Supporting Information

Hierarchical Mesoporous/Macroporous Perovskite $La_{0.5}Sr_{0.5}CoO_{3-x}$ Nanotubes: a Bi-functional Catalyst with Enhanced Activity and Cycle Stability for Rechargeable Lithium Oxygen Batteries

Guoxue Liu,[†] Hongbin Chen,[†] Lu Xia,[†] Suqing Wang,[*,†] Liang-Xin Ding,[†,‡] Dongdong Li,[†,‡] Kang Xiao[†], Sheng Dai[‡], Haihui Wang[*,†,‡]

[†]School of Chemistry and Chemical Engineering, South China University of Technology, Guangzhou 510640, China

[‡]School of Chemical Engineering, The University of Adelaide, Adelaide, SA 5005, Australia

Corresponding author's contact information:

*Email: cesqwang@scut.edu.cn.; hhwang@scut.edu.cn

Details of kinetic analysis:

The oxygen reduction reaction (ORR) polarization curves were measured in O_2 saturated 0.1 M KOH solution at 5 mV s^{-1} under different rotation rate from 400 rpm to 2025 rpm. Transfer electron numbers per oxygen molecule in the ORR was determined by the K-L equations as follows: [S1]

$$\frac{1}{j} = \frac{1}{j_k} + \frac{1}{B\omega^{1/2}} \quad (1)$$

where ***j*** is the measured current density, $\boldsymbol{j_k}$ is the kinetic current density and $\boldsymbol{\omega}$ is the angular velocity of the disk ($\boldsymbol{\omega}$=2πN, N is the linear rotation speed).

$$B = 0.62nFC_{O_2}(D_{O_2})^{2/3}\upsilon^{-1/6} \quad (2)$$

where ***n*** represents the overall number of electrons gained per oxygen, ***F*** is the Faraday constant (***F***=96485 C mol^{-1}), $\boldsymbol{C_{O2}}$ is the bulk concentration of O_2 (1.21×10^{-3} mol L^{-1}), $\boldsymbol{D_{O2}}$ is the diffusion coefficient of O_2 in 0.1 M KOH electrolyte (1.86×10^{-5} cm^2 s^{-1}), $\boldsymbol{\upsilon}$ is the kinetic viscosity of the electrolyte (1.009×10^{-2} cm^2 s^{-1}).

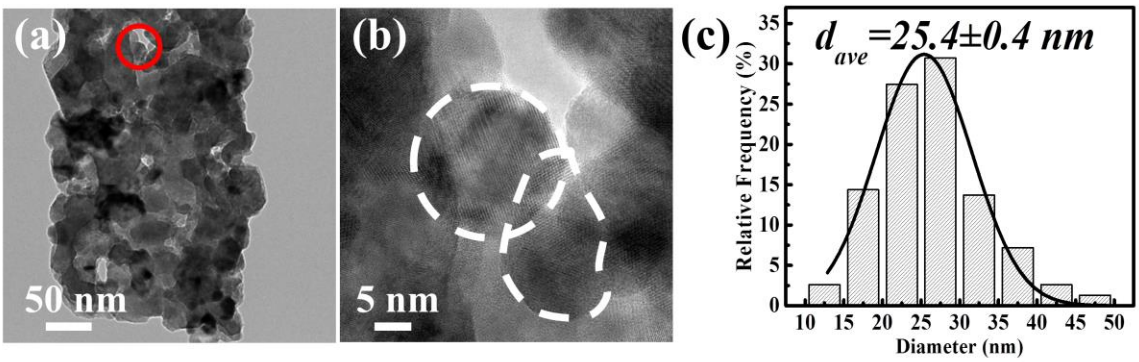

Figure S1. a) TEM image, b) HRTEM image c) histogram of diameter distributions of the synthesized HPN-LSC

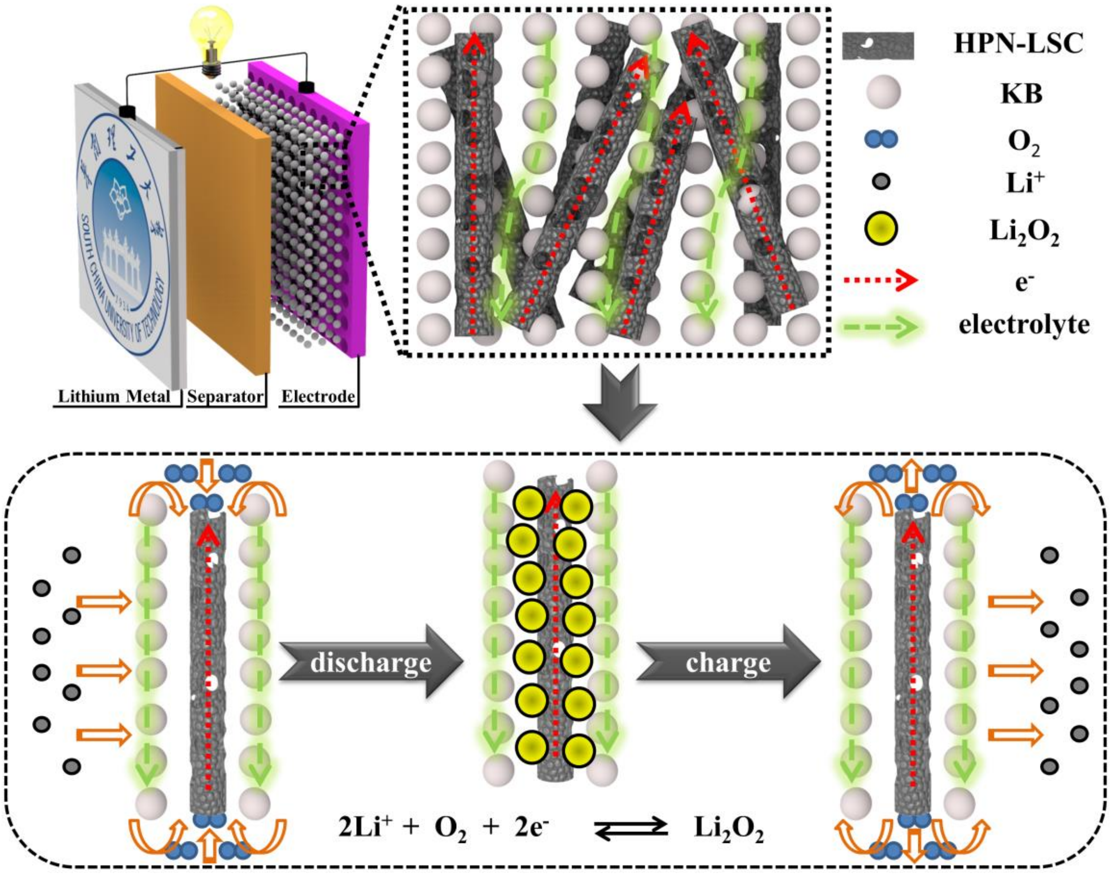

Figure S2. Structure of a rechargeable Li-O_2 battery with HPN-LSC catalysts and the working mechanism of the oxygen electrode containing HPN-LSC.

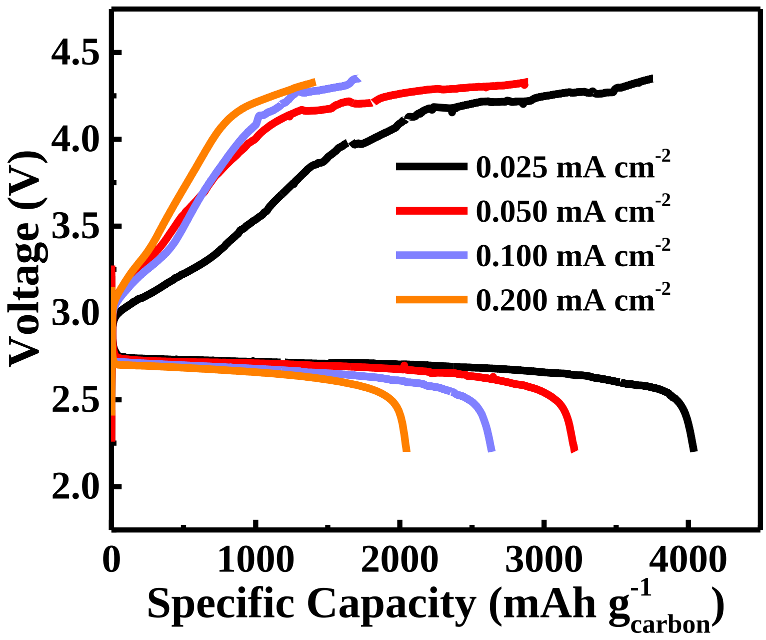

Figure S3. Discharge/charge profiles of Li-O_2 batteries with pure KB electrode at various current densities.

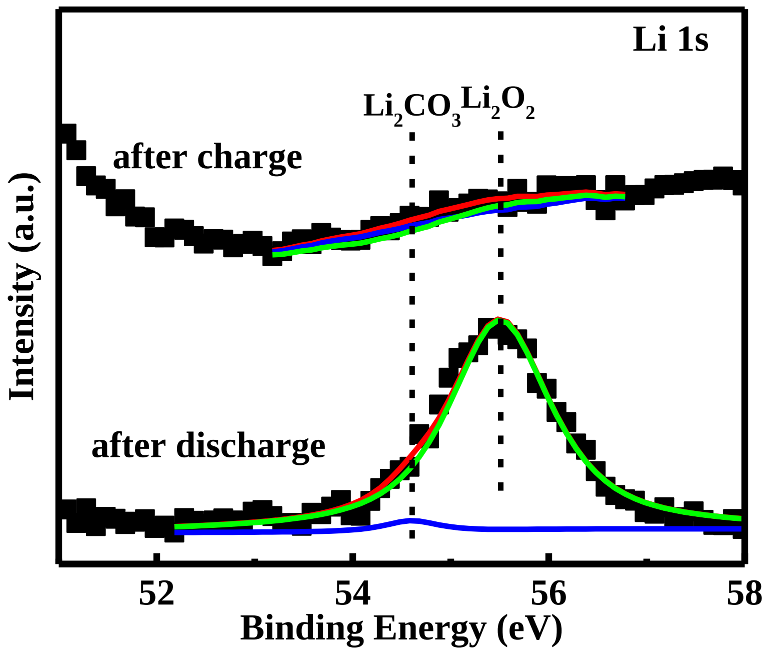

Figure S4. Li 1s XPS spectra of the HPN-LSC/KB electrode after discharge and after charge.

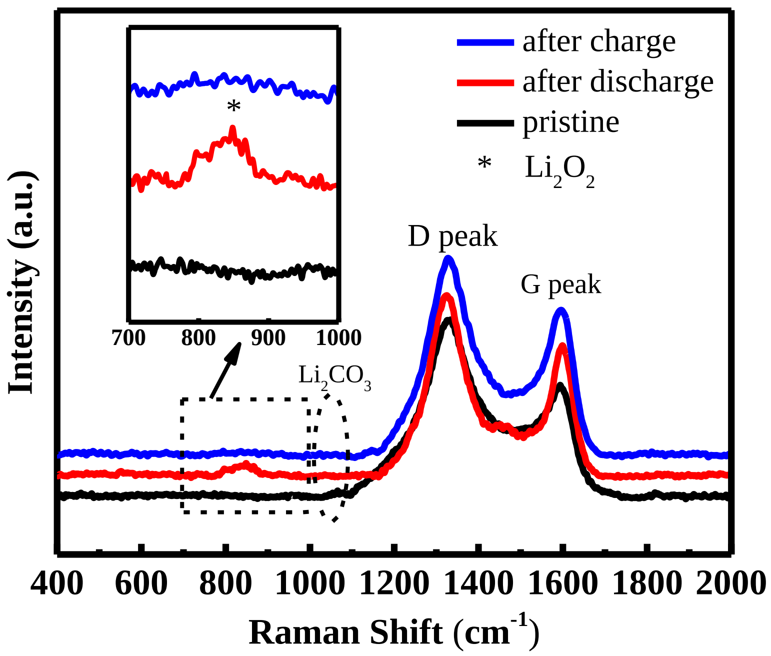

Figure S5. Raman spectra of HPN-LSC electrode before discharge, after discharge and after charge.

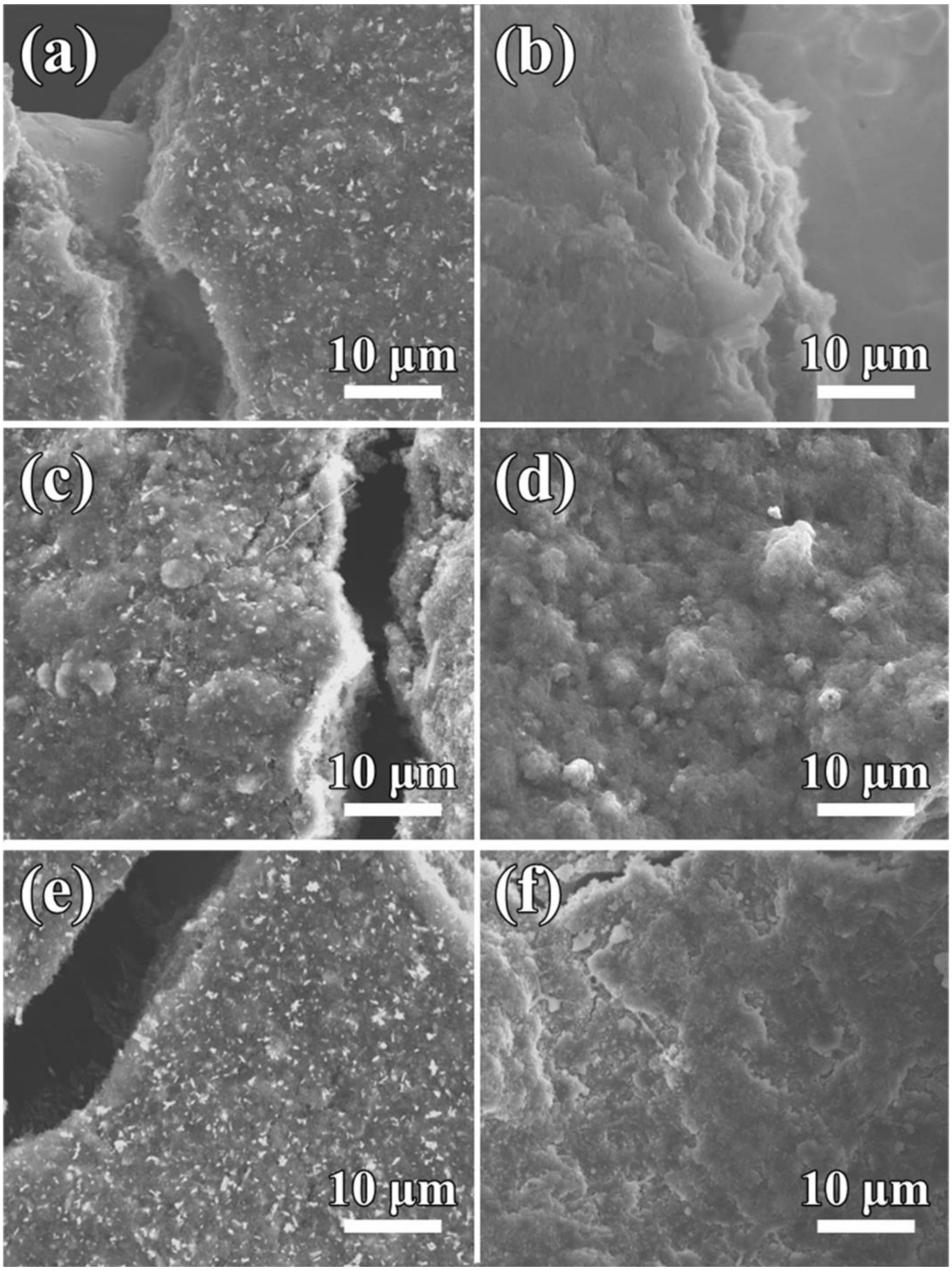

Figure S6. SEM images of HPN-LSC/KB electrode (a, c, e) and pure KB electrode (b, d, f) before 1st discharge (a, b) after 1st discharge (c, d) and after 1st charge (e, f).

Table S1. Comparison of electrochemical performance between the current work and micron-scale or nano-scale structured catalysts for Li-O_2 batteries.

Material	Current Density	Maximum Capacity	Upper-limit Capacity	Cyclic performance	Reference
mesoporous/macroporous $La_{0.5}Sr_{0.5}CoO_{3-x}$ nanotubes	**0.025 mA cm^{-2} (50 mA g^{-1})**	**5799 mAh g^{-1}_{carbon} 3866 mAh $g^{-1}_{carbon+catalyst}$**	**500 mAh g^{-1}**	**50 cycles at 0.100 mA cm^{-2}(200 mA g^{-1})**	**This work**
mesoporous $La_{0.5}Sr_{0.5}CoO_{2.91}$ nanowires	42 mA g^{-1}	11059 mAh g^{-1}	-	1cycle at 42 mA g^{-1}	S2
$La_{1.7}Ca_{0.3}Ni_{0.75}Cu_{0.25}O_4$ Particles	40 mA g^{-1}	1600 mAh g^{-1}_{carbon}	700 mAh g^{-1}	15 cycles at 80 mA g^{-1}	S3
$Sr_{0.95}Ce_{0.05}CoO_{3-x}$ Particles	0.05 mA cm^{-2}	1500 mAh g^{-1}	250 mAh g^{-1}	15 cycles at 0.2 mA cm^{-2}	S4
Sr_2CrMoO_{6-x} Particles	75 mA g^{-1}	2306 mA h g^{-1}_{carbon}	600 mAh g^{-1}	30 cycles at 0.2 mA cm^{-2}	S5
$LaNi_{1-x}Mg_xO_3$ Particles	-	620 mAh g^{-1}	-	-	S6
$LaNi_{1-x}Fe_xO_3$ Particles	50 mA g^{-1}	500 mAh g^{-1}_{carbon}	500 mAh g^{-1}	10 cycles at 50 mA g^{-1}	S7
Nano-sized $La_{0.8}Sr_{0.2}MnO_3$ Particles	0.1 mA cm^{-2}	1922 mAh g^{-1}_{carbon}	-	-	S8
Ketjen Black	0.025 mA cm^{-2}	3750 mAh g^{-1}			This work
Super P	75 mA g^{-1}	1434 mAh g^{-1}			S5
XC-72	0.08 mA cm^{-2}	2454 mAh g^{-1}			S9
Hierarchical Carbon-Nitrogen	50 mA g^{-1}	3200 mAh g^{-1}			S10
Ordered Mesoporous Carbon	200 mA g^{-1}	3000-5500 mAh g^{-1}			S11

References

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