Electronic Supplementary Information (ESI)

# A Composite of Co Nanoparticles Highly Dispersed on N-Rich Carbon Substrates: an Efficient Electrocatalyst for Li-$O_2$ Battery Cathodes

Zhang Zhang, Liwei Su, Mei Yang, Meng Hu, Jie Bao, Jinping Wei, and Zhen Zhou*

*Tianjin Key Laboratory of Metal and Molecule Based Material Chemistry, Key Laboratory of Advanced Energy Materials Chemistry (Ministry of Education), Institute of New Energy Material Chemistry, Synergetic Innovation Center of Chemical Science and Engineering (Tianjin), Nankai University, Tianjin 300071, China*

## Material Preparation

All the reagents were analytical grade without further purification. In the synthesis process, 0.6 g $CoCl_2 \cdot 6H_2O$, 10 g urea, and 1.0 g citric acid were dissolved in 150 mL ethanol and 50 mL distilled water through intense agitation, a gel formed after 3 h at 75°C until the liquid was almost vaporized, and then the gel was transferred to an oven at 100°C overnight. Before calcination, the gel was dried in dehumidification cabinet for 6 h and then ground into powder. The mixture was calcined at 350°C for 4 h and then 650°C for 10 h in Ar atmosphere. The obtained powder was used for further characterization.

## Material Characterization

X-ray diffraction (XRD) was performed on a D/MAX III diffractometer with Cu Kα radiation. Field emission scanning electron microscope (FESEM) images were obtained on a JEOL-JSM7500 microscope. The energy dispersive X-ray spectroscopy (EDX) attached to the FESEM instrument was used to confirm the composition of the samples. Transmission electron microscope (TEM) graphs were taken on FEI Tecnai $G^2$F-20, and X-ray photoelectron spectroscopy (XPS) was

performed on Axis Ultra DLD (Kratos Analytical). $N_2$ adsorption/desorption isotherms were obtained by using ASAP 2020/Tristar 3000 Surface Area and Pore Size Analyzer.

## Electrochemical Tests

The electrochemical behaviors were measured in swagelok cells with a 1.0 $cm^2$ hole placed on the cathode which enabled the oxygen flow in. The cells were assembled in a glove box filled with high-purity argon ($O_2$ and $H_2O$ < 1 ppm). For the cathode preparation, the slurry was mixed with Ketjen black (KB), the catalyst and polyvinylidene fluoride (PVDF) with the ratio 60/20/20. The slurry was uniformly deposited on a circular piece of nickel foam, and then dried in a vacuum oven at 80°C. Li foil was used as the anode, and PTFE membrane as the separator. The electrolyte was 1 mol $L^{-1}$ lithium bis(trifluoromethanesulfonyl)imide (LiTFSI) dissolved in TEGDME. The first discharge was recorded within a LAND-CT2001A tester till 2 V (vs. $Li/Li^+$) at a current density of 300 mA $g^{-1}$. The cycling charge/discharge tests were performed with the cut-off capacity of 600 mAh $g^{-1}$ at 200 mA $g^{-1}$ (the cells were discharged and charged for 3 h separately). Cyclic voltammograms (CVs) were conducted on a Zahner-Elektrik IM6e electrochemical workstation within 2-4.3V (vs. $Li/Li^+$).

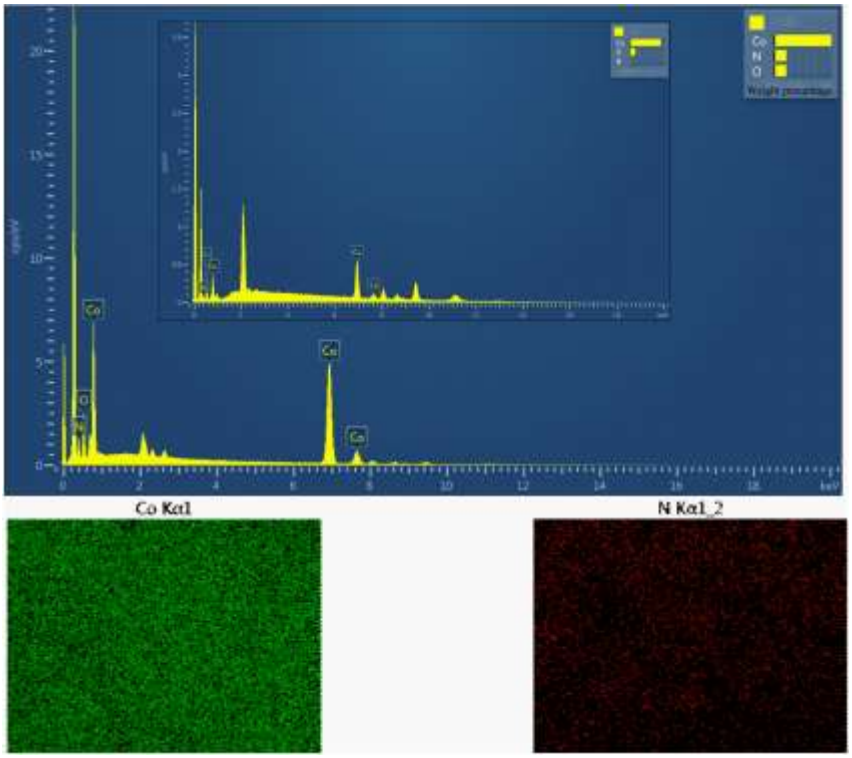


**Fig. S1**. EDX of carbon nanosheets and nanotubes.

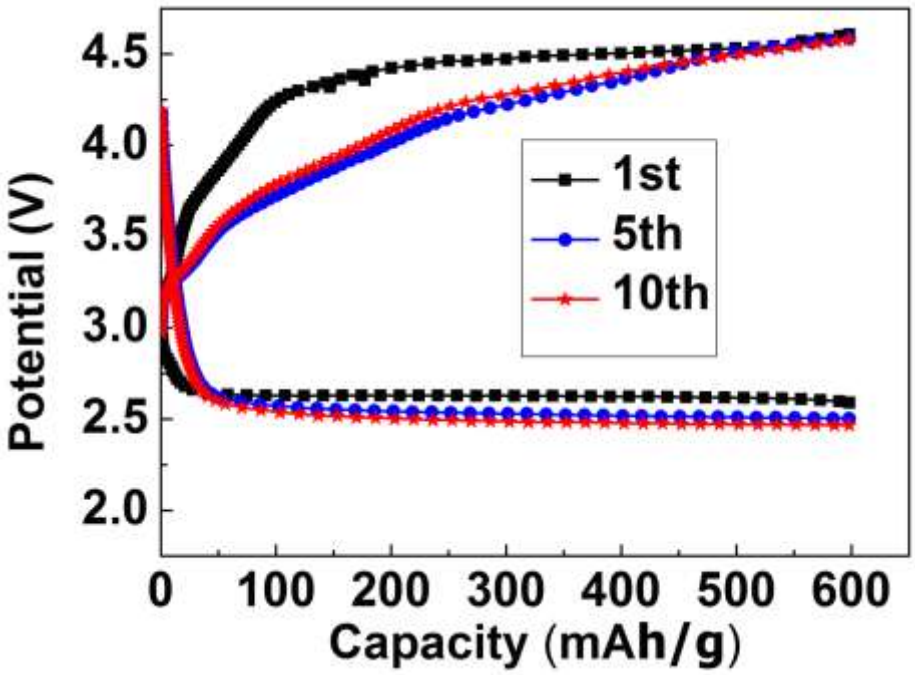


**Fig. S2**. Curtailing capacity of 600 mAh $g^{-1}$ at a current density of 200 mA $g^{-1}$ for KB electrode.

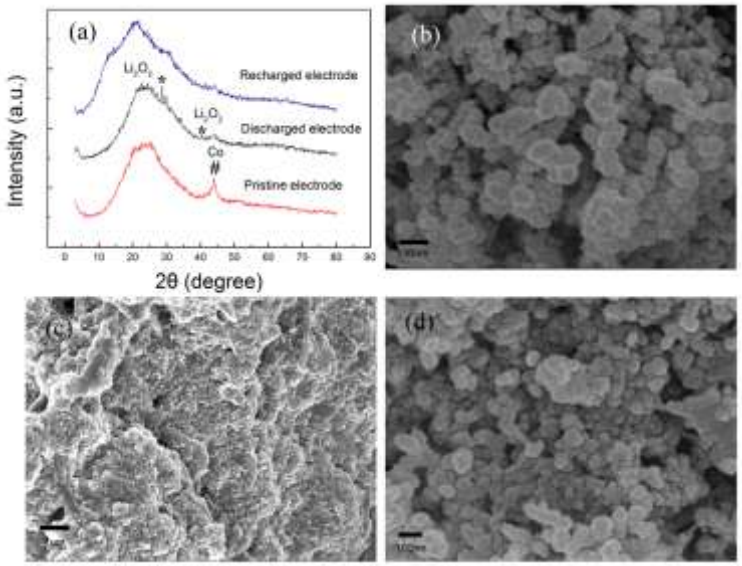


**Fig. S3**. (a) XRD patterns for the pristine cathode, and the discharged and recharged cathode during the 5th cycle. SEM images of the pristine cathode (b), and the discharged (c) and recharged (d) cathode during the 5th cycle.