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Novel Electrolytes for Zinc-Air Batteries

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Abstract:

Zinc-air batteries are promising candidates for next-generation energy storage based on cheap and abundant materials. These batteries are commercialized based on alkaline electrolytes. We show how carbon dioxide absorption of alkaline electrolytes from ambient air limits their lifetime to a few months [1]. Therefore, we study novel electrolytes for zinc batteries, i.e., neutral aqueous solvents and ionic liquids. A long cycle life and homogeneous zinc deposition has been demonstrated for the former [2,3]. Ionic liquids have been shown to minimize dendrite growth [4] and allow cycling of zinc ion batteries [5].

In our previous works, we have developed a consistent modeling methodology for metal-air batteries [1,6]. We describe transport and reactions in the cell along one dimension. In the gas diffusion electrode, it is important to describe convection of electrolyte; in the metal anode, nucleation and growth of the discharge product must be modeled. Inside this macroscopic perspective, we take into account microscopic phenomena, e.g., precipitation and electrochemical reactions [7,8].

In this contribution, we derive consistent equations for ionic transport in ionic liquids and neutral aqueous electrolytes [9]. For ionic liquids, we validate our framework with a zinc / Prussian blue battery [5]. The quasi-crystalline surface structure of ionic liquids is contained in our theory when taking into account the hardcore nature of molecules [10]. For the neutral aqueous $ZnCl_2$-NH_4Cl electrolyte, we find that the distribution of the aqueous zinc-ligand complexes shifts significantly with small changes in concentration. This affects the ionic conductivity and the pH stability. Our model shows that the pH may strongly vary locally and accelerate cell degradation. We design the cell architecture to maintain a stable, neutral pH during cycling.

Key words: zinc-air battery, alkaline aqueous electrolyte, ionic liquids, neutral aqueous electrolyte

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