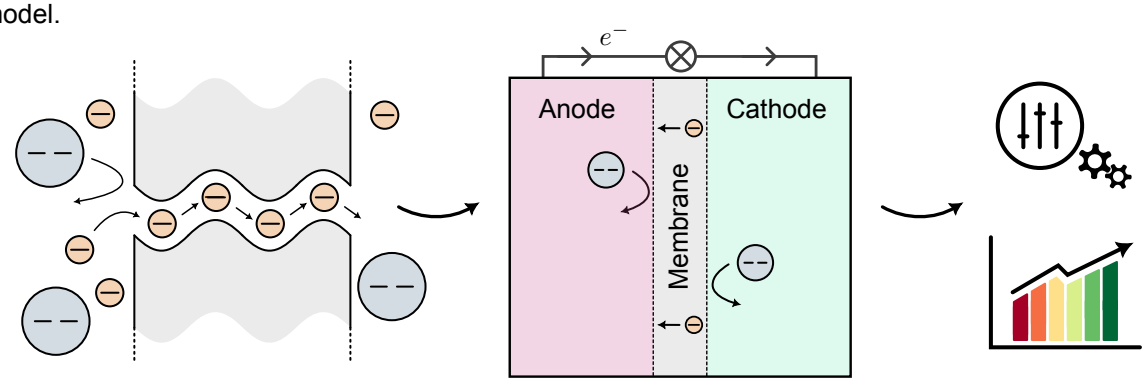

Figure 1: From membrane transport and cell behaviour to the identification of optimization parameters

References

[1] Borchers, N. et al., Innovative zinc-based batteries. *Journal of Power Sources* (2021, Vol. 484), https://doi.org/10.1016/j.jpowsour.2020.229309

[2] Schmitt, T. et al., Zinc electrode shape-change in secondary air batteries: A 2D modeling approach. *Journal of Power Sources* (2019, Vol. 432), https://doi.org/10.1016/j.jpowsour.2019.126649

[3] Tsehaye, M.T. et al., Membranes for zinc-air batteries: Recent progress, challenges and perspectives. *Journal of Power Sources* (2020, Vol. 457), https://doi.org/10.1016/j.jpowsour.2020.228689

[4] Bowen, W.R. et al., Modelling the performance of membrane nanofiltration. *Chemical Engineering Science* (2002, Vol. 57/7), https://doi.org/10.1016/S0009-2509(01)00413-4

[5] Freger, V., Ion partitioning and permeation in charged low-T* membranes. *Advances in Colloid and Interface Science* (2020, Vol. 277), https://doi.org/10.1016/j.cis.2020.102107