Enhanced power and rechargeability of a Li−O_2 battery based on a hierarchical-fibril CNT electrode

Hee-Dae Lim,[†] Kyu-Young Park,[†] Ray H. Baughman,[§] and Kisuk Kang[*,†]
† Department of Materials Science and Engineering, Seoul National University, 1 Gwanak-ro, Gwanak-gu, Seoul 151-742 (Republic of Korea)
§ Alan G. MacDiarmid NanoTech Institute, University of Texas at Dallas, Richardson, TX 75083-0688 (USA)
E-mail: matlgen1@snu.ac.kr

Recently Li-air batteries have been considered to be a promising candidate for EV and HEV applications due to their exceptionally high energy density.[1-3] A key factor for the practical application of Li-air batteries is to solve the poor reversibility of nonconductive discharge products, which remains a significant limiting factor for Li-air batteries. Therefore, the air electrode needs to be designed such that it minimizes the undesirable clogging and promotes the electrochemical reactivity. As the control of the morphology and porosity of the electrode greatly affects on the capacity and rate capability, various nanostructured air electrodes have been reported using carbon nanoparticles, graphene, graphene oxide, or carbon nanotubes (CNTs).[4,5] However, the poor cyclability and low rate capability remain as critical drawbacks of the Li−O_2 batteries, and the ideally designed electrode architecture is still awaited.

We show that a hierarchical porous electrode comprising well-aligned CNTs fibrils can serve as an important model for controlled porosity and demonstrate that they can significantly enhance the cycle stability and rate capability of the Li−O_2 batteries. The controlled porous framework of these woven CNT electrodes enables effective formation/decomposition of lithium peroxide by providing facile accessibility of oxygen to the inner side of the air electrode and preventing the clogging of pores by discharge product, even during the deep discharge. We found that the discharge products were uniformly deposited on the individual CNTs and CNT bundles, so pores are not clogged. This unique feature led to the high cycle life and unprecedentedly high rate performance of the Li−O_2 cell. We believe that the facile controllability of porous morphology using well-aligned CNT fibrils can provide an important tool in identifying an ideally designed air electrode.

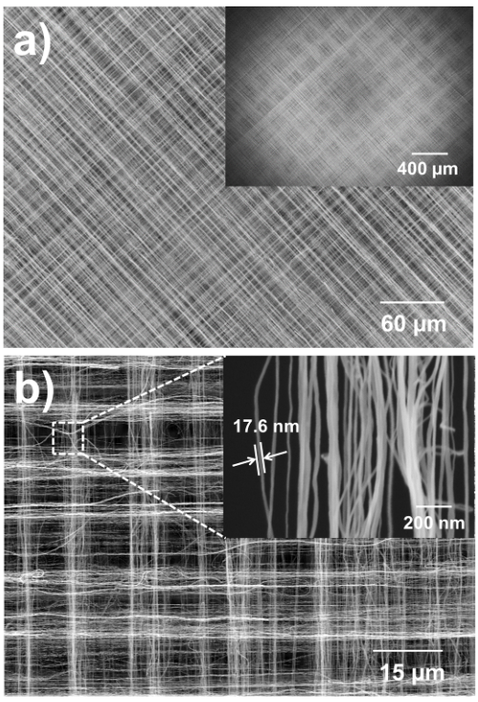

Figure 1. SEM images of the CNT fibril at (a) low magnification (inset: large area image of the air electrode), and (b) high magnification.

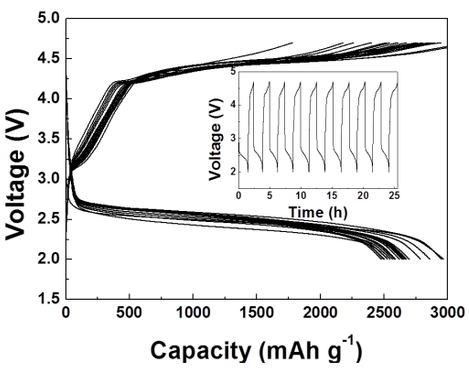

Figure 2. Discharge/charge profiles of the Li−O_2 cells using an air electrode based on a woven CNT for 20 cycles between 2.0 − 4.7 V at a current rate of 2,000 mA g^{-1}.

References

[1] P. G. Bruce, S. A. Freunberger, L. J. Hardwick, J.-M. Tarascon, *Nat. Mater.* **2012**, 11, 19.
[2] A. Débart, A. J. Paterson, J. Bao, P. G. Bruce, *Angew. Chem.* **2008**, *120*, 4597.
[3] H.-D. Lim, K.-Y. Park, H. Gwon, J. Hong, H. Kim, K. Kang, *Chem. Commun.* **2012**, *48*, 8374.
[4] Y. Li, J. Wang, X. Li, D. Geng, R. Li, X. Sun, *Chem. Commun.* **2011**, *47*, 9438.
[5] X. Ren, S. S. Zhang, D. T. Tran, J. Read, *J. Mater. Chem.* **2011**, *21*, 10118.