Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Embedding CoO nanoparticles in yolk-shell N-doped porous carbon support for ultrahigh and stable lithium storage

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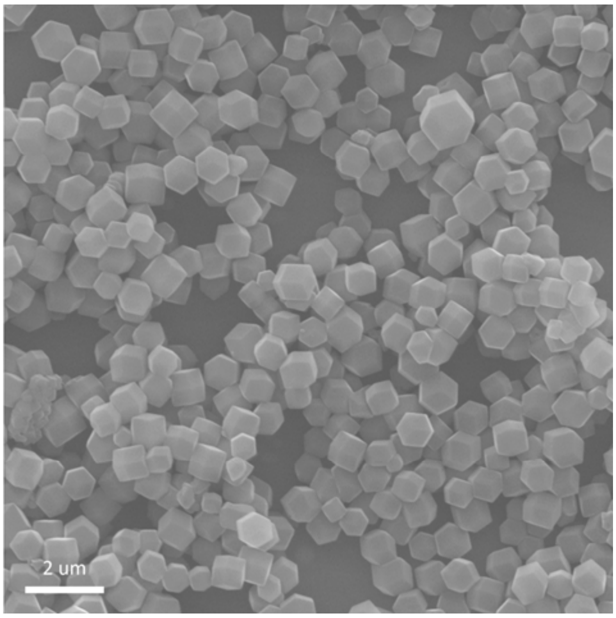

Figure S1. SEM image of the as-synthesized ZIF-67 nanocrystals.

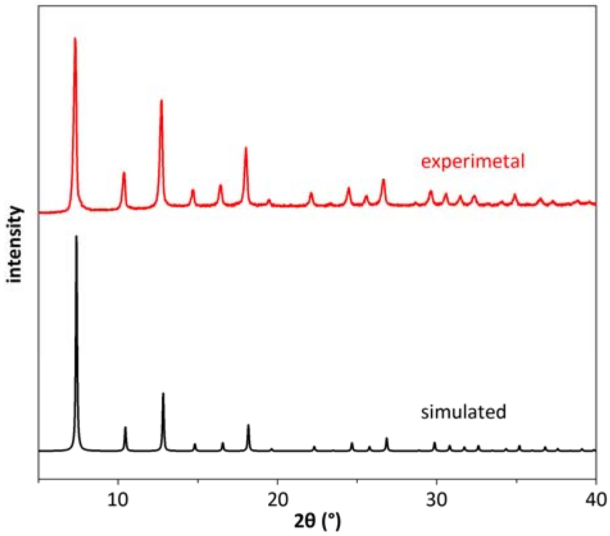

Figure S2. PXRD patterns of ZIF-67 nanocrystals.

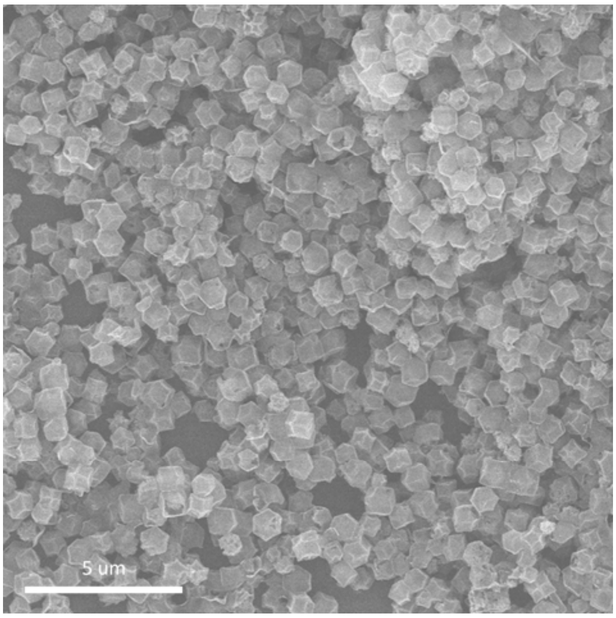

Figure S3. SEM image of the as-synthesized CoO/C YSNSs.

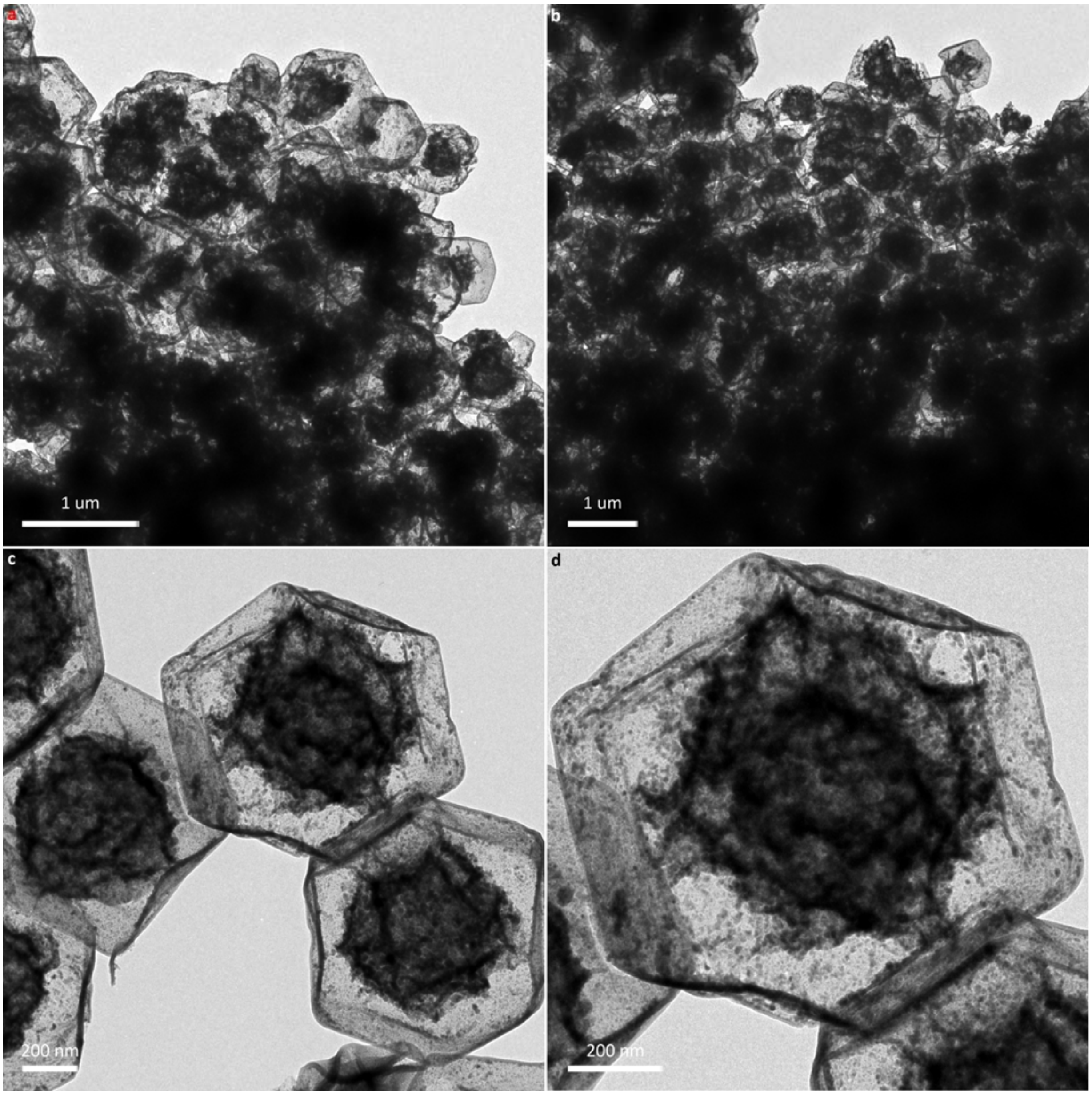

Figure S4. TEM images of the as-synthesized CoO/C YSNSs at different magnification.

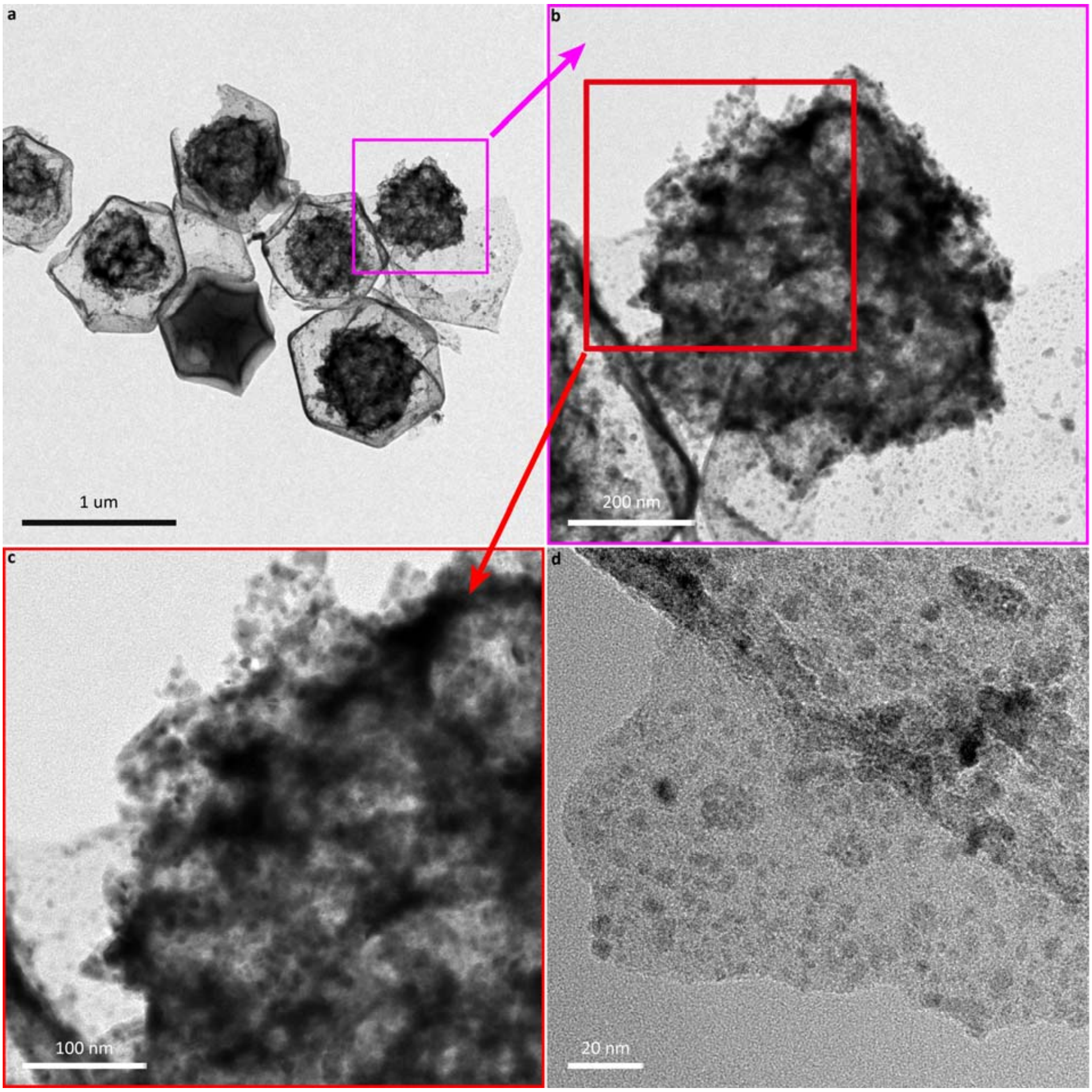

Figure S5. (a, b) TEM images of cracked CoO/C YSNSs. (c,d) TEM images of (c) the yolk and (d) the shell of cracked CoO/C YSNSs.

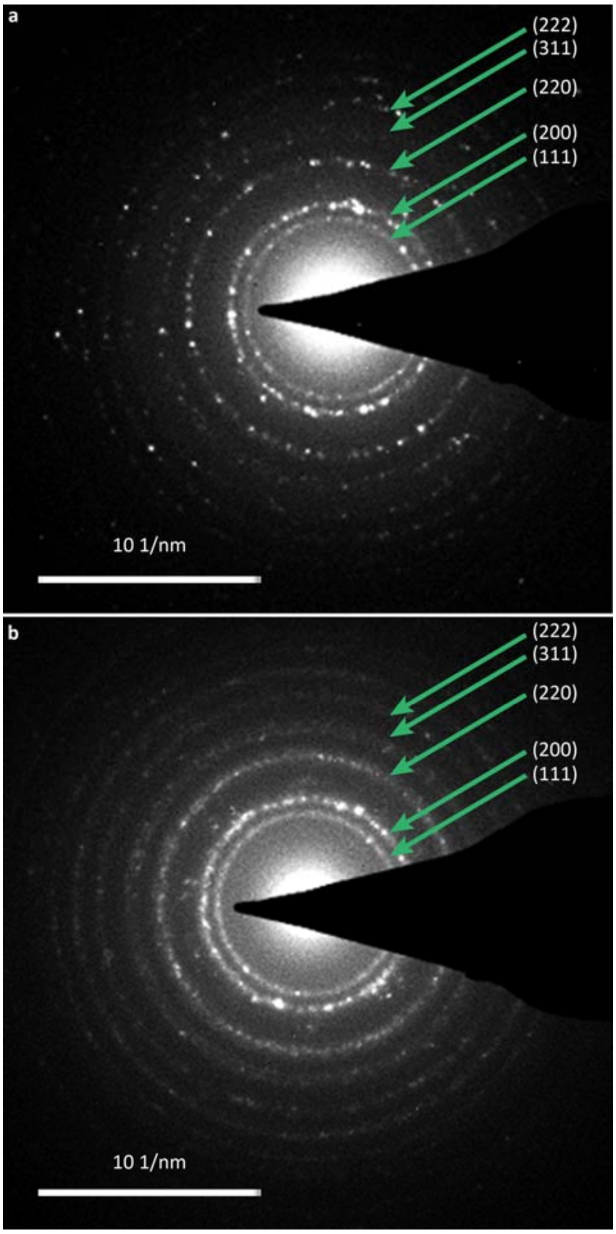

Figure S6. SAED patterns of (a) the outer shell and (b) inner yolk of cracked CoO/C YSNS.

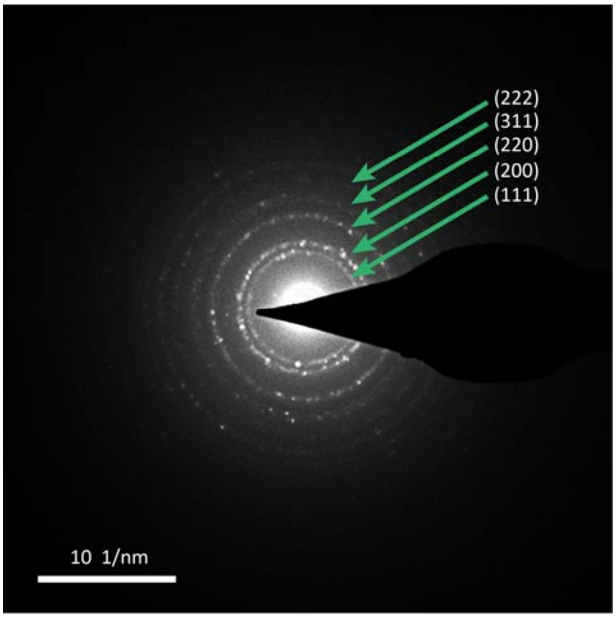

Figure S7. SAED pattern of single CoO/C YSNS, which is in excellent agreement with the SAED patterns of the outer shell or inner yolk of cracked CoO/C YSNS (shown in Figure S6a and S6b, respectively). All these three SAED patterns can be assigned to face-centered cubic CoO crystals (JCPDS No. 43-1004), suggesting that the nanoparticles are CoO.

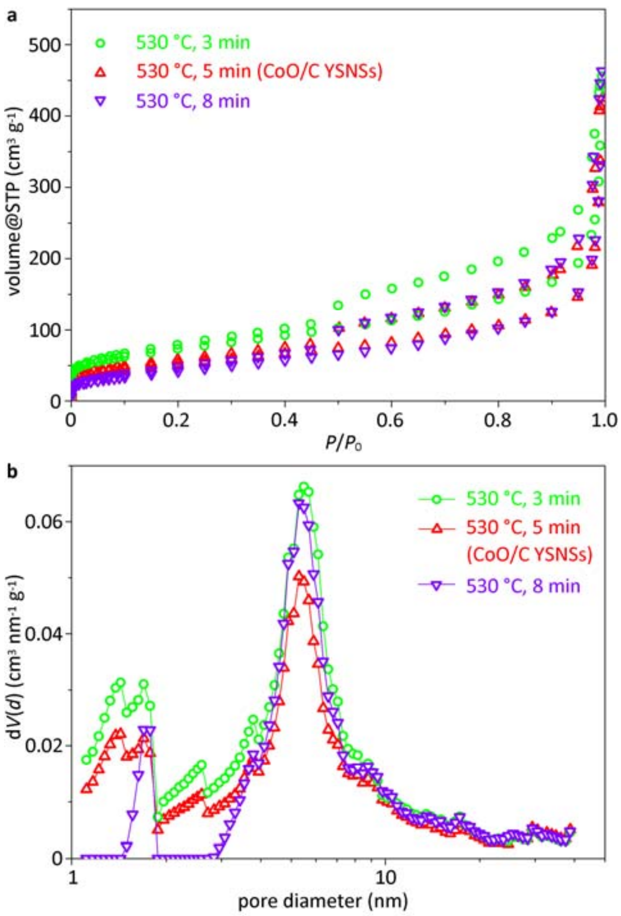

Figure S8. (a) N_2 sorption isotherms and (b) pore size distribution of the products synthesized by the controlled pyrolysis of ZIF-67 under diffrent conditions.

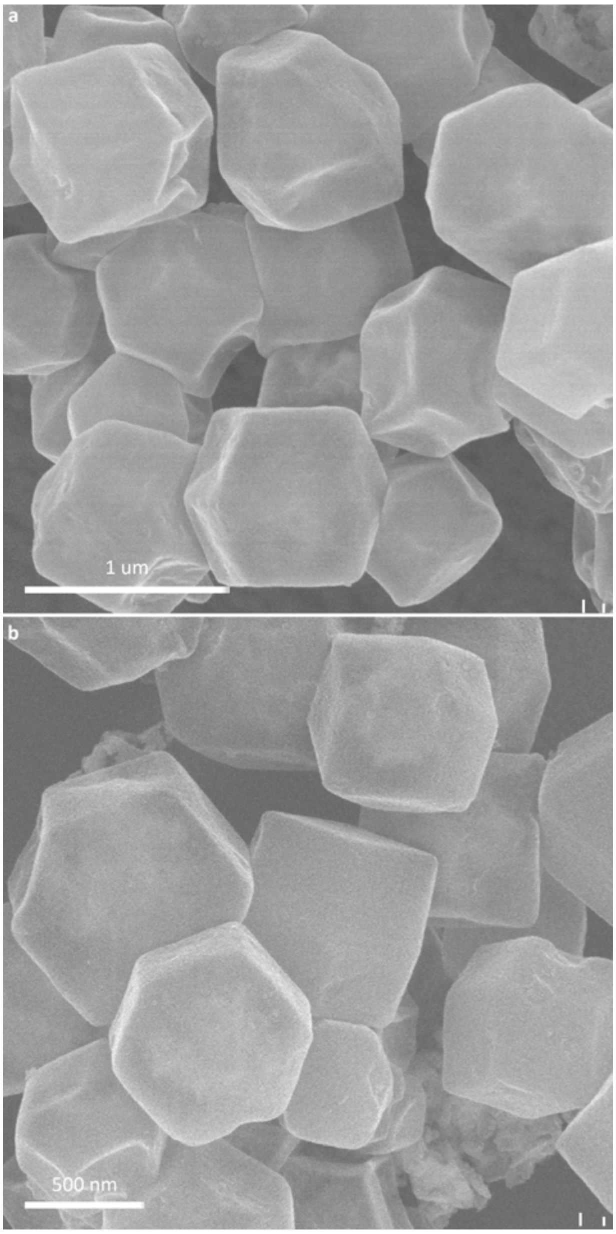

Figure S9. SEM images of the CoO/C YSNSs synthesized through the pyrolysis of ZIF-67 nanocrystals at 530 °C for 5 min. The Ar flow rate was 50 mL min^{-1} and the temperature was raised to 530 °C at a ramp rate of 1 °C min^{-1}.

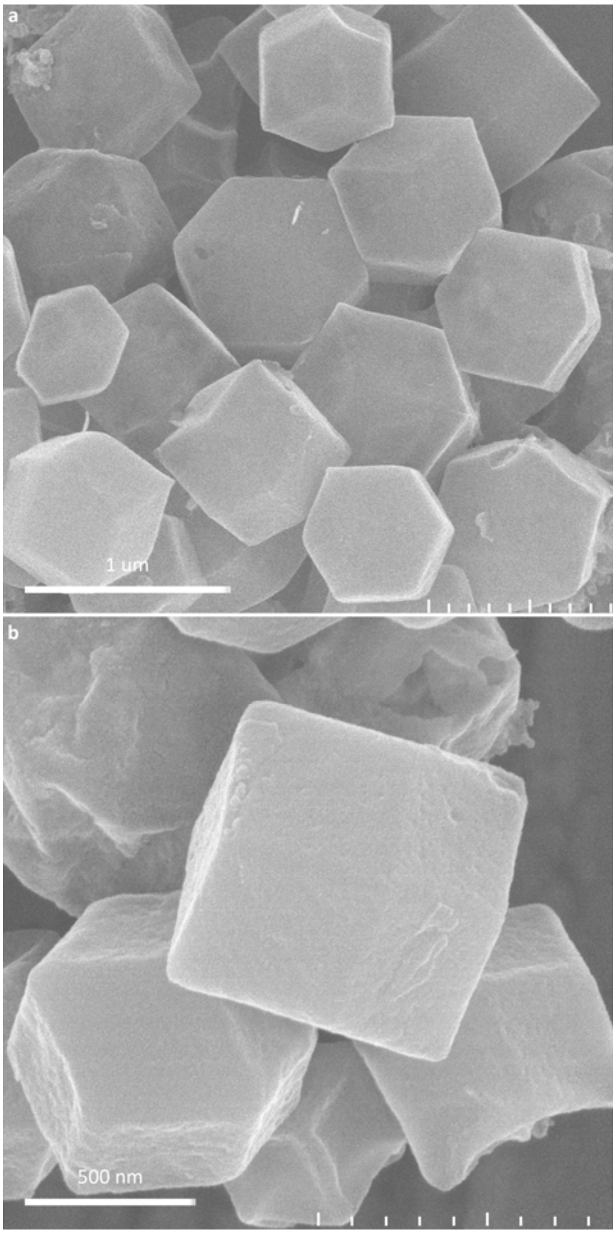

Figure S10. SEM images of the samples synthesized through the pyrolysis of ZIF-67 nanocrystals at 530 °C for 3 min. The Ar flow rate was 50 mL min^{-1} and the temperature was raised to 530 °C at a ramp rate of 1 °C min^{-1}.

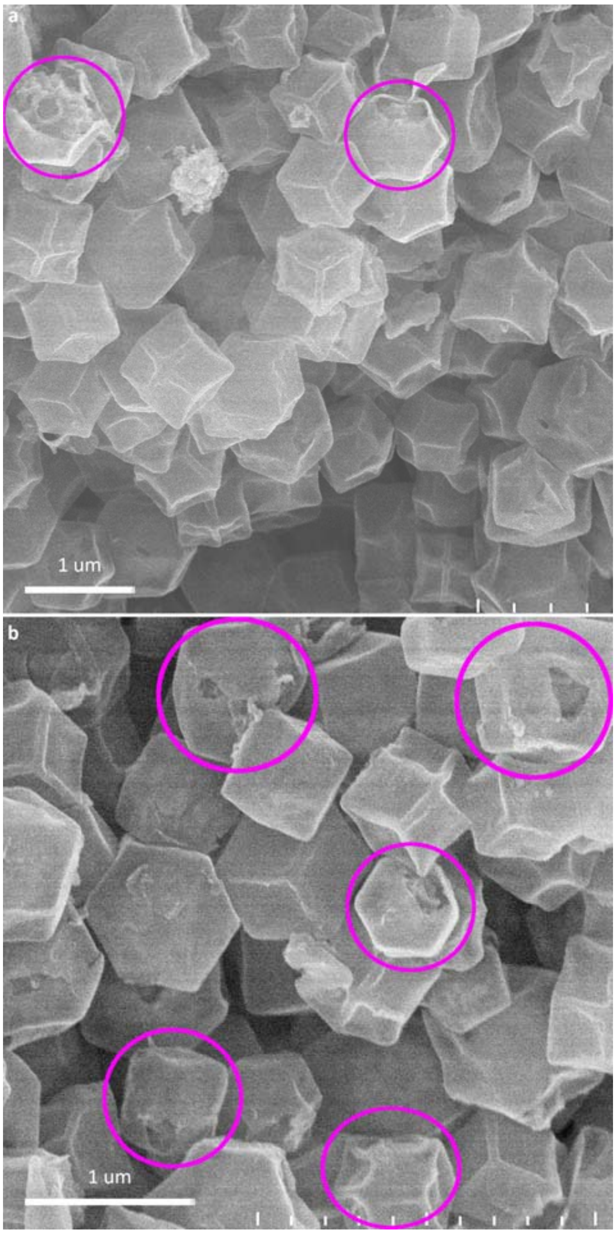

Figure S11. SEM images of cracked samples, in which the cracks (indicated with magenta circles) were introduced by the grinding and subsequent ultrasonication of samples synthesized through the pyrolysis of ZIF-67 nanocrystals at 530 °C for 3 min. SEM images of the samples taken prior to crack treatment are shown in Figure S10.

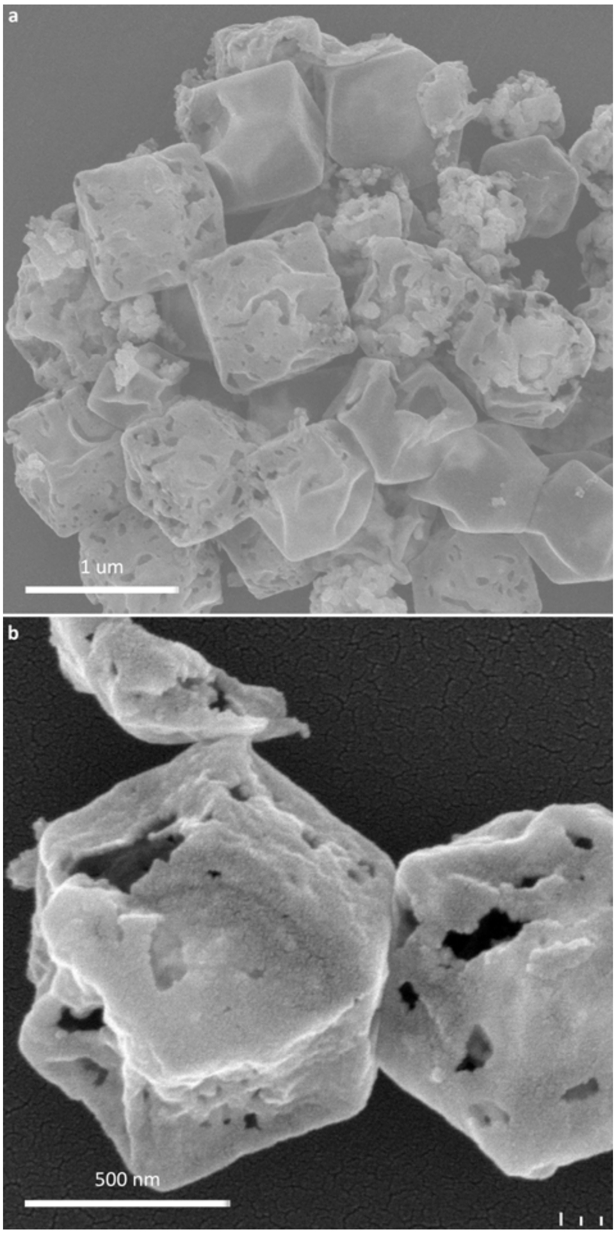

Figure S12. SEM images of the samples synthesized through the pyrolysis of ZIF-67 nanocrystals at 530 °C for 8 min. The Ar flow rate was 50 mL min^{-1} and the temperature was raised to 530 °C at a ramp rate of 1 °C min^{-1}.

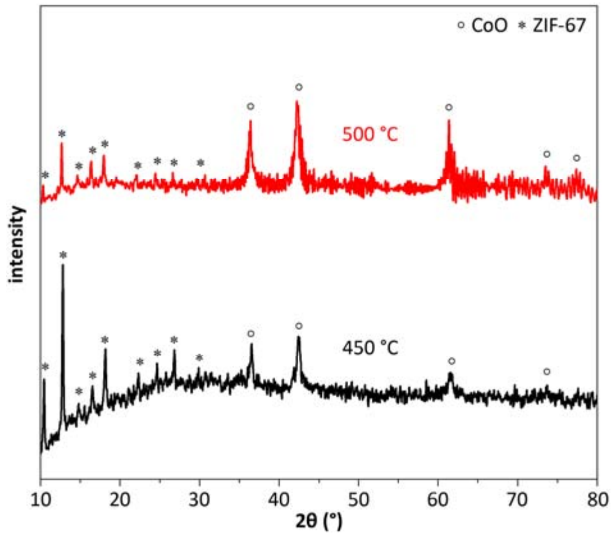

Figure S13. PXRD patterns of samples collected after heating ZIF-67 nanocrystals to (a) 450 and (b) 500 °C, respectively.

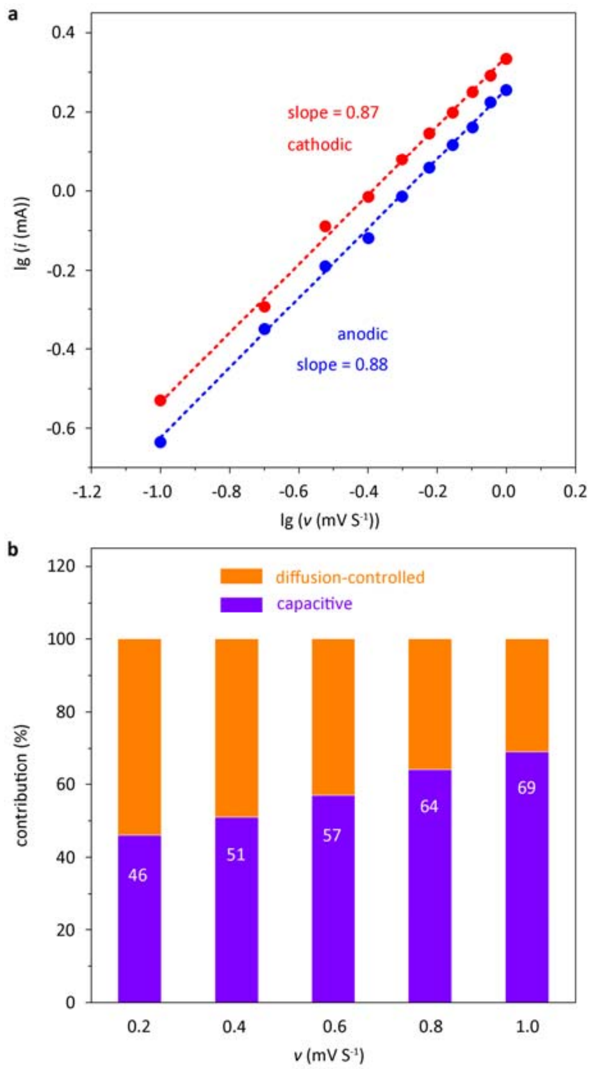

Figure S14. Kinetics analysis of the lithium storage behavior of CoO/C YSNSs. (a) Dependence of the cathodic/anodic peak current (*i*) on the sweep rate (*v*) at the log scale. (b) Normalized contribution of the capacitance and diffusion at various sweep rates.

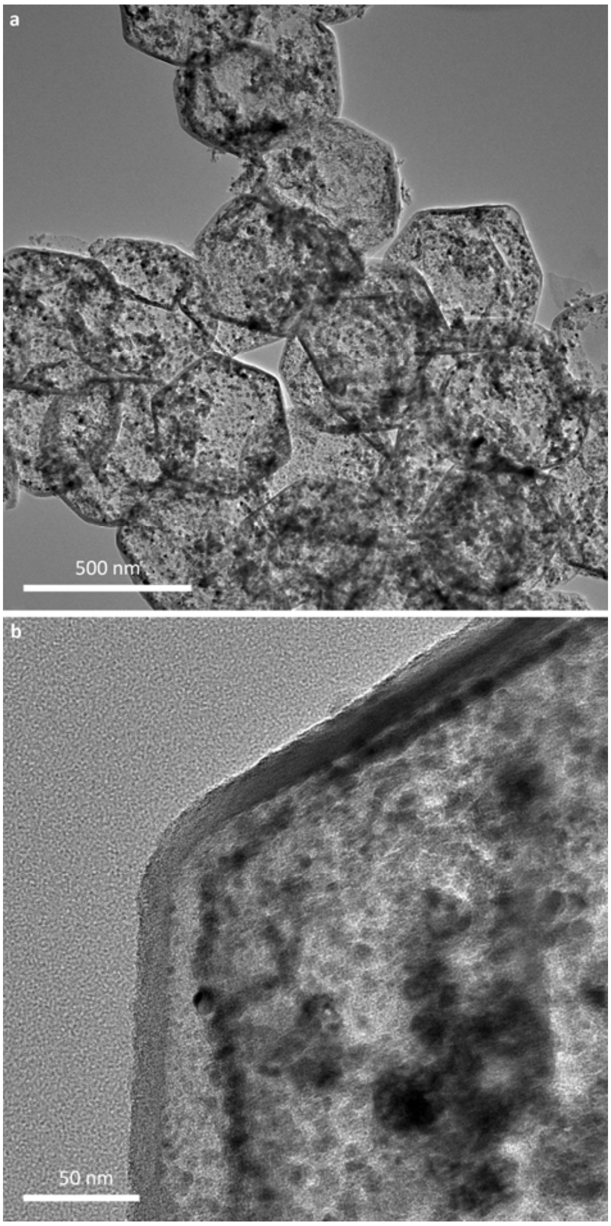

Figure S15. TEM images at (a) low and (b) high magnification of the conventional CoO@C YSNSs.

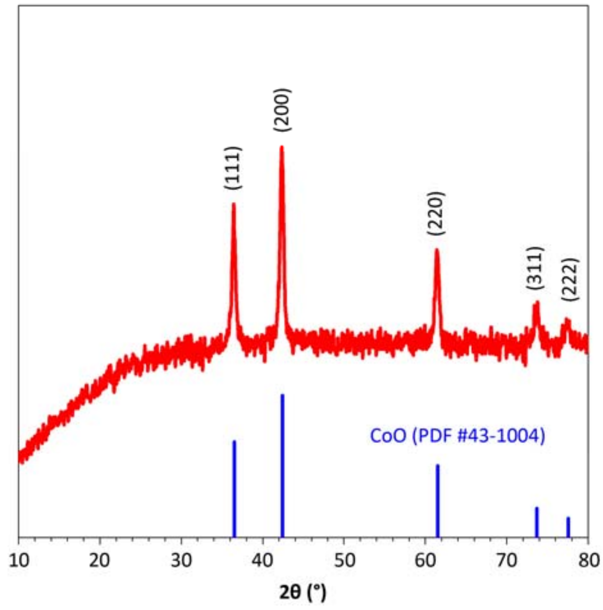

Figure S16. PXRD pattern of the conventional CoO@C YSNSs.

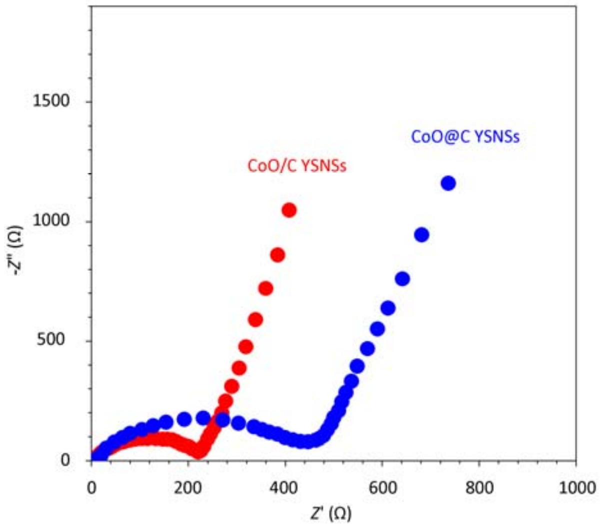

Figure S17. Electrochemical impedance spectra of the CoO/C YSNSs and conventional CoO@C YSNSs.

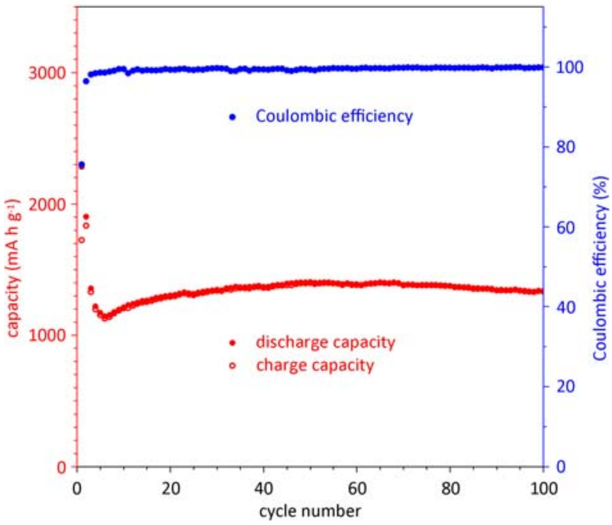

Figure S18. (a) Specific capacities and (b) Coulombic efficiency of the conventional CoO@C YSNSs at a current density of 100 mA g^{-1}.

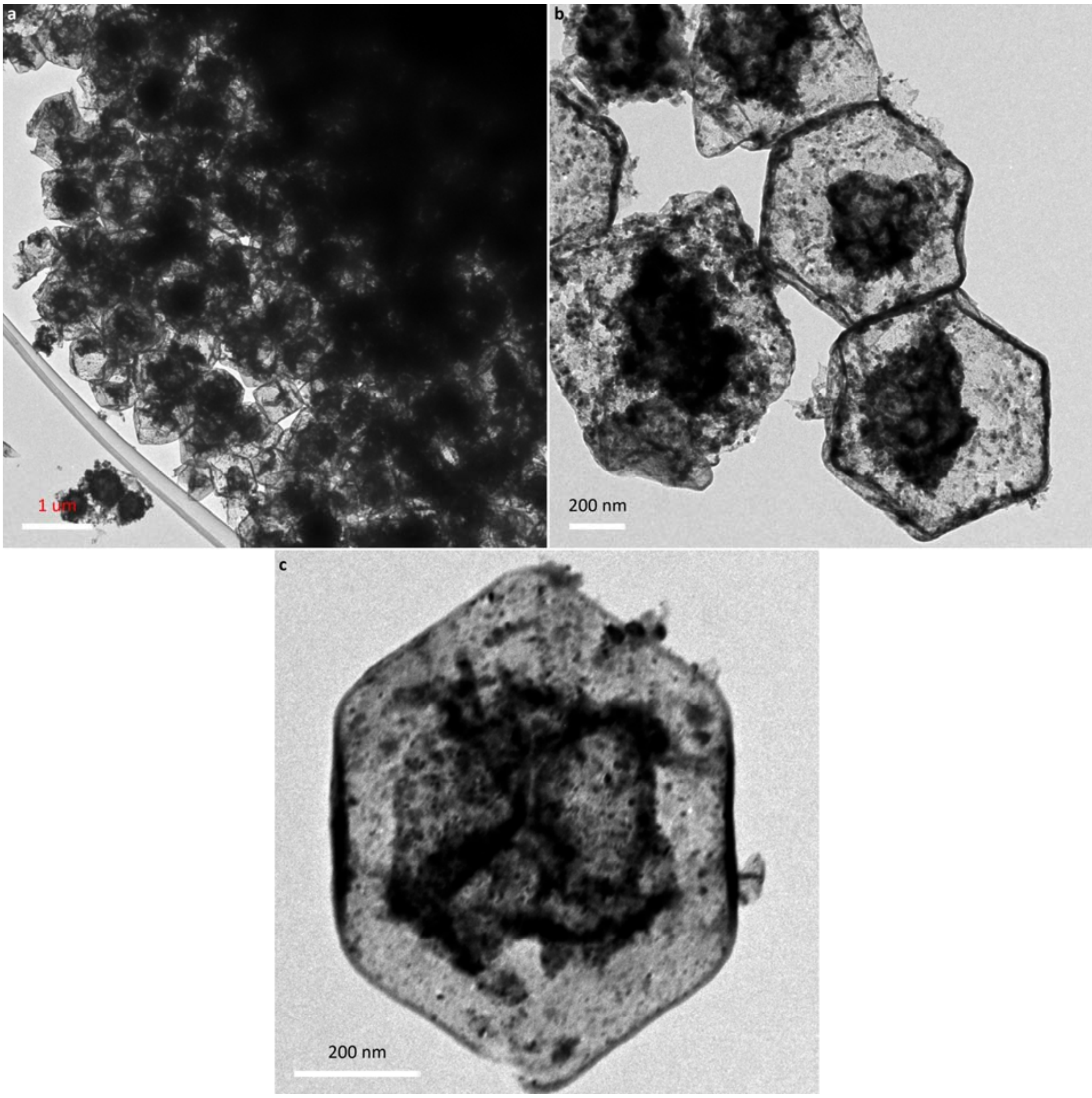

Figure S19. TEM imgaes of CoO/C YSNSs after 1000 charge-discharge cycles at a current density of 100 mA g^{-1}.

Table S1. Lithium stroage capacity and stability of representative high-performance cobalt oxides (CoO and Co_3O_4) based anode materials for lithium-ion batteries.

Samples	Procedure	Capacity at low current density (mAh g^{-1}/mA g^{-1})	Capacity at high current density (mAh g^{-1}/mA g^{-1})	Cycling performance (mAh g^{-1}/mA g^{-1}/cycle)	Reference
CoO nanowire clusters	Multistep	1516/716	1331/3580	1249/0.716/50	*Adv Funct Mater* 2015 [S1]
CoO/NC	Multistep	1200/89	533/8900	1300/89/150	*J Mater Chem A* 2017 [S2]
CoO@C	Multistep	866/100	400/5000	991/200/300	*Adv Energy Mater* 2018[S3]
CoO/NC	One-step	1383/100	382/7140	1383/100/200	*Small* 2016 [S4]
CoO/Co-C cuboids	Multistep	1050/100	195/20000	580/1000/2000	*J Mater Chem A* 2016 [S5]
CoO@BNG nanotubes	Multistep	1554/100	410/1750	394/480/1750	*Adv Mater* 2018 [S6]
CoO/graphene	Multistep	720/100	297/5000	707/1000/1000	*J Power Sources* 2014 [S7]
CoO/graphene/carbon	Multistep	1030/100	400/2000	690/500/352	*J Mater Chem A* 2014 [S8]
CoO/graphene	Multistep	640/100	170/20000	604/1000/5000	*Adv Funct Mater* 2013 [S9]
CoO@RGO	Multistep	950/198	750/8900	890/880/400	*Adv Funct Mater* 2016 [S10]
CoO@C-Ni	Multistep	1193/200	536/4000	1120/1000/600	*Nano Energy* 2014 [S11]
Co_3O_4 nanoparticles	Multistep	1000/100	870/1000	600/1000/500	*J Power Sources* 2015 [S12]
Co_3O_4 microframes	Multistep	1092/100	620/8000	757/5000/4000	*Chem Commun* 2016 [S13]
Co_3O_4 networks	Multistep	1033/100	758/2000	485/5000/700	*Adv Funct Mater* 2017 [S14]
Co_3O_4 nanosheets	Multistep	1477/100	775/1000	775/1000/200	*Inorg Chem Front* 2018 [S15]
Co_3O_4/C nanotubes	Multistep	1160/500	853/10000	950/500/300	*Adv Funct Mater* 2018 [S16]
Co_3O_4/C nanofibers	Multistep	1173/50	607/3000	1121/50/100	*Adv Funct Mater* 2016 [S17]
Co_3O_4/NC	Multistep	1293/100	835/2000	798/1000/500	*J Mater Chem A* 2018 [S18]
Co_3O_4/NC	Multistep	1117/100	839/5000	892/100/100	*Nano Energy* 2015 [S19]
Co_3O_4/NC	Multistep	730/500	128/5000	612/1000/500	*J Mater Chem A* 2016 [S20]
Co_3O_4/NC	Multistep	818/100	529/5000	620/1000/2000	*ACS Appl Mater Interfaces* 2017 [S21]
Co_3O_4/CNT	Multistep	1281/100	643/3000	782/1000/200	*Angew Chem Int Ed* 2016 [S22]
Co_3O_4/graphene	Multistep	2015/98	1134/2000	852/2000/2000	*Adv Energy Mater* 2016 [S23]
Co_3O_4/N-graphene	Multistep	1200/100	838/1000	812/1000/230	*Small* 2016 [S24]
Co_3O_4/RGO	Multistep	1200/1000	842/10000	1156/2000/200	*Nano Energy* 2015 [S25]
CoO/C YSNSs	**One-step**	**2050/100**	**748/790**	**1970/100/1000**	**This work**
		1021/395	**398/3950**	**680/1000/1000**	

Note: NC: N-doped carbon; BNG: B, N-doped graphitic; CNT: carbon nanotubes; GO: graphene oxides; RGO: reduced graphene oxide.

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