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

Supporting Information

Lithium-ion Batteries Recycling Technology Based on Controllable Product Morphology and Excellent Performance

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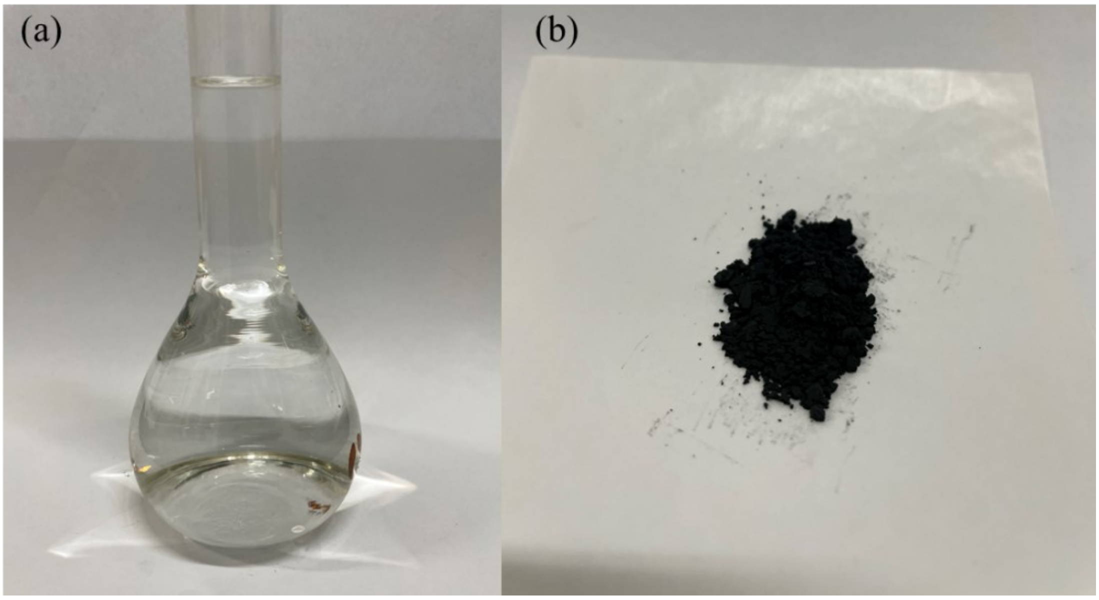

Figure S1 The separated Li_2SO_4 solution and Co_3O_4 powder.

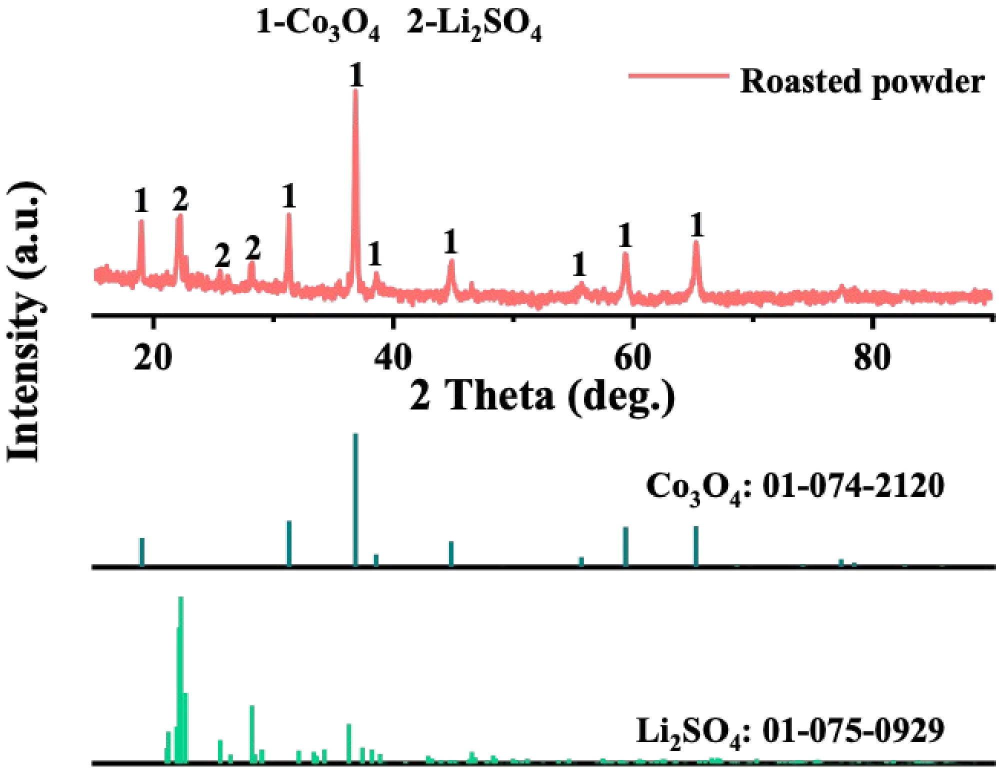

Figure S2 XRD patterns of the roasted powder.

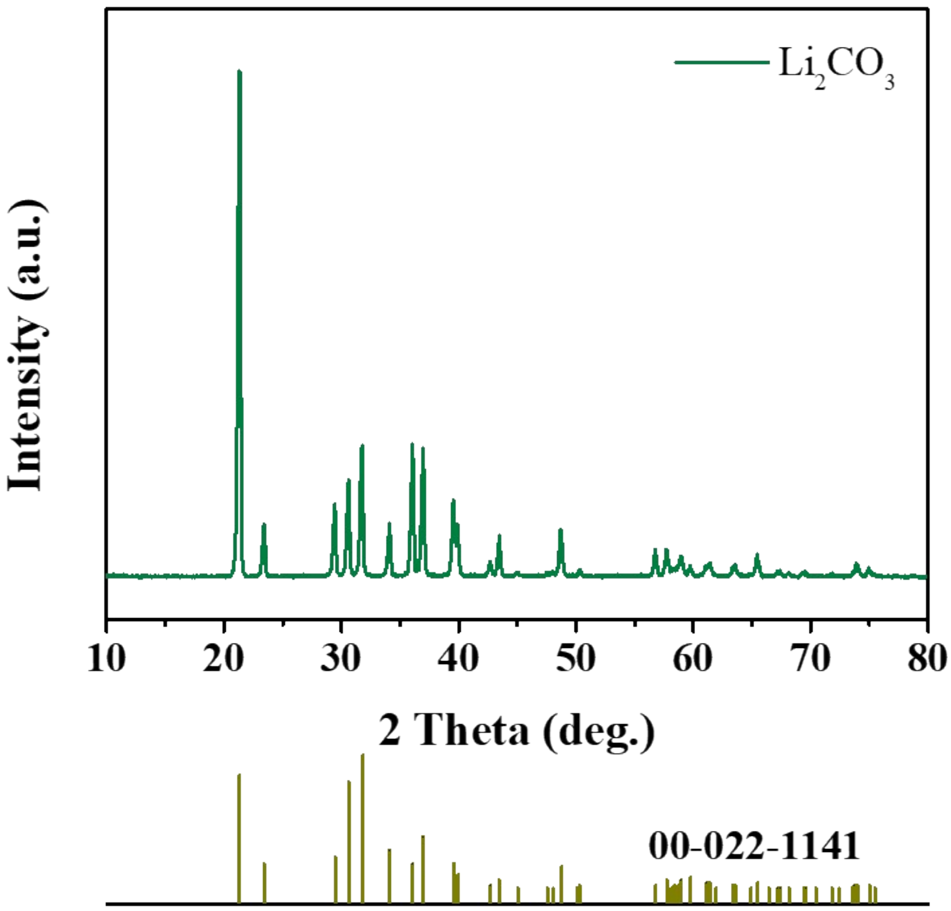

Figure S3 The XRD patterns of the Li_2CO_3 powder.

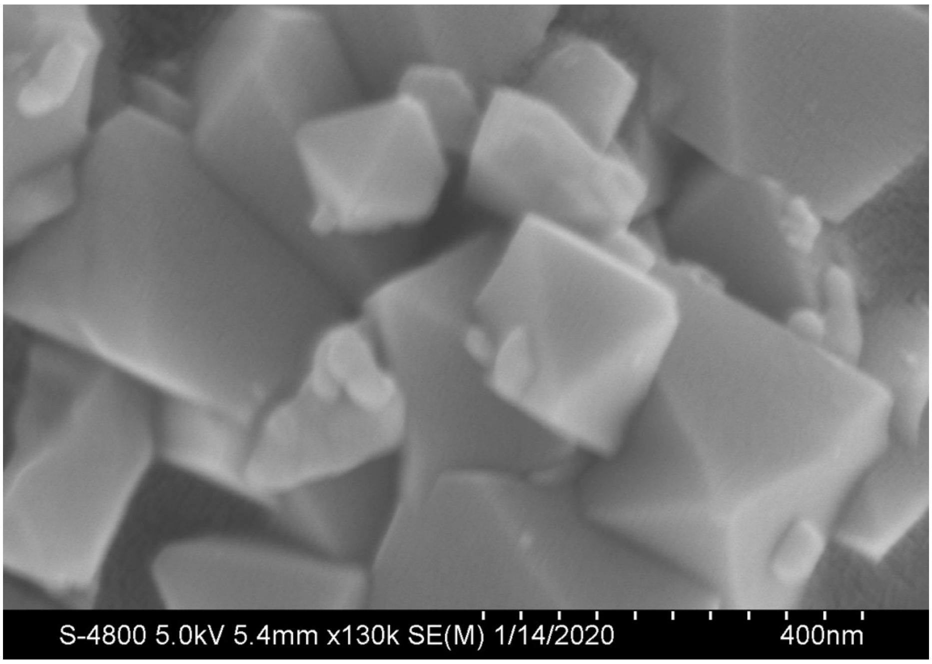

Figure S4 SEM images of Co_3O_4 particles

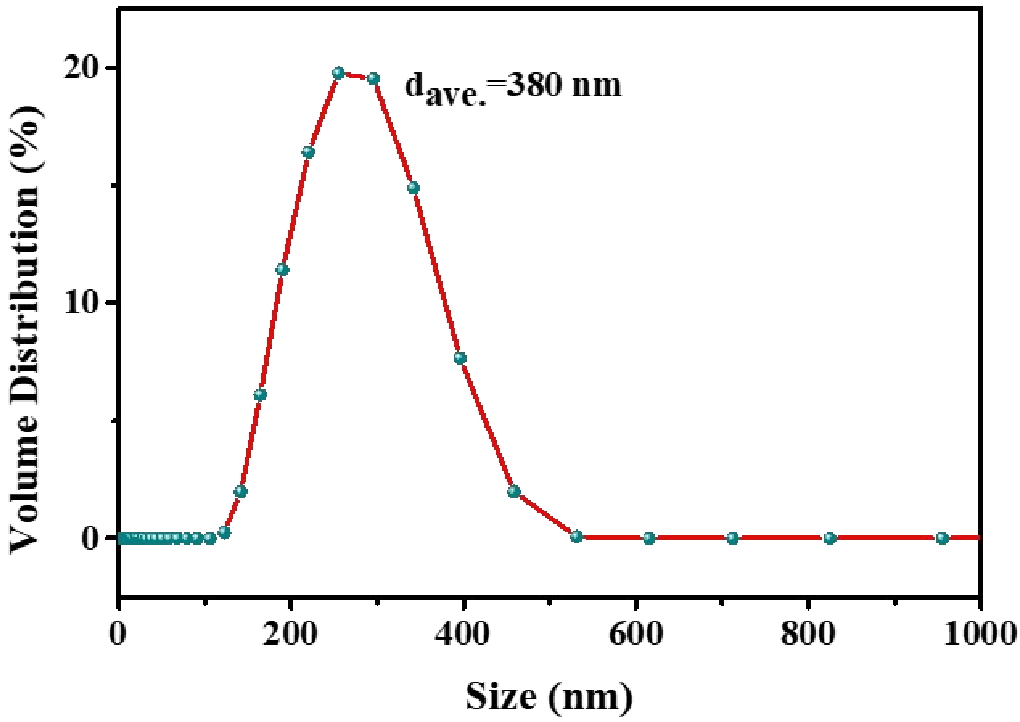

Figure S5 Particle size analysis results of the Co_3O_4 particles

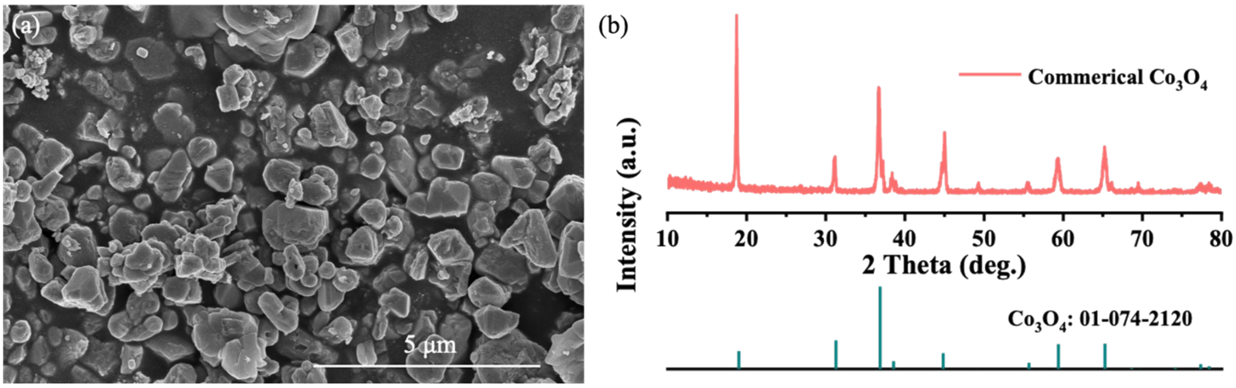

Figure S6 (a)SEM image and (b)XRD patterns of commercial Co3O4 powder.

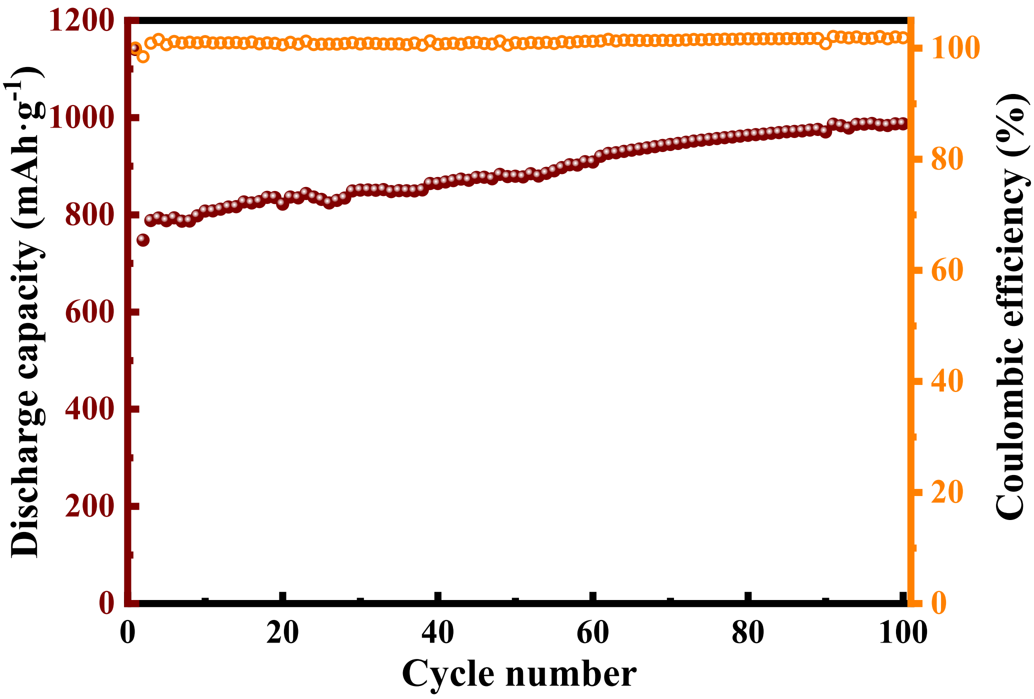

Figure S7 Cycle performance of the nano-Co_3O_4 electrode at a current density of 50 mA g^{-1}.

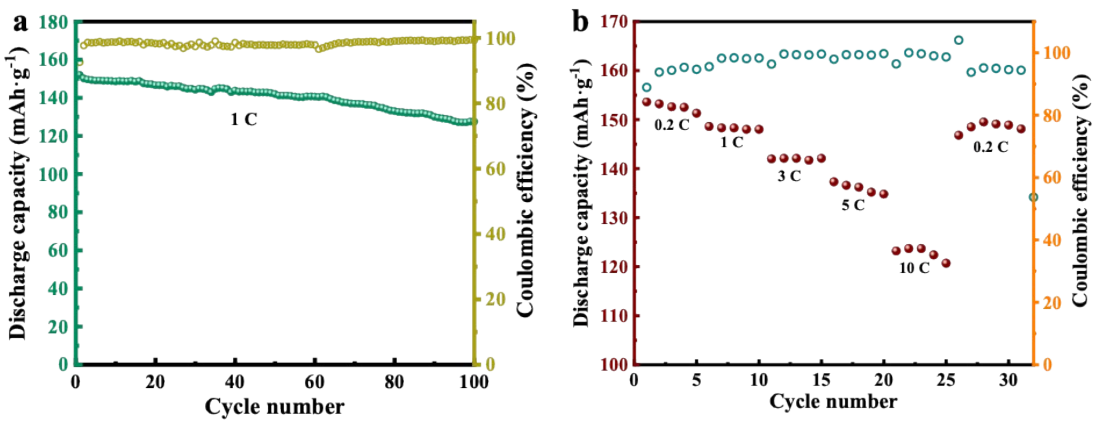

Figure S8 (a) Cycle performance of the re-synthesized $LiCoO_2$ powder at 1C (1C=150 mA h/g), (b) Discharge curves for the re-synthesized $LiCoO_2$ powder at different current densities

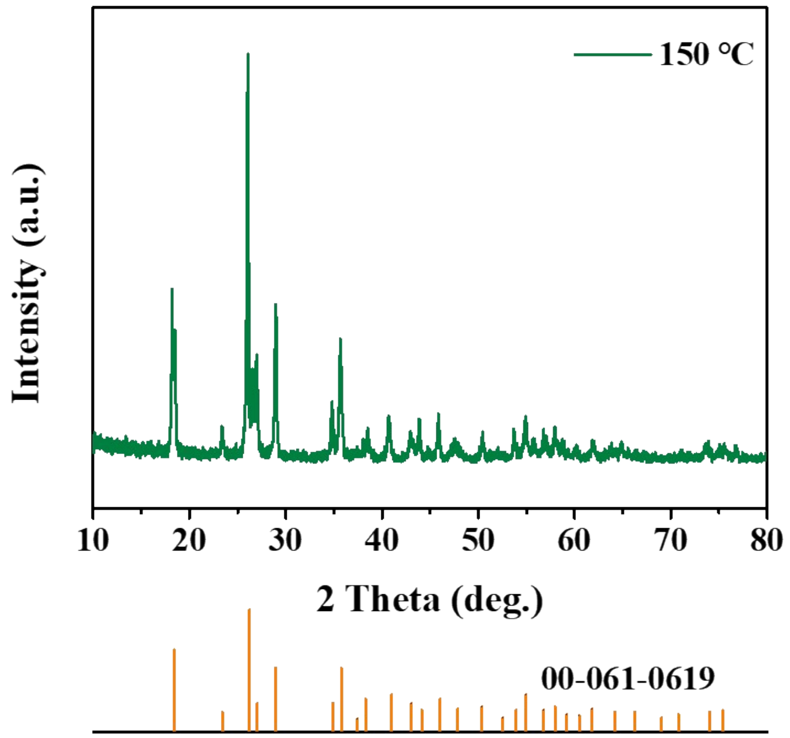

Figure S9 The XRD patterns of scrap $CoSO_4 \cdot 7H_2O$ powder. (The powder was obtained by heating CoSO4·7H2O to 150°C for 20min.)

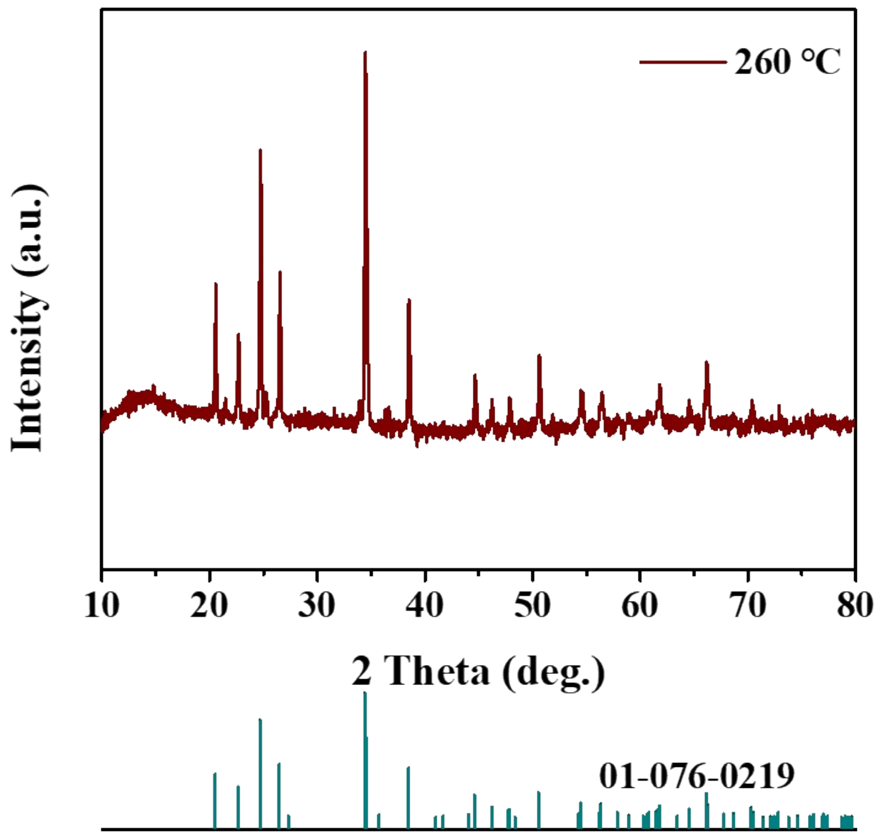

Figure S10 The XRD patterns of scrap $CoSO_4 \cdot 7H_2O$ powder. (The powder was obtained by heating CoSO4·7H2O to 260°C for 20min.)

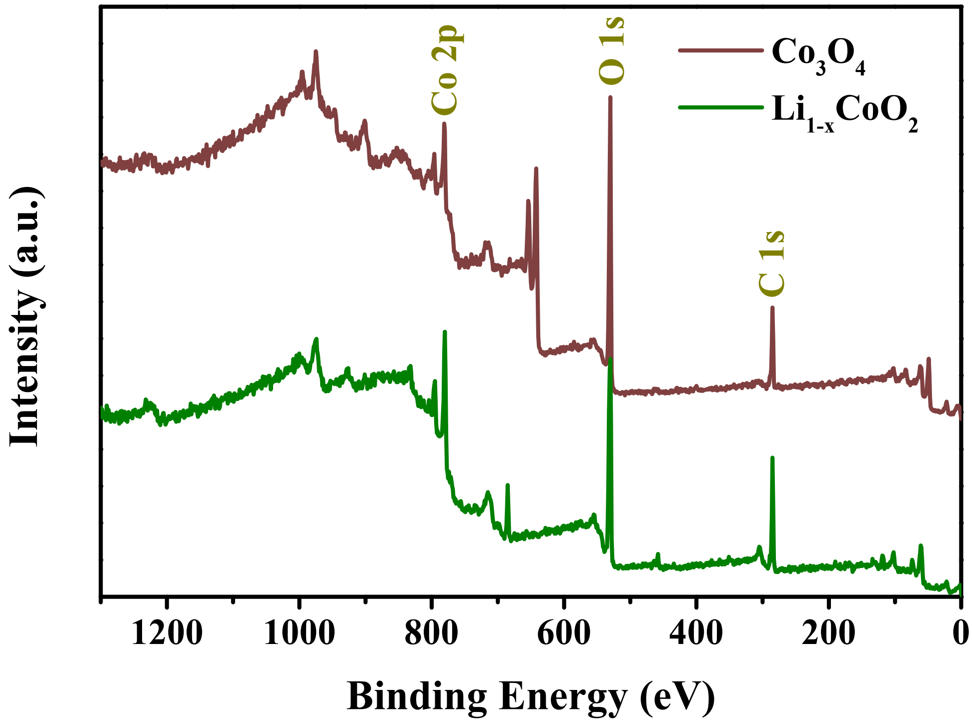

Figure S11 The XPS survey spectra of the $Li_{1-x}CoO_2$ and Co_3O_4.

Table S1 A brief review of published laboratory work on Co_3O_4

NO.	Sample	Initial capacity (mA h/g)	Charge/discharge condition	Performance (mA h/g)	Ref.
1	nanoparticles	1140	50 mA/g, 100 cycles	987.2	This work
2	Co_3O_4@Carbon Nanotube	1250	100 mA/g, 60 cycles	781	[1]
3	nanotube	928	50 mA/g, 80 cycles	380	[2]
4	nanoparticles	1109	50 mA/g, 30 cycles	970	[3]
5	hollow microspheres	1087.2	50 mA/g, 30 cycles	792.7	[4]
6	nanoparticles	1118.5	100 mA/g, 200 cycles	955.5	[5]
7	hollow-structured	1107	50 mA/g, 50 cycles	880	[6]
8	porous nanoflaked	1108	0.2 C, (1 C = 890 mA/g) ,100 cycles	908	[7]
9	MOF	1200	200 mA/g, 100 cycles	924.1	[8]

Table S2 The fit result of EIS parameters

Samples	**Element (Ω)**					
	R_s	**R_{ct}**	**CPE_1-T**	**CPE_1-P**	**W_1-R**	**W_1-T**	**W_1-P**

Nano-Co_3O_4	3.175	66.78	0.000003.4241	0.76968	137.8	0.27638	0.58672
Commercial Co_3O_4	1.95	146.2	0.00015207	0.56753	306.1	0.52531	0.69768

Table S3 Refined lattice parameters of all samples

Samples	a	c	volume	c/a	$I_{(003)}/I_{(104)}$	$I_{(006)}+I_{(012)}/I_{(104)}$
$Li_{1-x}CoO_2$	2.8144	14.0408	96.3149	4.9889	3.0347	0.9275
Co_3O_4→$LiCoO_2$	2.8143	14.0451	96.3356	4.9907	5.0975	0.4035
Commercial $LiCoO_2$	2.8159	14.0499	96.4798	4.9895	12.1334	0.7169

Table S4 Peak binding energies for all deconvoluted C 1s, O 1s and Co 2p peaks from XPS.

Peak		**Peak binding energy**	
		$Li_{1-x}CoO_2$	Co_3O_4
C 1s		284.8	284.8
		285.97	286.25
		288.66	288.3
O 1s		529.21	529.87
		529.75	531.37
		531.4	532.54
Co 2p	Co_I P3	779.27	780.04
	Co_I P1	794.35	795.34
	Co_{II} P3	780.62	781.51
	Co_{II} P1	795.86	796.87

Table S5 Electronic configuration of Co ion

Co ion	**Atomic orbital (3d)**				
Co^{3+}	↑	↑	↑	↑	
Co^{2+}	↑	↑	↑	↑	↑

Table S6 The bond length of the reactants

$LiCoO_2$	**Bond length/Å**
Li-O	1.63147
Li-Co	1.61547
Co=O	1.56039
$CoSO_4$	**Bond length/Å**
S=O	1.42715
S-O	1.61271
Co-O	1.77578

Reference:

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