Improving electrolyte design for Li-air batteries

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Abstract

Multiple directions in battery research are now being pursued in hopes of advancing beyond the specific energy limits imposed by conventional Li-ion electrode materials. For example, 'beyond Li-ion' battery chemistries, such as Li-O_2, Li-S, and Mg-ion, are currently being explored as potential successors to Li-ion batteries given their very high theoretical specific energies; yet severe technical challenges have prohibited them from becoming a practical reality. The objective of this presentation is to provide an assessment of such challenges, in particular, instabilities of the electrolyte, and Li_2O_2 electronic conductivity limitations, facing the nonaqueous Li-O_2 battery cathode. Results will be presented on the characterization of the Li_2O_2 formation mechanism and how the mechanism can be manipulated through electrolyte engineering to potentially alleviate problems associated with Li_2O_2 deposition on the cathode.

We report on our recent results that appropriately selecting the salt anion in the electrolyte solution can circumvent passivation related to Li_2O_2 deposition, resulting in a fourfold increase in Li-O_2 cell capacity without adversely affecting electrochemical stability. This improvement is a result of enhanced Li^+ stability in solution imparted by anions with high Lewis basicity. Enhanced Li^+ stability in solution induces solubility of the lithium superoxide (LiO_2) intermediate to Li_2O_2 formation, leading to Li_2O_2 formation in aggregated toroid structures, leaving carbon sites open for further reaction. Our anion selection was confirmed to have no effect on electrochemical stability via differential electrochemical mass spectrometry and Li_2O_2 titrations. This anion selection strategy could be useful in any electrochemical system where adjusting intermediate stability in solution could induce desired mechanisms of product formation, and it corroborates the development of a molten salt electrolyte of entirely $LiNO_3$ and KNO_3 toward high Li_2O_2 solubility and the absence of organic solvent decomposition.

Biography

Bryan D. McCloskey holds a joint appointment as an Assistant Professor in the Department of Chemical and Biomolecular Engineering at the University of California, Berkeley, and as a Faculty Scientist in the Energy Storage and Distributed Resources Division at Lawrence Berkeley National Laboratory. His laboratory focuses on characterization of fundamental electrochemical processes to provide guidance for the development of energy storage, electrocatalytic, and corrosion-resistant materials. Before joining UC/LBNL in Jan. 2014, he was a Research Staff Member at IBM Almaden Research Center, where he worked to elucidate fundamental aspects of nonaqueous Li-O_2 electrochemistry.