

CNT Sheet Air Electrode for the development of Lithium-Air Battery Cells with Ultra-High Capacities

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Lithium-Air Battery (LAB) is expected to develop battery cells with extremely high energy density, 5-10 times higher than that of the current lithium-ion battery technology. In the cells, however, solid insulative discharge products are deposited on the cathode (air electrode) surface during discharge, which increasingly clogs the air electrode and suddenly stops the discharge to show much less cell capacities than expected. The development of practically available LAB cells needs new air electrode that can accommodate large volume of the discharge product and hence can demonstrate huge cell capacities.

Conductive porous carbons are traditionally used as air electrode material of LAB. But the air electrode suffers from pore clogging by the discharge product deposit, so far providing areal cell capacity as large as ~ 10 mAh/cm². We employed carbon nanotube (CNT) sheet as air electrode, which successfully developed a huge cell capacities reaching 30 mAh/cm², 15 times higher capacity than the current lithium-ion cells of 2 mAh/cm² [1]. The ultra-high cell capacity was developed by layering GDLs, in which the CNT sheet swelled into GDL uniformly accumulating massive discharge product of lithium peroxide (Li₂O₂). Using thicker GDL (190→370 μ m) extended the ultra-high cell capacity up to 58 mAh/cm² (Fig. 1, gray line), and double layered CNT/GDL composite further increased the capacity up to 86 mAh/cm² (Fig. 1, dotted line).

The cell with the CNT sheet air electrode is fully chargeable keeping the conductive CNT bundle network, but the charging voltage exceeds 4.0V at which severe electrode/electrolyte degradation occurs [1]. The charge overpotential needs to be suppressed to repeat the discharge-charge cycle. Our group recently reported LiNO₃/LiBr in electrolyte decreases charging voltage to ~ 3.5 V at limited cycle capacity [2]. The lithium salts are suggested working as redox mediator that avoid shuttle effect at lithium anode. The salts were also effective for the cells with CNT sheet air electrode, showing charging voltage almost lower than 4.0 V from deeply discharged state of 25 mAh/cm² (Fig. 2). The cycle performance of the cells with ultra-high cell capacity will be discussed.

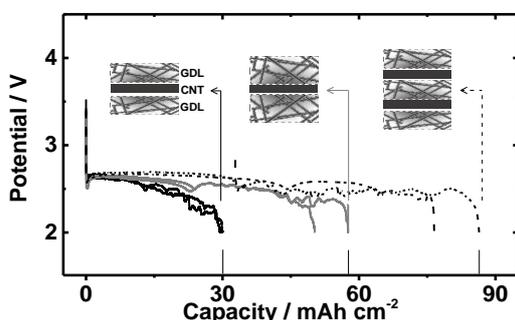


Fig. 1 Discharge profiles of LAB cells with CNT/GDL composite air electrode. Insets show images of the CNT/GDL air electrode configuration for each profile.

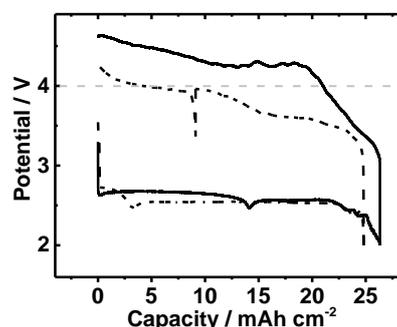


Fig. 2. Discharge-charge profiles of LAB cells with 1 M LiTFSI in TEGDME electrolyte (solid line) and 0.5 M LiTFSI / 0.5 M LiNO₃ / 0.2 M LiBr in TEGDME electrolyte (dotted line).

References:

[1] A. Nomura, K. Ito, Y. Kubo, *Scientific Reports* 7 45596 2017

[2] X. Xin, K. Ito, Y. Kubo *ACS Applied Materials & Interfaces* 9 31, 25976 2017.