Aluminum Chloride–Natural Graphite Battery and its Energy Density

K. V. Kravchyk[1,2], S. Wang[1,2], L. Piveteau[1,2], F. Krumeich[1,2], M. V. Kovalenko[1,2]*

[1]Institute of Inorganic Chemistry, Department of Chemistry and Applied Biosciences, ETH Zürich, CH-8093 Zürich, Switzerland, [2]Empa – Swiss Federal Laboratories for Materials Science and Technology, CH-8060, Dübendorf, Switzerland

Non-aqueous, ionic liquid-based aluminum chloride-graphite batteries emerge as a highly promising post-Li-ion technology for low-cost and large-scale storage of electricity, because it features exclusively highly abundant chemical elements and simple fabrication methods. In this work, we examined the recently proposed aluminum–ionic liquid–graphite architecture.[1] Although previous studies have focused on graphitic cathodes, we analyzed the practicality of achievable energy densities and found that the $AlCl_3$-based ionic liquid is a capacity-limiting anode material. By focusing on both the graphitic cathode and the $AlCl_3$-based anode, we improved the overall energy density.[3,4] First, high cathodic capacities of ≤150 mAh g^{-1} and energy efficiencies of 90% at high electrode loadings of at least 10 mg cm^{-2} were obtained with highly crystalline natural graphite flakes or with synthetic kish graphite flakes, which were subjected to minimal mechanical processing. Second, the $AlCl_3$ content in the ionic liquid was increased to its maximal value, which essentially doubled the energy density of the battery, resulting in a cell-level energy density of ≤65 Wh kg^{-1}.

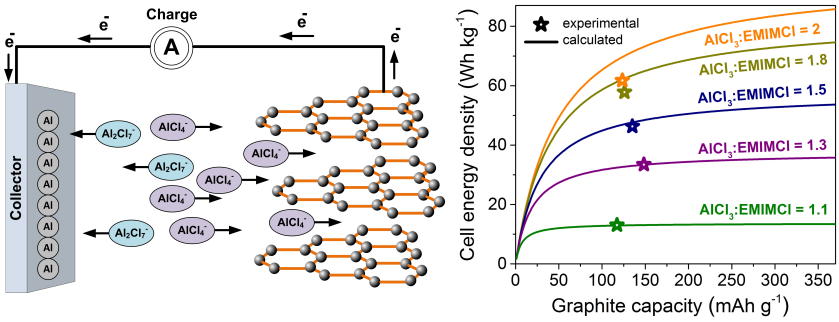

Figure 1. An aluminum chloride-graphite battery. (a) Schematics of the charging process. (b) Comparison of the calculated (curves) and experimental (data points) cell-level energy densities.

[1] Meng-Chang Lin, Ming Gong, Bingan Lu, Yingpeng Wu, Di-Yan Wang, Mingyun Guan, Michael Angell, Changxin Chen, Jiang Yang, Bing-Joe Hwang Hongjie Dai, Nature **2015**, 520, 324-328.
[2] Kostiantyn V. Kravchyk, Shutao Wang, Laura Piveteau and Maksym V. Kovalenko, Chem. Mater. **2017**, DOI: 10.1021/acs.chemmater.7b01060.
[3] Shutao Wang, Kostiantyn V. Kravchyk, Frank Krumeich and Maksym V. Kovalenko. Chem. Mater. **2017**, submitted.