A semi-liquid catholyte based Li-S system for fast charging energy storage

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Today the need for energy storage is of ever increasing interest, however for some applications the low power density of standard Li-batteries has proven to limit their usefulness. Similarly, several of the next generation battery concepts, such as Lithium Sulphur (LiS) batteries, show a very promising energy density but still suffer from poor rate capabilities. In this work we present a new approach for a battery with very good rate capability and high energy density.

The very high specific capacities reported for LiS-cells are typically achieved at very low rates (C/20-C/10) whereas the capacity rapidly fades approaching even moderate rates such as 1C. We show that fast kinetics can be achieved in LiS-cells based on catholyte concepts, i.e. where the active material is dissolved in the electrolyte and carbon electrodes on the cathode side act as support for the electrochemical reaction.[1] Thanks to the semi-liquid nature of the catholyte system the kinetics of the electrochemical reaction is faster and sustain current rates as high as 40C. The key to stabilize the performance is to limit the voltage of the cell to the region were all reactions take place in the liquid phase, i.e. avoiding the formation of Li_2S and furthermore, to tailor the structure of the carbon support. We achieve the latter by using a self-standing and highly conductive carbon nanofibers electrode, which combines high surface area and short diffusion paths to support fast kinetics. We investigate the electrochemical mechanism of the proposed semi-liquid system by cyclic voltammetry, impedance spectroscopy and constant current cycling. The results are promising even at current rate of 60C, and show exceptional long cycle life compared to traditional systems. The systems here proposed opens new routes for the development of high power energy storage devices.

References:

[1] H.-d. Shin, M. Agostini, I. Belharouak, J. Hassoun, Y.-K. Sun, Carbon 96 (2016) 125–130.