

Supplementary Information

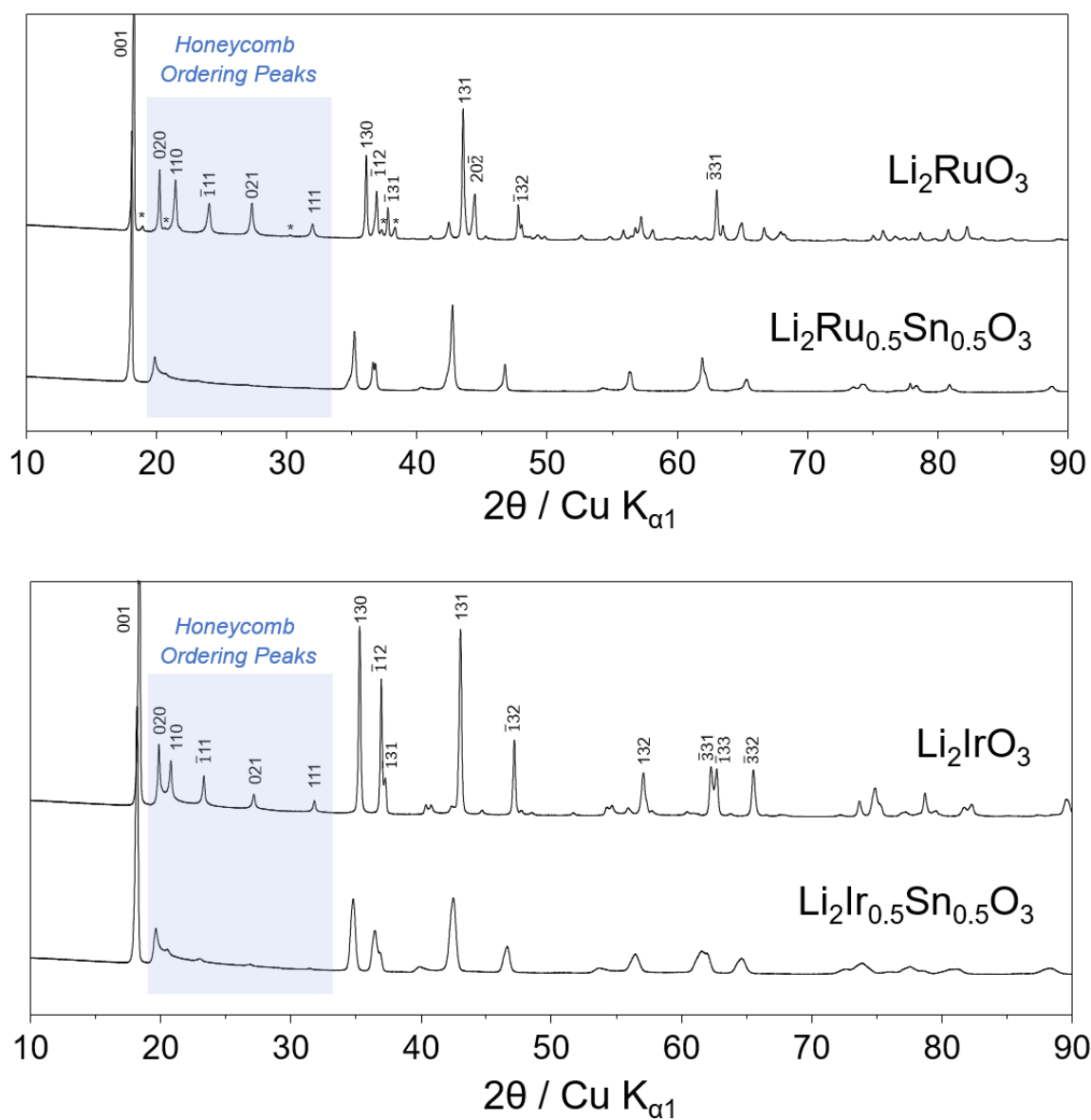
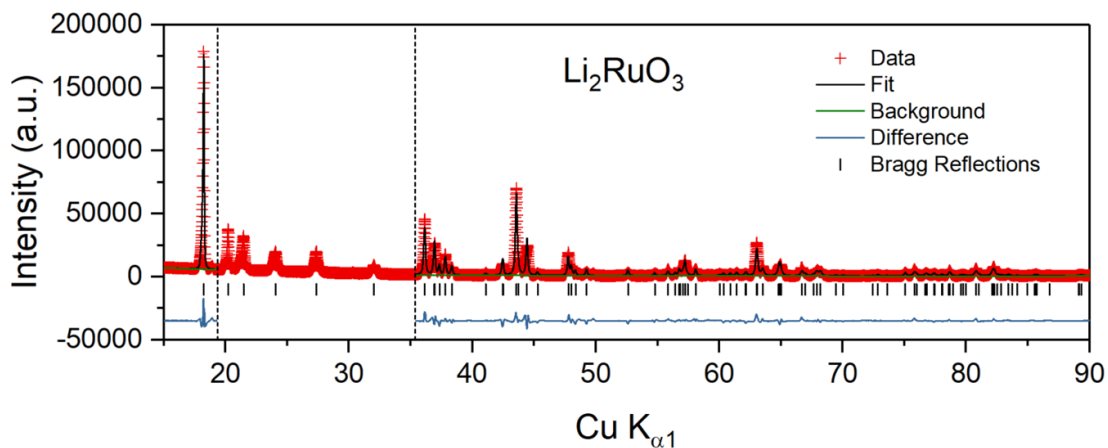
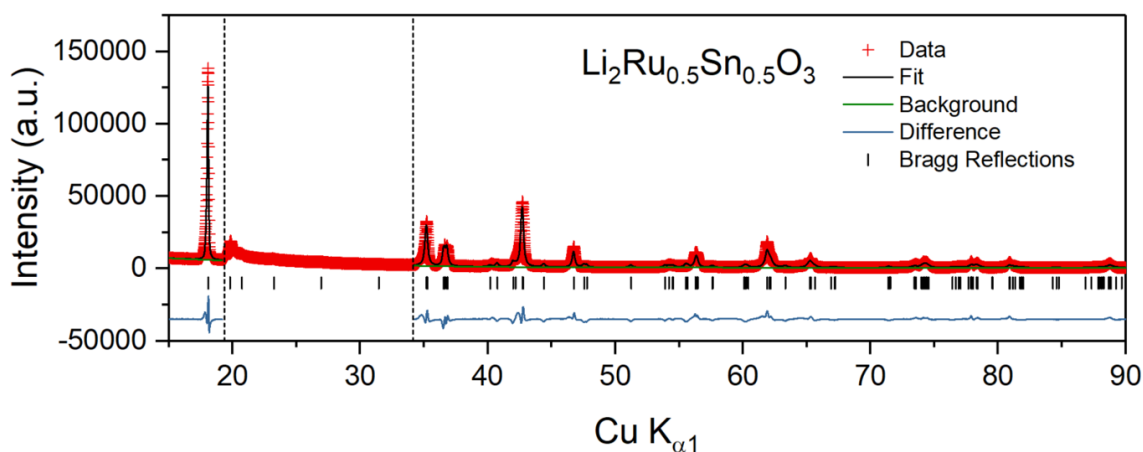


Figure S1 Powder X-ray diffraction patterns for the pristine cathode materials indexed to the $C2/m$ space group. The peaks arising from the in-plane honeycomb ordering are highlighted. The superstructure peaks for the Sn-substituted samples exhibit substantial asymmetric peak broadening arising from stacking faults between the honeycomb ordered layers as previously reported. Additional Bragg peaks in the superlattice region labelled* in Li_2RuO_3 arise from slight distortions of Ru to form Ru-Ru dimers as discussed elsewhere.



Atom	Wyckoff Position	x	y	z	Occupancy	U_{iso}
Ru	4g	0	0.1721(2)	0	1	0.0187(5)
Li	2b	0	0.5	0	1	0.01
Li	2c	0	0	0.5	1	0.01
Li	4h	0	0.3333	0.5	1	0.01
O	4i	0.223(1)	0	0.237(1)	1	0.01
O	8j	0.255(1)	0.330(1)	0.231(1)	1	0.01

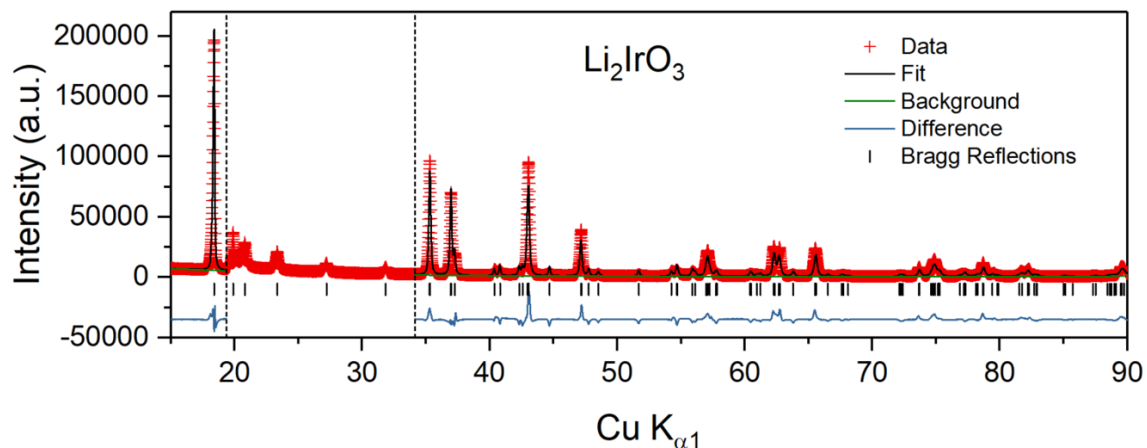
Space Group: C2/m, a = 4.941(1), b = 8.780(1), c = 5.120(1), β = 108.303(2). χ^2 = 9.5



Atom	Wyckoff Position	x	y	z	Occupancy	U_{iso}
Ru / Sn	4g	0	0.1656(3)	0	0.5 / 0.5	0.0282(9)
Li	2b	0	0.5	0	1	0.01
Li	2c	0	0	0.5	1	0.01
Li	4h	0	0.3333	0.5	1	0.01
O	4i	0.185(4)	0	0.206(1)	1	0.01
O	8j	0.221(3)	0.321(2)	0.241(2)	1	0.01

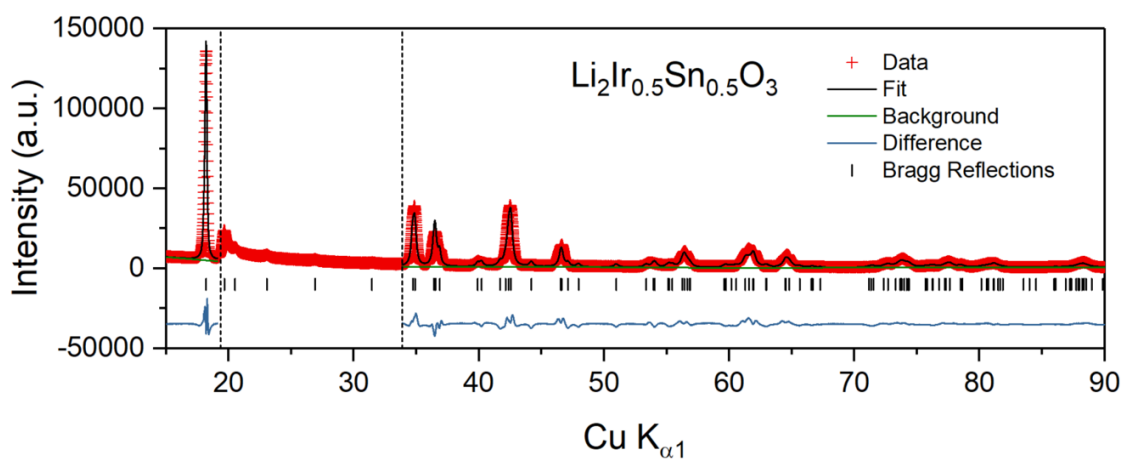
Space Group: C2/m, a = 5.166(4), b = 8.964(1), c = 5.192(4), β = 109.309(1). χ^2 = 12.2

Figure S2 Rietveld Refinements for pristine ruthenates cathodes. Superstructure peaks between $2\theta = 18^\circ$ and 34° have been omitted from the refinement due to the asymmetric peak broadening which conventional rietveld refinement cannot capture.



Atom	Wyckoff Position	x	y	z	Occupancy	U_{iso}
Ir	4g	0	0.1650(2)	0	1	0.0197(6)
Li	2b	0	0.5	0	1	0.01
Li	2c	0	0	0.5	1	0.01
Li	4h	0	0.3333	0.5	1	0.01
O	4i	0.168(4)	0	0.190(4)	1	0.01
O	8j	0.230(4)	0.324(2)	0.240(2)	1	0.01

Space Group: C2/m, a = 5.162(2), b = 8.928(1), c = 5.123(2), β = 109.744(5). χ^2 = 15.0



Atom	Wyckoff Position	x	y	z	Occupancy	U_{iso}
Ir / Sn	4g	0	0.1651(3)	0	0.5 / 0.5	0.0207(7)
Li	2b	0	0.5	0	1	0.01
Li	2c	0	0	0.5	1	0.01
Li	4h	0	0.3333	0.5	1	0.01
O	4i	0.167(4)	0	0.189(4)	1	0.01
O	8j	0.227(4)	0.328(2)	0.225(2)	1	0.01

Space Group: C2/m, a = 5.242(4), b = 9.028(1), c = 5.178(4), β = 109.814(1). χ^2 = 13.4

Figure S3 Rietveld Refinements for pristine iridate cathodes. Superstructure peaks between $2\theta = 18^\circ$ and 34° have been omitted from the refinement due to the asymmetric peak broadening which conventional rietveld refinement cannot capture.

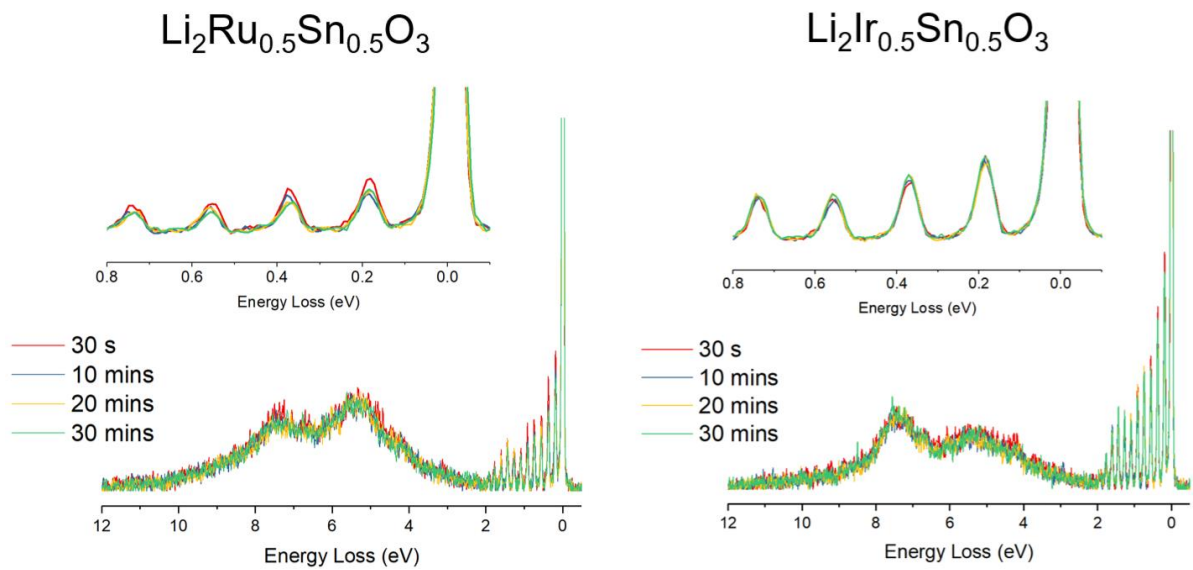


Figure S4 RIXS beam sensitivity studies for charged $\text{Li}_2\text{Ru}_{0.5}\text{Sn}_{0.5}\text{O}_3$ and $\text{Li}_2\text{Ir}_{0.5}\text{Sn}_{0.5}\text{O}_3$ cathode materials measured using an excitation energy of 531 eV at 20K. Spectra were continually acquired every 30s for up to 30 mins at the same sample location. Only a slight decrease in intensity is observed over time for $\text{Li}_2\text{Ru}_{0.5}\text{Sn}_{0.5}\text{O}_3$ and there is little change for $\text{Li}_2\text{Ir}_{0.5}\text{Sn}_{0.5}\text{O}_3$.