

Supporting Information

Long cycle life of CoMn₂O₄ lithium ion battery anodes with high crystallinity

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Table S1. Results of whole pattern decomposition and Rietveld refinement for samples S1-S4

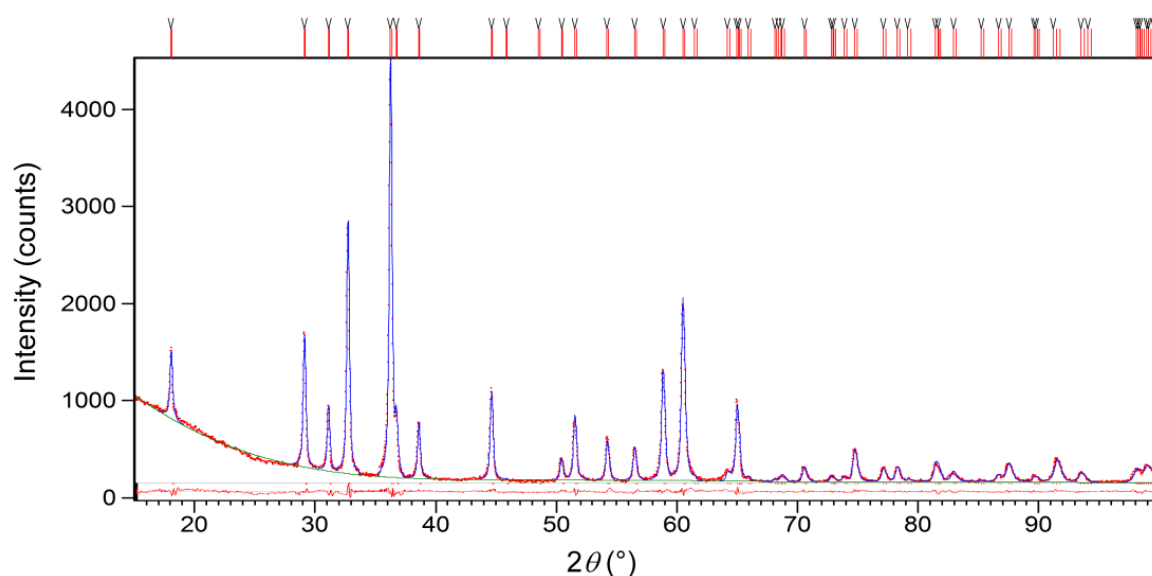
	Lattice parameters (Å)		Site occupancy		Oxygen coordinates		Isotropic displacement parameter (Å ²)			Discrepancy parameters (%)	
	a	c	A-site	B-site	y(O)	z(O)	U(A)	U(B)	U(O)	R _p	R _{wp}
S1	5.7111(4)	9.2701(4)	Co _{0.94} Mn _{0.06}	Co _{0.06} Mn _{1.94}	0.2299(1)	0.3814(2)	0.34(1)	0.45(1)	0.97(6)	4.32	5.21
S2	5.7100(4)	9.2511(4)	Co _{0.90} Mn _{0.10}	Co _{0.10} Mn _{1.90}	0.2292(1)	0.3818(2)	0.41(2)	0.51(2)	1.1(1)	4.07	5.11
S3	5.7073(5)	9.2301(3)	Co _{0.84} Mn _{0.16}	Co _{0.16} Mn _{1.84}	0.2282(1)	0.3820(2)	0.36(1)	0.56(1)	0.95(8)	3.98	4.98
S4	5.7056(4)	9.2216(6)	Co _{0.79} Mn _{0.21}	Co _{0.21} Mn _{1.79}	0.2273(1)	0.3821(1)	0.39(2)	0.49(3)	1.1(1)	4.11	5.17

Table S2. Peak frequencies of Raman bands for differently treated CoMn₂O₄ materials and single crystals of Co₃O₄ and Mn₃O₄.

#	S1	S2	S3	S4	Co ₃ O ₄ [(Hadjiev et al., 1988a)]	Mn ₃ O ₄ [(Kim et al., 2011a)]
Frequencies in cm ⁻¹						
1	178	179	179	179	194 T(F _{2g})	-
2	295	296	295	298	-	298 T(F _{2g})
3	315	317	318	319	-	328 ν ₂ (E _{2g})
4	365	366	366	369	-	371 ν ₄ (F _{2g})
5	375	377	377	377	-	
6	479	481	481	484	482 ν ₂ (E _{2g})	479 ν ₃ (F _{2g})
7	577	578	577	577	522 ν ₄ (F _{2g})	-
8	620	622	621	623	618 ν ₃ (F _{2g})	-
9	661	663	663	665	691 ν ₁ (A _{1g})	668 ν ₁ (A _{1g})

Table S3 EIS parameters obtained from fitting the equivalent circuit.

		$R_s (\Omega)$	$R_{ct} (\Omega)$
S1	Initial	0.5±0.1	530±10
	After 10 cycles	3.2±0.2	108±13
	After 100 cycles	1.0±0.8	259±18
	After 200 cycles	5.2±0.7	265±20
S2	Initial	0.3±0.1	730±10
	After 10 cycles	2.4±0.1	107±10
	After 100 cycles	3.7±0.2	127±9
	After 200 cycles	3.4±0.1	98±6
S3	Initial	0.7±0.1	1040±18
	After 10 cycles	2.8±0.1	42±2
	After 100 cycles	3.2±0.1	62±2
	After 200 cycles	4.0±0.1	97±2
S4	Initial	1.8±0.2	992±12
	After 10 cycles	3.2±0.1	43±3
	After 100 cycles	3.2±0.1	85±3
	After 200 cycles	3.6±0.1	105±2

**Figure S1.** Graphical result of the Rietveld refinement on XRPD data at RT for sample S3. The red vertical marks represent positions of diffraction lines of CoMn₂O₄. Experimental data are shown as red dots, the calculated pattern in represented by blue line while difference curve is given below in red.

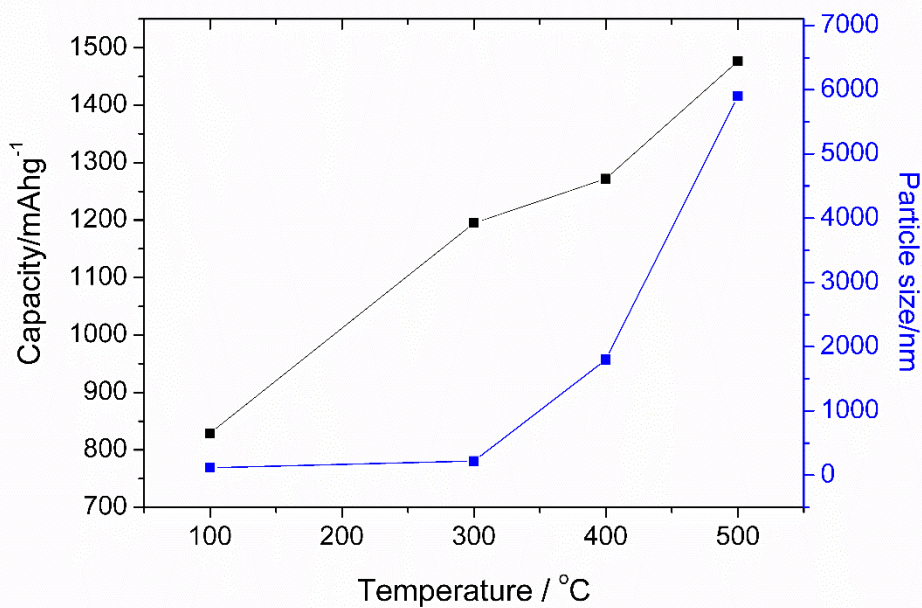


Figure S2. Particle sizes and capacity in 1st cycle for samples S0 (as prepared at 100 °C) –S4 (treated at 500 °C)

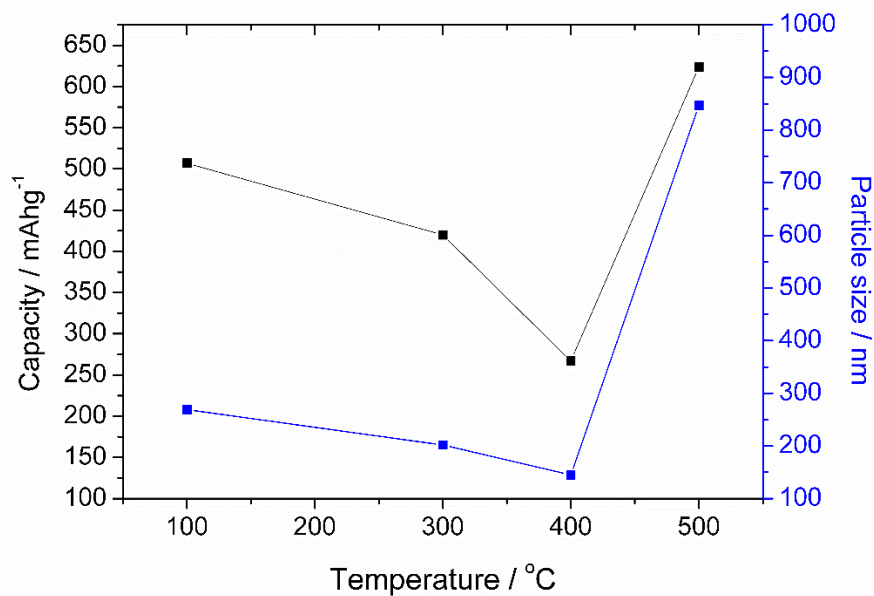


Figure S3. Particle sizes and capacity in 1000th cycle for samples S0 (as prepared at 100 °C) – S4 (treated at 500 °C)

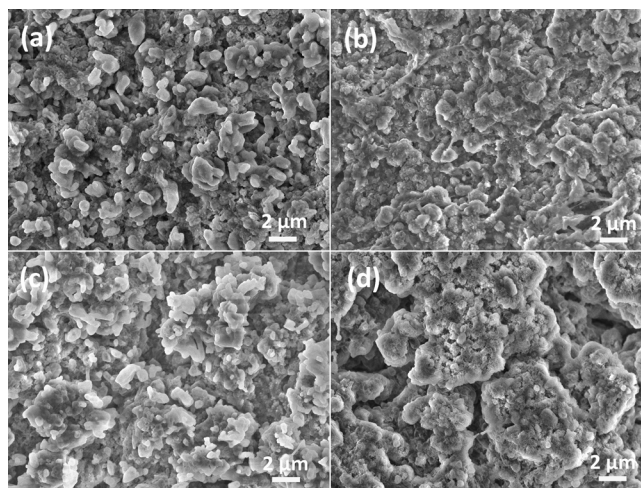


Figure S4. SEM images of CoMn₂O₄ particles for different annealing temperatures after 300 cycles: (a) as prepared (sample S1), (b) 300°C (sample S2), (c) 400°C (sample S3), and (d) 500°C (sample S4).

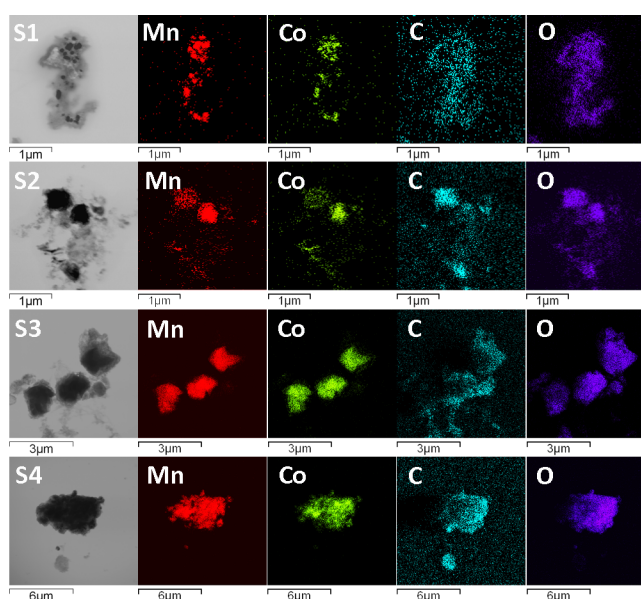


Figure S5. TEM images and corresponding element mapping of CoMn₂O₄ electrode after 300 cycles: as-prepared (sample S1), 300°C (sample S2), 400°C (sample S3) and 500°C (sample S4) (from top to bottom).

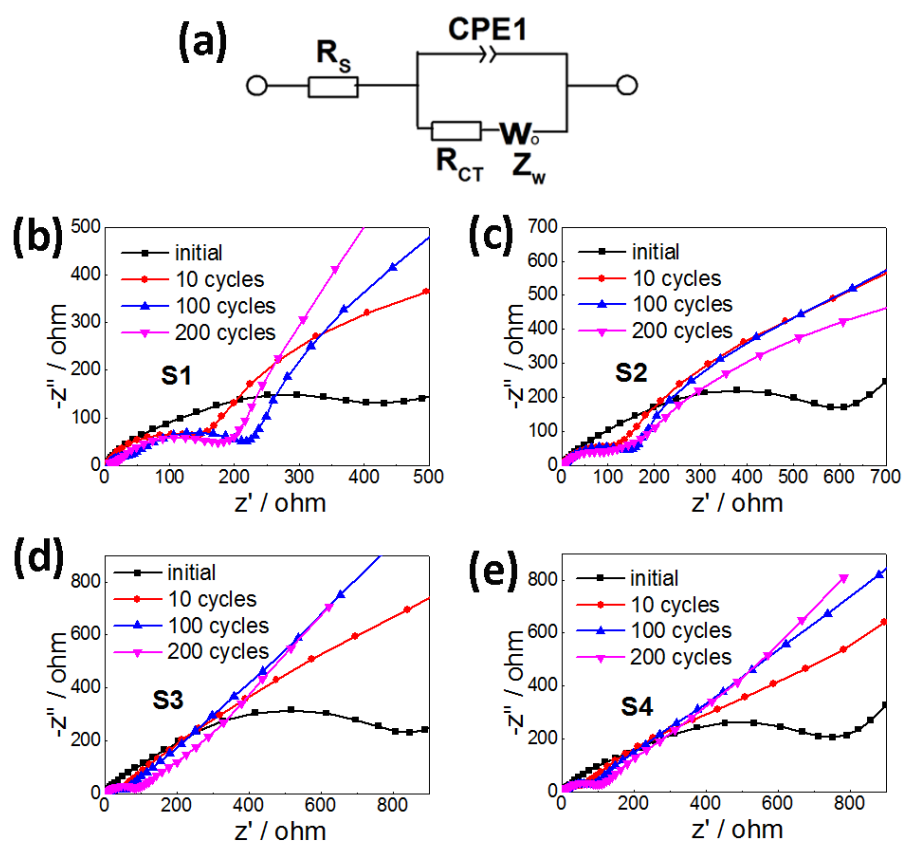


Figure S6. (a) Equivalent circuit and Nyquist plots of CoMn_2O_4 anodes for different annealing temperatures (b) as-prepared (sample S1), (c) $300\text{ }^\circ\text{C}$ (sample S2), (d) $400\text{ }^\circ\text{C}$ (sample S3), and (e) $500\text{ }^\circ\text{C}$ (sample S4) after different cycles at delithiated state over the frequency range from 100 kHz to 0.01 Hz.