Electrochemistry and Structure of the Cobalt-free Li$_{1+x}$MO$_2$ ($M = \text{Li, Ni, Mn, Fe}$) Composite Cathode

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Supporting information

**Figure S1.** Operando NPD data detailing the graphite 002 reflection during battery charge and discharge, with the intensity (arbitrary units) scale given on the right (top). The battery voltage and current profile is also shown (bottom). The inset (top) highlights the battery voltage during the electrolyte decomposition that causes the drop in NPD background intensity (top) and is identified by the red box in the voltage curve (bottom).

**Figure S2.** Operando NPD anode reflections corresponding to the lithiation and delithiation of graphite during charge and discharge, respectively, in the second cycle. The intensity ratios are determined by Gaussian peak-fitting (see Figure S3).
Figure S3. Gaussian peak-fitting for graphite, LiC\textsubscript{18}, and LiC\textsubscript{12} 002 reflections at (a) 2 V, (b) 4.2 V, and (c) 4.5 V during charging and at (d) 3.3 V and (e) 2.0 V during discharging. Data are shown as black crosses, a flat background as an olive line, with Gaussian functions in varying colors (graphite: blue, LiC\textsubscript{18}: orange, and LiC\textsubscript{12}: magenta) and the total is the red solid line through the data points.
Figure S4. Intensity contour plot of the cathode 006/012 reflections in the in-situ NPD data during battery cycling.

Figure S5. Intensity contour plot of the cathode 018 reflections in the in-situ NPD data during battery cycling.
**Figure S6.** Simulated NPD patterns of LNMFOD with various oxygen positional parameter (z). Patterns are offset by 5° on the x-axis and by 20 a.u. on the y-axis for clarity.

**Figure S7.** AC-impedance (Nyquist) plot of a LNMFOD-containing coin-cell before and after 100 cycles.