Facile synthesis of cubic spinel cobalt oxide/multi-walled carbon nanotube hybrid material as a bifunctional electrocatalyst for metal-air batteries

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Rechargeable metal-air batteries have attracted enormous attention as alternative energy sources owing to their advantages over traditional batteries in aspects of low-cost, environmental benignity and extremely high energy density. Nevertheless, the most critical issue that hampers large-scale implementations of metal-air batteries is the sluggish kinetics of oxygen evolution and reduction reactions occurring during charge and discharge of a metal-air battery. Aiming to overcome this, scientists have devoted considerable efforts for developing low-cost and efficient bifunctional electrocatalysts that are capable of catalyzing both oxygen reduction reactions (ORRs) and oxygen evolution reactions (OERs). Currently, to reach satisfactory performance, precious metal-based bifunctional materials such as Pt-IrO_2 and PtIrRu are the best choices. Due to the high cost and scarcity of precious metals, it is challenging but highly desirable to develop low-cost and efficient bifunctional electrocatalysts.

Spinels are potential candidates as low-cost electrocatalysts for both ORRs and OERs. However, very little has been reported to date about utilizing Co_3O_4 as bifunctional electrocatalysts components for metal-air batteries. Liang et al [1] brought insights into the synergistic coupling between Co_3O_4 and graphene, and demonstrated excellent bifunctionality and stability of the hybrid material. Inspired by his idea, coupling Co_3O_4 and multi-walled carbon nanotubes (MWCNTs) could also display bifunctionality and stability. Furthermore, it is well believed that the electrochemical activities of nanostructured catalysts are closely related to their morphologies. Different shaped Co_3O_4 such as nanocubes, nanoplatelets, and so forth has been synthesized with a variety of methods [2,3]; however, the morphology related bifunctionality of Co_3O_4 has never been reported. As a result, evaluating the ORR/OER activities of cubic Co_3O_4 (cCo_3O_4) and its MWCNT hybrid material will be very intriguing and worth studying, but also quite challenging owing to the difficulty of maintaining the cubic morphology while chemically attaching MWCNTs onto cCo_3O_4. Herein, we report a highly active and stable bifunctional electrocatalyst synthesized via a facile hydrothermal process. To the best of our knowledge, this is the first reported cubic Co_3O_4 and MWCNT hybrid material (cCo_3O_4/MWCNT) with outstanding bifunctionality and stability.

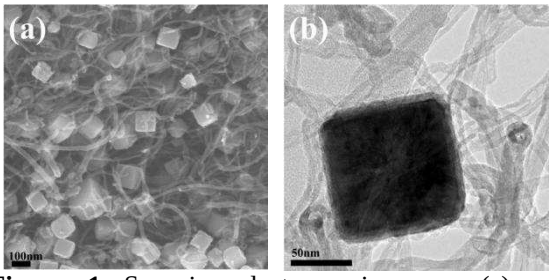

Figure. 1. Scanning electron microscopy (a) and transmission electron microscopy (b) images of cCo_3O_4 /MWCNT

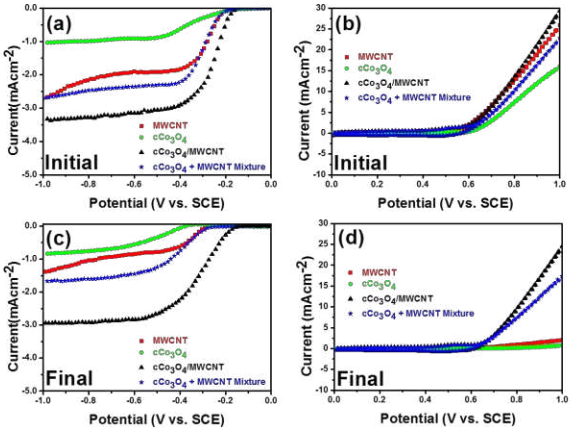

Figure. 2. Initial ORR (a)/OER (b) and final ORR (c)/OER (d) polarization curves after durability tests of MWCNT, cCo_3O_4, cCo_3O_4/MWCNT, cCo_3O_4 + MWCNT Mixture at 900rpm.

References:

[1] Liang, Y., et al., Co3O4 nanocrystals on graphene as a synergistic catalyst for oxygen reduction reaction. Nat Mater, 2011. **10**(10): p. 780-786.

[2] Hou, Y., et al., High-Yield Preparation of Uniform Cobalt Hydroxide and Oxide Nanoplatelets and Their Characterization. The Journal of Physical Chemistry B, 2005. **109**(41): p. 19094-19098.

[3] Controlled synthesis of Co3O4 nanocubes under external magnetic fields and their magnetic properties. Dalton Transactions, 2011. **40**(3): p. 597.