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

Table S1 EXAFS fit parameters at the Mn K-edge of $0.5Li_2MnO_3 \cdot 0.5LiCoO_2$ in the pristine state. The values in parentheses indicate uncertainties to the least significant digit(s). The parameters without uncertainties were constrained in the fit.

$S_0^2 = 0.67\,(6)$						
$\Delta E_0 = 6.8\,(1.0)$						
Path[a]	N_{degen}[b]	R_{theory}[c] (Å)	α_{fit}	ΔR[d] (Å)	R_{fit}[e] (Å)	σ^2_{fit} (Å^2)
Mn-O_{n-n}	2	1.904	-0.003 (3)	-0.006 (6)	1.898 (6)	0.0023 (7)
	2	1.912		-0.006 (6)	1.906 (6)	
	2	1.919		-0.006 (6)	1.913 (6)	
Mn-TM	2	2.845	0.000 (2)	0.000 (6)	2.845 (6)	0.0010 (6)
	1	2.851		0.000 (6)	2.851 (6)	
Mn-O	2	3.513	-0.021 (8)	-0.074 (30)	3.439 (30)	0.005 (3)
	2	3.515		-0.074 (30)	3.441 (30)	
	2	3.516		-0.074 (30)	3.442 (30)	
	2	3.686		-0.077 (30)	3.609 (30)	
Mn-O	2	4.388	0.024 (6)	0.105 (28)	4.493 (28)	0.002 (2)
	2	4.390		0.105 (28)	4.495 (28)	
	2	4.395		0.105 (28)	4.500 (28)	
	2	4.578		0.110 (28)	4.688 (28)	
	2	4.579		0.110 (28)	4.689 (28)	
	2	4.587		0.110 (28)	4.697 (28)	
	2	4.594		0.110 (28)	4.704 (28)	
	2	4.599		0.110 (28)	4.709 (28)	
	2	4.638		0.111 (28)	4.749 (28)	
	2	4.672		0.112 (28)	4.784 (28)	
	2	4.693		0.113 (28)	4.806 (28)	
	2	4.721		0.113 (28)	4.834 (28)	
Mn-TM	4	4.929	0.004 (3)	0.020 (15)	4.949 (15)	0.002 (1)
	2	4.937		0.020 (15)	4.957 (15)	
	2	5.012		0.020 (15)	5.032 (15)	
	2	5.030		0.020 (15)	5.050 (15)	

[a] Scattering paths from the theoretical model
[b] N_{degen} = Degeneracy of scattering paths from the theoretical model
[c] R_{theory} = Interatomic distances from the theoretical model
[d] $\Delta R = \alpha_{fit} \times R_{theory}$
[e] $R_{fit} = R_{theory} + \Delta R$

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Table S2 EXAFS fit parameters at the Mn K-edge of $0.5Li_2MnO_3 \cdot 0.5LiCoO_2$ when charged to 4.8 V.

$S_0^2 = 0.68$ $\Delta E_0 = 5.1\,(9)$						
Path	N_{degen}	R_{theory} (Å)	α_{fit}	ΔR (Å)	R_{fit} (Å)	σ^2_{fit} (Å^2)
Mn-O_{n-n}	6.7 (6)	1.921	-0.014 (2)	-0.027 (4)	1.894 (4)	0.0066 (9)
Mn-TM	6	2.816	0.016 (2)	0.045 (6)	2.861 (6)	0.0069 (3)
Mn-O	6 2	3.409 3.661	0.016 (7)	0.055 (26) 0.059 (26)	3.419 (26) 3.672 (26)	0.009 (3)
Mn-O	12 12	4.422 4.619	-0.020 (7)	-0.088 (32) -0.092 (32)	4.334 (32) 4.527 (32)	0.009 (5)
Mn-TM	6 6	4.878 4.959	0.003 (4)	0.015 (20) 0.015 (20)	4.893 (20) 4.974 (20)	0.012 (2)

Table S3 EXAFS fit parameters at the Mn K-edge of $0.5Li_2MnO_3 \cdot 0.5LiCoO_2$ when discharged to 2.5 V.

$S_0^2 = 0.68$ $\Delta E_0 = 3.0\,(1.4)$						
Path	N_{degen}	R_{theory} (Å)	α_{fit}	ΔR (Å)	R_{fit} (Å)	σ^2_{fit} (Å^2)
Mn-O_{n-n}	4.9 (6)	1.904	-0.003 (3)	-0.006 (6)	1.898 (6)	0.003 (1)
Mn-TM	2 1	2.845 2.851	0.001 (2)	0.003 (6) 0.003 (6)	2.848 (6) 2.854 (6)	0.0019 (4)
Mn-O	2 2 2 2	3.513 3.515 3.516 3.686	-0.036 (13)	-0.127 (48) -0.127 (48) -0.127 (48) -0.133 (48)	3.386 (48) 3.388 (48) 3.389 (48) 3.553 (48)	0.011 (7)
Mn-O	2 2 2 2 2 2 2 2 2 2 2 2	4.388 4.390 4.395 4.578 4.579 4.587 4.594 4.599 4.638 4.672 4.693 4.721	0.012 (5)	0.053 (24) 0.053 (24) 0.053 (24) 0.055 (24) 0.055 (24) 0.055 (24) 0.055 (24) 0.055 (24) 0.056 (24) 0.056 (24) 0.056 (24) 0.057 (24)	4.441 (24) 4.443 (24) 4.448 (24) 4.633 (24) 4.634 (24) 4.642 (24) 4.649 (24) 4.654 (24) 4.694 (24) 4.728 (24) 4.749 (24) 4.778 (24)	0.003 (2)
Mn-TM	4 2 2 2	4.929 4.937 5.012 5.030	-0.001 (4)	-0.005 (20) -0.005 (20) -0.005 (20) -0.005 (20)	4.924 (20) 4.932 (20) 5.007 (20) 5.025 (20)	0.007 (2)

Table S4 EXAFS fit parameters at the Co K-edge of $0.5Li_2MnO_3 \cdot 0.5LiCoO_2$ in the pristine state.

$S_0^2 = 0.82\,(5)$ $\Delta E_0 = 2.5\,(7)$						
Path	N_{degen}	R_{theory} (Å)	α_{fit}	ΔR (Å)	R_{fit} (Å)	σ^2_{fit} (Å^2)
Co-O	6	1.921	-0.001 (2)	-0.002 (4)	1.919 (4)	0.0037 (6)
Co-TM	6	2.816	0.004 (1)	0.011 (3)	2.827 (3)	0.0040 (4)
Co-O	6 2	3.409 3.661	-0.002 (4)	-0.007 (15) -0.007 (15)	3.402 (15) 3.654 (15)	0.005 (2)
Co-O	12 12	4.422 4.619	0.000 (6)	0.000 (28) 0.000 (28)	4.422 (28) 4.619 (28)	0.005 (3)
Co-TM	6 6	4.878 4.959	0.005 (3)	0.024 (15) 0.025 (15)	4.902 (15) 4.984 (15)	0.008 (2)

Table S5 EXAFS fit parameters at the Co K-edge of $0.5Li_2MnO_3 \cdot 0.5LiCoO_2$ when charged to 4.8 V.

$S_0^2 = 0.78\,(6)$ $\Delta E_0 = 1.5\,(8)$						
Path	N_{degen}	R_{theory} (Å)	α_{fit}	ΔR (Å)	R_{fit} (Å)	σ^2_{fit} (Å^2)
Co-O	6	1.921	-0.013 (2)	-0.025 (4)	1.896 (4)	0.0048 (7)
Co-TM	6	2.816	0.007 (2)	0.020 (6)	2.836 (6)	0.0063 (5)
Co-O	6 2	3.409 3.661	-0.008 (5)	-0.027 (18) -0.029 (18)	3.382 (18) 3.632 (18)	0.006 (2)
Co-O	12 12	4.422 4.619	-0.002 (8)	-0.009 (37) -0.009 (37)	4.413 (37) 4.610 (37)	0.007 (4)
Co-TM	6 6	4.878 4.959	0.002 (4)	0.010 (20) 0.010 (20)	4.888 (20) 4.969 (20)	0.011 (2)

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Table S6 EXAFS fit parameters at the Co K-edge of $0.5Li_2MnO_3 \cdot 0.5LiCoO_2$ when discharged to 2.5 V.

$S_0^2 = 0.78\,(4)$ $\Delta E_0 = 1.7\,(6)$						
Path	N_{degen}	R_{theory} (Å)	α_{fit}	ΔR (Å)	R_{fit} (Å)	σ^2_{fit} (Å^2)
Co-O	6	1.921	-0.003 (2)	-0.006 (4)	1.915 (4)	0.0042 (5)
Co-TM	6	2.816	0.006 (1)	0.017 (3)	2.833 (3)	0.0050 (4)
Co-O	6 2	3.409 3.661	-0.001 (4)	-0.003 (15) -0.003 (15)	3.406 (15) 3.657 (15)	0.005 (1)
Co-O	12 12	4.422 4.619	0.002 (6)	0.009 (28) 0.009 (28)	4.431 (28) 4.628 (28)	0.006 (3)
Co-TM	6 6	4.878 4.959	0.009 (3)	0.043 (15) 0.045 (15)	4.921 (15) 5.004 (15)	0.010 (2)

Table S7 Statistical EXAFS fit parameters at the Mn and Co K-edges of $0.5Li_2MnO_3 \cdot 0.5LiCoO_2$ in the pristine, charged and discharged states.

K-edge	State of cathode	Δk (Å^{-1})	ΔR (Å)	N_{idp}	N_{vary}	ν	χ^2	χ^2_ν	R
Mn	Pristine	3.8 - 12.5	1.0 - 5.1	23	12	11	237	22	0.016
	4.8 V	3.8 - 11.7	1.1 - 5.0	19	12	7	68	10	0.005
	2.5 V	3.8 - 12.3	1.2 - 5.0	20	12	8	83	10	0.014
Co	Pristine	3.8 - 12.4	1.2 - 4.9	20	12	8	11	2	0.005
	4.8V	3.7 - 12.2	1.2 - 4.9	20	12	8	42	5	0.007
	2.5V	3.7 - 12.3	1.2 - 4.9	20	12	8	43	6	0.004

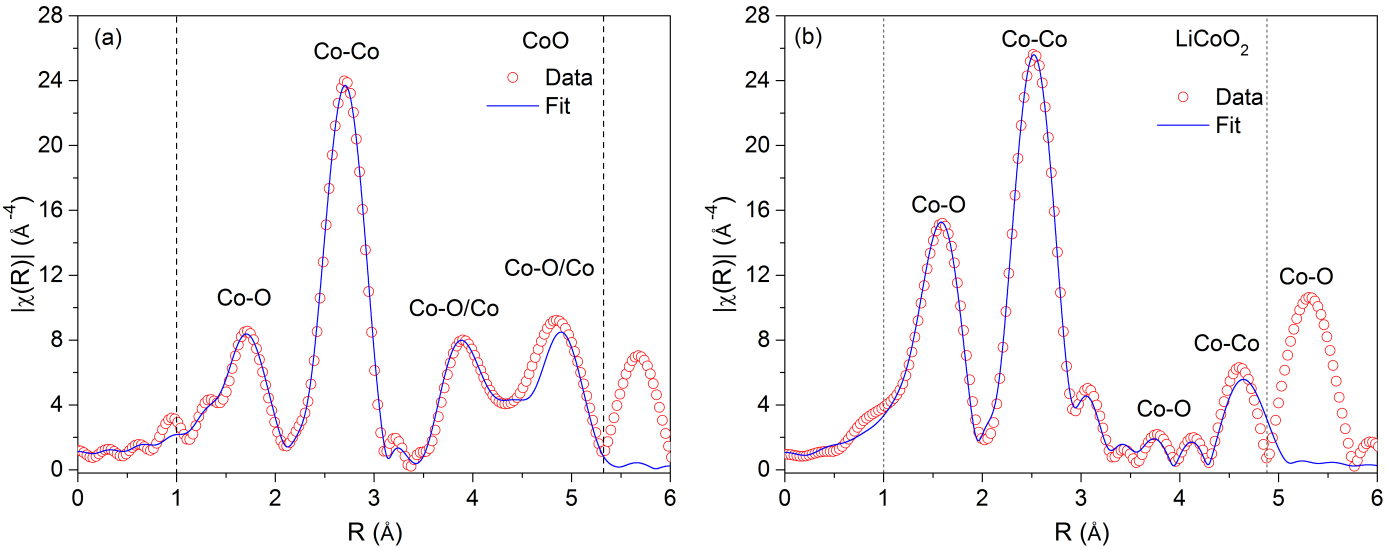

Fig. S1 EXAFS fits to the data of (a) CoO and (b) $LiCoO_2$ reference compounds.

Table S8 EXAFS fit parameters for the 1st shell of O atoms around Co absorbers in CoO and $LiCoO_2$ reference compounds.

Sample	Degeneracy of O atoms	R_{theory} (Å)	ΔR (Å)	R_{fit} (Å)	σ^2_{fit} (Å^2)
CoO	6	2.133	-0.013 (11)	2.120 (11)	0.0085 (1)
$LiCoO_2$	6	1.921	-0.006 (4)	1.915 (4)	0.0039 (6)

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