Solid-state lithium sulfur batteries using nanoconfined complex hydrides as solid electrolytes

Das, Supti; Lefevr, Jessica; Ngene, Peter; Jongh, Petra E. de ; Blanchard, Didier

Publication date:
2017

Document Version
Publisher's PDF, also known as Version of record

Materials/Applications Poster Abstract

Solid-state lithium sulfur batteries using nanoconfined complex hydrides as solid electrolytes.

Supti Das[1], Jessica Lefevr[1], Peter Ngene[2], Petra E. de Jongh[2] and Didier Blanchard[1]

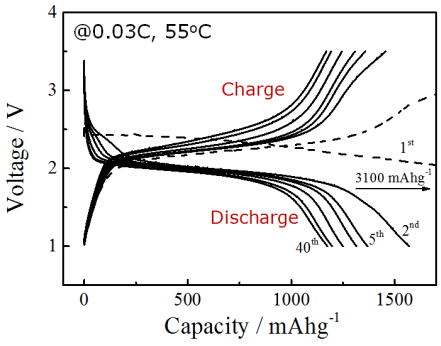
[1] 1Department of Energy Conversion and Storage, Technical University of Denmark, Frederiksborgvej 399, DK-4000 Roskilde, Denmark
[2] Inorganic Chemistry and Catalysis, Debye Institute for Nanomaterials Science, Utrecht University, Universiteitsweg 99, 3584 CG Utrecht, The Netherlands

The development of cost-effective technologies for electricity storage is crucial to achieve carbon-free energy systems, for large market penetration of electrical vehicle and integration of renewable, but intermittent, energy sources into the grid system. For the best technology, i.e. state-of-the-art lithium-ion batteries, limited improvement in capacity and cost are expected because of the use of liquid or gel electrolytes, typically lithium salts dissolved in organic solvents, which limits the choice of electrode materials and exposes to safety concerns.

A solution of choice would be to replace the liquid electrolytes by solid-state electrolyte. However to find a good material with the adequate properties is a challenging task.

During the last years, $LiBH_4$ has been proposed as a solid-state electrolyte. It shows a high ionic conductivity, but only at elevated temperatures. Since then a range of other complex metal hydrides has been reported to show similar characteristics.[1] Strategies have been developed to extend the high ionic conductivity of $LiBH_4$ down to room temperature, e.g. by partial anion substitution[2] and we recently found that if $LiBH_4$ is confined in a mesoporous SiO2 scaffold, the lithium conductivity is multiplied by 1000![3].

We have successfully built and characterized all-solid-state lithium-sulfur batteries based on these solid electrolyte. The batteries show very good performances, delivering high capacities versus sulfur mass, typically 1220 $mAhg^{-1}$ after 40 cycles at moderate temperature (55 ^{o}C), 0.03 C rates and working voltage of 2 V. To date, this is the first report of lithium-sulfur batteries based on complex hydrides solid electrolyte, achieving such high capacities at moderate temperature.[4]



Charge / discharge of a Solid-State Lithium Sulfur battery build around nano-confined $LiBH_4$ in MCM-41 mesoporous silica as solid electrolyte.

References

1. P. E. de Jongh, D. Blanchard, M. Matsuo, T. J. Udovic, S. Orimo, Appl. Phys. A 2016, 122, 251.
2. D. Sveinbjörnsson, J. S. G. Myrdal, D. Blanchard, J. J. Bentzen, T. Hirata, M. B. Mogensen, P. Norby, S.-I. Orimo, T. Vegge, J. Phys. Chem. C 2013, 117, 3249.
3. D. Blanchard, A. Nale, D. Sveinbjörnsson, T. M. Eggenhuisen, M. H. W. Verkuijlen, Suwarno, T. Vegge, A. P. M. Kentgens, P. E. de Jongh, Adv. Funct. Mater. 2015, 25, 184.
4. S. Das, P. Ngene, P. Norby, T. Vegge, P. E. De Jongh, D. Blanchard, J. Electrochem. Soc.2016, 163 (9), 2029.