Zinc Electrode Shape Change in Alkaline Air Batteries: A Validated 2D Model

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Zinc-air batteries are a promising candidate for stationary energy storage. Zinc metal electrodes are stable in water relying on non-toxic materials and enabling low manufacturing costs. Current experimental research in this field deals with cycle-life limiting effects, such as anode shape change and electrolyte passivation. We contribute to this topic by performing multi-dimensional simulations.

Recently, we developed a theory-based model of aqueous alkaline zinc-air batteries that consistently couples the dynamics of its solid, liquid, and gaseous phases [1,2]. 1D simulations predicted the effects of inhomogeneous zinc oxide nucleation and growth as well as carbonate formation in the electrolyte. We validated the model predictions of discharge voltage and shelf-life.

Here, we present the first multi-dimensional simulations of zinc-air batteries and extend our model by simulating zinc shape change [3,4]. Our 2D simulations of button cells are enabled by local volume-averaging theory [5]. We present a implementation that deals with the numerical instabilities of a multi-component incompressibility-constraint. We validate our model by in-situ tomographies of commercial button cells [3,4]. To this regard, we compare the voltage profile and the phase distribution during discharge. Finally, we discuss various strategies to enhance cycle-life.

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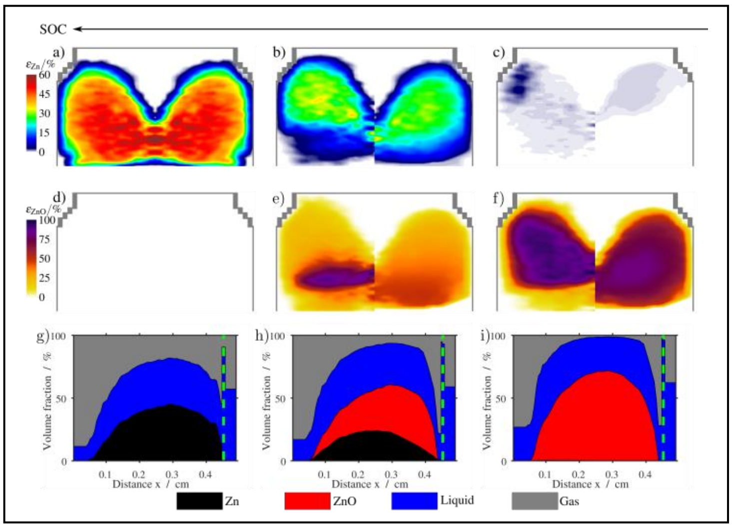

Figure 1: Validation of the zinc and zinc oxide volume fractions during discharge.

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