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A long-life, high-rate lithium/sulfur cell

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Among many energy storage devices developed thus far, rechargeable lithium-ion batteries still represent the state-of-the-art technology in the market. However, there is a key challenge which must be overcome; current lithium-ion batteries are not able to meet the ever-increasing demands of advanced technologies[1]. For example, we have to dramatically improve the energy-storage capacity of batteries to increase the driving range of current electric vehicles. It is well known, however, that current oxide-based cathode materials have insufficient capacities to meet these rigorous requirements of rapidly emerging advanced technologies such as electric vehicles.

Recently, lithium/sulfur cells have gained significant attention as alternative power sources for zero-emission vehicles and advanced electronic devices due to the very high theoretical specific capacity (1675 mAh/g) of sulfur cathodes[2-5]. However, the poor cycle life and rate capability of sulfur cathodes have limited the practical application of this attractive technology. For example, for the development of advanced electric vehicles, the cycle life must be improved to more than 500 cycles, preferably up to 1000 cycles. Additionally, more than 2C rate-performance would be favorable to provide peak power of ~600 W/kg.

Here, we report that a lithium/sulfur cell employing a nanostructured sulfur-graphene oxide (S-GO) composite cathode can be cycled at rates as high as 4C with a long cycle life exceeding 1000 cycles. The initial estimated cell-level specific energy (including weight of all cell components except the cell housing) of our cell was over ~500 Wh/kg, which is much higher than energy deliverable by current Li-ion cells (~200 Wh/kg).

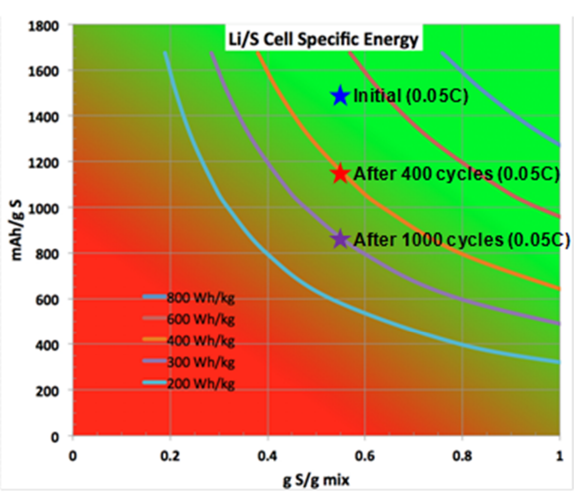

Figure 1. Estimated cell-level specific energy of lithium/sulfur cells employing S-GO nanocomposite cathodes: initial performance and after long-term cycling test.

Even after 1000 cycles, we demonstrated a very high specific capacity ~846 mAh/g of sulfur (which corresponds to ~470 mAh/g of electrode), which is still higher than state-of-the-art Li-ion cells.

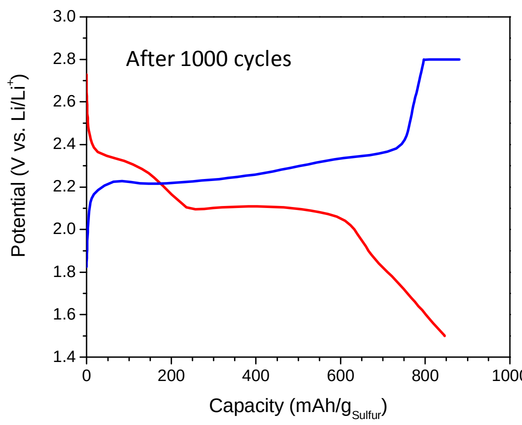

Figure 2. Discharge and charge profile of a lithium/sulfur cell obtained with 0.05C (1C = 1675 mA/g) after long-term cycling test with 1C and 0.5C for discharging and charging, respectively.

The performance we demonstrated herein suggests that lithium/sulfur cells may be already suitable for high-power applications such as power tools. With further improvement of sulfur loading in the electrode and capacity retention, S-GO nanocomposite cathodes may provide a significant opportunity toward the development of zero-emission vehicles with much longer driving range.

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References

1 Song, M.-K., Park, S., Alamgir, F. M., Cho, J. & Liu, M. Nanostructured electrodes for lithium-ion and lithium-air batteries: the latest developments, challenges, and perspectives. *Materials Science and Engineering: R: Reports* **72**, 203-252, (2011).
2 Song, M.-K., Cairns, E. J. & Zhang, Y. Lithium/sulfur batteries with high specific energy: old challenges and new opportunities. *Nanoscale* **5**, 2186-2204 (2013).
3 Bruce, P. G., Freunberger, S. A., Hardwick, L. J. & Tarascon, J.-M. Li-O_2 and Li-S batteries with high energy storage. *Nat. Mater.* **11**, 19-29, (2012).
4 Cai, K., Song, M.-K., Cairns, E. J. & Zhang, Y. Nanostructured Li_2S–C Composites as Cathode Material for High-Energy Lithium/Sulfur Batteries. *Nano Lett.* **12**, 6474-6479, (2012).
5 Ji, L. *et al.* Graphene Oxide as a Sulfur Immobilizer in High Performance Lithium/Sulfur Cells. *J. Am. Chem. Soc.* **133**, 18522-18525, (2011).