

Fast Charge Storage Kinetics by Surface Engineering for Ni-Rich Layered Oxide Cathode

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Table S 1. Element composition of NCM-A2, NCM-S0 and NCM-W3 measured by ICP.

Sample	Li content (wt.%)	Ni content (wt.%)	Co content (wt.%)	Mn content (wt.%)
NCM-A2	7.7271	48.4030	7.1868	2.7350
NCM-S0	7.1215	49.4750	7.4864	2.8243
NCM-W3	7.0148	51.4457	7.4276	2.8990

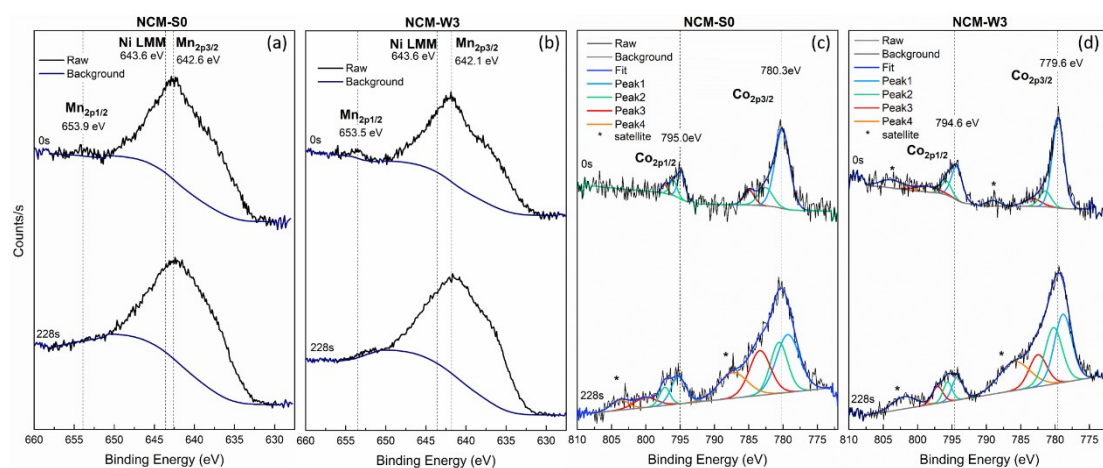


Figure S1. XPS spectra of Mn for NCM-S0 (a) and NCM-W3 (b); XPS spectra of Co for NCM-S0 (c) and NCM-W3 (d).

Table S1. XPS spectral features for $\text{LiNi}_{0.83}\text{Co}_{0.11}\text{Mn}_{0.06}\text{O}_2$ (NCM-S0).

$\text{LiNi}_{0.83}\text{Co}_{0.11}\text{Mn}_{0.06}\text{O}_2$ (NCM-S0)				
Etch time (s)	Element/Transition	Binding Energy (eV)	Concentration (at. %)	Peak Assignment
0	Li 1s	54.78	21.76	Li_2CO_3
	Co2p3/2	780.2	0.82	Co in $\text{LiNi}_{0.83}\text{Co}_{0.11}\text{Mn}_{0.06}\text{O}_2$
	Co2p3/2	784.09	0.2	Satellite
	Ni2p3/2	855.1	2.83	Ni^{2+} in $\text{LiNi}_{0.83}\text{Co}_{0.11}\text{Mn}_{0.06}\text{O}_2$
	Ni2p3/2	860.77	2.83	Satellite
	Ni2p3/2	856.32	1.08	Ni^{3+} in $\text{LiNi}_{0.83}\text{Co}_{0.11}\text{Mn}_{0.06}\text{O}_2$
	Ni2p3/2	864.08	2.05	Satellite
	Ni2p1/2	872.76	0.41	Ni^{2+} in $\text{LiNi}_{0.83}\text{Co}_{0.11}\text{Mn}_{0.06}\text{O}_2$
	Ni2p1/2	879.92	0.39	Satellite
	Ni2p1/2	875.65	1.27	Ni^{3+} in $\text{LiNi}_{0.83}\text{Co}_{0.11}\text{Mn}_{0.06}\text{O}_2$
	Ni2p1/2	883.78	1.27	Satellite
	Mn2p1/2	653.79	0.23	Mn in $\text{LiNi}_{0.83}\text{Co}_{0.11}\text{Mn}_{0.06}\text{O}_2$
	C1s	284.82	16.97	Adventitious carbon
	C1s	289.68	5.71	Li_2CO_3
	C1s	286.68	2.05	Hydrocarbon
	O1s	528.52	6.86	Li_2O
	O1s	531.61	26.88	$\text{LiOH/Li}_2\text{CO}_3$
	O1s	529.57	6.39	O in $\text{LiNi}_{0.83}\text{Co}_{0.11}\text{Mn}_{0.06}\text{O}_2$
228	Li 1s	54.45	8.56	Li_2CO_3
	Li 1s	53.66	3.66	Li in $\text{LiNi}_{0.83}\text{Co}_{0.11}\text{Mn}_{0.06}\text{O}_2$

	Co2p3/2	780.09	1.77	Co in LiNi _{0.83} Co _{0.11} Mn _{0.06} O ₂
	Co2p3/2	784.29	1.62	Satellite
	Ni2p3/2	854.33	4.33	Ni ²⁺ in LiNi _{0.83} Co _{0.11} Mn _{0.06} O ₂
	Ni2p3/2	860.84	4.33	Satellite
	Ni2p3/2	855.85	1.17	Ni ³⁺ in LiNi _{0.83} Co _{0.11} Mn _{0.06} O ₂
	Ni2p3/2	862.44	2.15	Satellite
	Ni2p1/2	872.06	2.87	Ni ²⁺ in LiNi _{0.83} Co _{0.11} Mn _{0.06} O ₂
	Ni2p1/2	879.04	1.43	Satellite
	Ni2p1/2	874.64	4.99	Ni ³⁺ in LiNi _{0.83} Co _{0.11} Mn _{0.06} O ₂
	Ni2p1/2	881.57	5	Satellite
	Mn2p1/2	652.7	0.09	Mn in LiNi _{0.83} Co _{0.11} Mn _{0.06} O ₂
	C1s	284.8	19.5	Adventitious carbon
	C1s	289.18	3.61	Li ₂ CO ₃
	O1s	528.08	5.32	Li ₂ O
	O1s	531.64	15.61	LiOH/Li ₂ CO ₃
	O1s	529.74	13.98	O in LiNi _{0.83} Co _{0.11} Mn _{0.06} O ₂

Table S2. XPS spectral features for LiNi_{0.83}Co_{0.11}Mn_{0.06}O₂ (NCM-W3).

LiNi _{0.83} Co _{0.11} Mn _{0.06} O ₂ (NCM-W3)				
Etch time (s)	Element/ Transition	Binding Energy (eV)	Concentration (at. %)	Peak Assignment
0	Li 1s	53.34	8.31	Li in LiNi _{0.83} Co _{0.11} Mn _{0.06} O ₂
	Li 1s	54.8	4.33	Li ₂ CO ₃
	Co2p3/2	779.68	1.2	Co in LiNi _{0.83} Co _{0.11} Mn _{0.06} O ₂
	Co2p3/2	788.95	0.04	Satellite
	Ni2p3/2	854.2	2.41	Ni ²⁺ in LiNi _{0.83} Co _{0.11} Mn _{0.06} O ₂
	Ni2p3/2	860.47	1.68	Satellite
	Ni2p3/2	855.42	2.69	Ni ³⁺ in LiNi _{0.83} Co _{0.11} Mn _{0.06} O ₂
	Ni2p3/2	863.69	0.34	Satellite
	Ni2p1/2	871.7	2.41	Ni ²⁺ in LiNi _{0.83} Co _{0.11} Mn _{0.06} O ₂
	Ni2p1/2	877.82	1.73	Satellite
	Ni2p1/2	873.28	2.69	Ni ³⁺ in LiNi _{0.83} Co _{0.11} Mn _{0.06} O ₂
	Ni2p1/2	880.71	3.14	Satellite
	Mn2p1/2	653.5	0.37	Mn in LiNi _{0.83} Co _{0.11} Mn _{0.06} O ₂
	C1s	284.79	20.49	Adventitious carbon
	C1s	289.47	2.74	Li ₂ CO ₃
	C1s	285.48	5	Hydrocarbon
O1s	531.65	20.91	LiOH/Li ₂ CO ₃	
O1s	528.78	19.53	O in LiNi _{0.83} Co _{0.11} Mn _{0.06} O ₂	
228	Li 1s	53.26	6.11	Li in LiNi _{0.83} Co _{0.11} Mn _{0.06} O ₂
	Li 1s	54.73	2.53	Li ₂ CO ₃
	Co2p3/2	779.46	2.03	Co in LiNi _{0.83} Co _{0.11} Mn _{0.06} O ₂

	Co2p3/2	783.03	2.27	Satellite
	Ni2p3/2	853.33	4.38	Ni ²⁺ in LiNi _{0.83} Co _{0.11} Mn _{0.06} O ₂
	Ni2p3/2	860.41	6.97	Satellite
	Ni2p3/2	855	7.24	Ni ³⁺ in LiNi _{0.83} Co _{0.11} Mn _{0.06} O ₂
	Ni2p3/2	865.29	1.27	Satellite
	Ni2p1/2	870.99	4.39	Ni ²⁺ in LiNi _{0.83} Co _{0.11} Mn _{0.06} O ₂
	Ni2p1/2	877.1	2.95	Satellite
	Ni2p1/2	872.91	7.24	Ni ³⁺ in LiNi _{0.83} Co _{0.11} Mn _{0.06} O ₂
	Ni2p1/2	880.09	6	Satellite
	Mn2p1/2	653.04	0.17	Mn in LiNi _{0.83} Co _{0.11} Mn _{0.06} O ₂
	C1s	284.8	8.21	Adventitious carbon
	C1s	288.97	2.57	Li ₂ CO ₃
	O1s	531.05	12.55	LiOH/Li ₂ CO ₃
	O1s	528.71	23.1	O in LiNi _{0.83} Co _{0.11} Mn _{0.06} O ₂

Table S3. Proportions of different species in LiNi_{0.83}Co_{0.11}Mn_{0.06}O₂ (NCM-S0) measured by XPS.

	LiNi _{0.83} Co _{0.11} Mn _{0.06} O ₂ (NCM-S0) species proportion (%)						
Etch time (s)	Ni ²⁺	Ni ³⁺	Co	Mn	Li ₂ O	Li ₂ CO ₃	Ni/Co/Mn
0	11.37	5.10	3.15	0.64	43.51	36.22	81/16/3
228	15.92	18.36	9.48	0.15	33.39	22.70	78/22/0

Table S4. Proportions of different species in LiNi_{0.83}Co_{0.11}Mn_{0.06}O₂ (NCM-W3) measured by XPS.

	LiNi _{0.83} Co _{0.11} Mn _{0.06} O ₂ (NCM-W3) species proportion (%)					
Etch time (s)	Ni ²⁺	Ni ³⁺	Co	Mn	Li ₂ CO ₃	Ni/Co/Mn
0	29.65	33.09	11.47	3.87	21.91	80/15/5
228	24.98	41.30	14.93	0.59	18.20	81/18/1