Synthesis and characterization of LiNi 0.85 Mn 0.075 Co 0.075 O 2 cathode for Li-ion batteries

Nicholas Du
Binghamton University--SUNY

Anshika Goel
Binghamton University--SUNY

Effects of calcination temperatures on $LiNi_{0.85}Mn_{0.075}Co_{0.075}O_2$ (NMC)

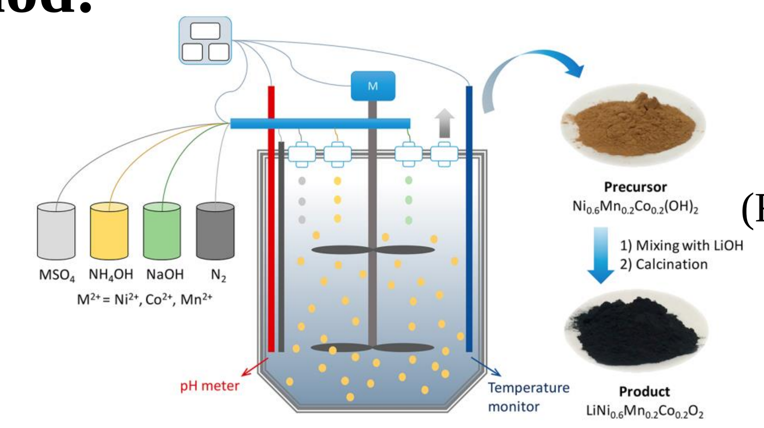
Nicholas Du, Anshika Goel, and M. Stanley Whittingham

Introduction:

Ni-rich NMC (Ni ≥ 80%) are state-of-the-art cathode materials for Lithium-ion batteries which are currently used in electric and hybrid electric vehicles. This material is sensitive to the synthesis parameters such as *pH*, stirring rate, etc. which requires extensive tweaking to produce the most optimized material. In this study, we are showing the optimization of the synthesis temperature for $LiNi_{0.85}Mn_{0.075}Co_{0.075}O_2$ [Step 2].

Method:

Step 1



(Ren et al.)

Figure 1. Diagram of continuous stirred tank reactor (CSTR) that produces precursor material

Figure 2. NMC hydroxide after washing, filtering, drying, and sieving at 25 µm

Step 2

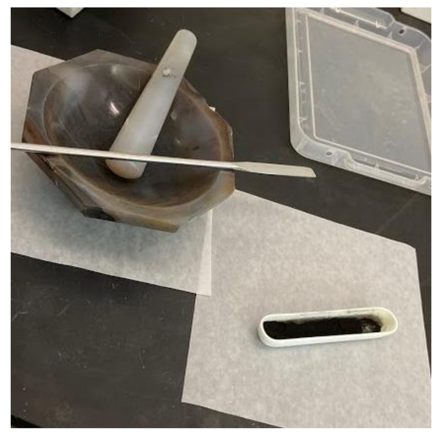


Figure 3. Black powder in boat is NMC after LiOH mixing and heating

Step 3

Step 4

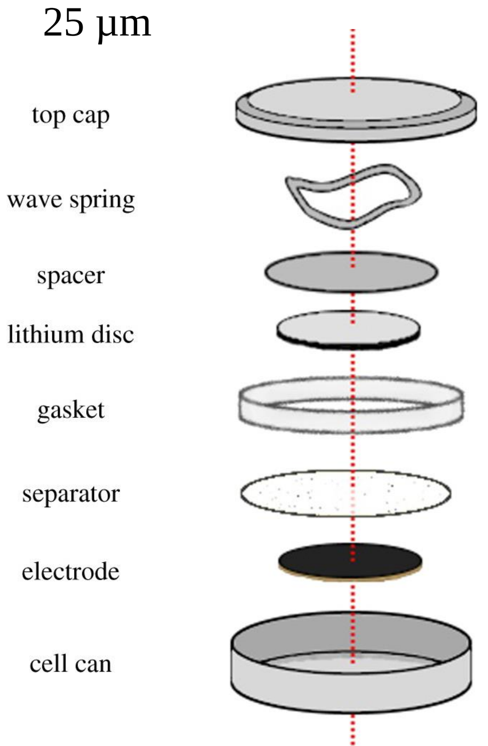


Figure 4. Schematic of the parts used to produce a coin cell (Gorman et al.)

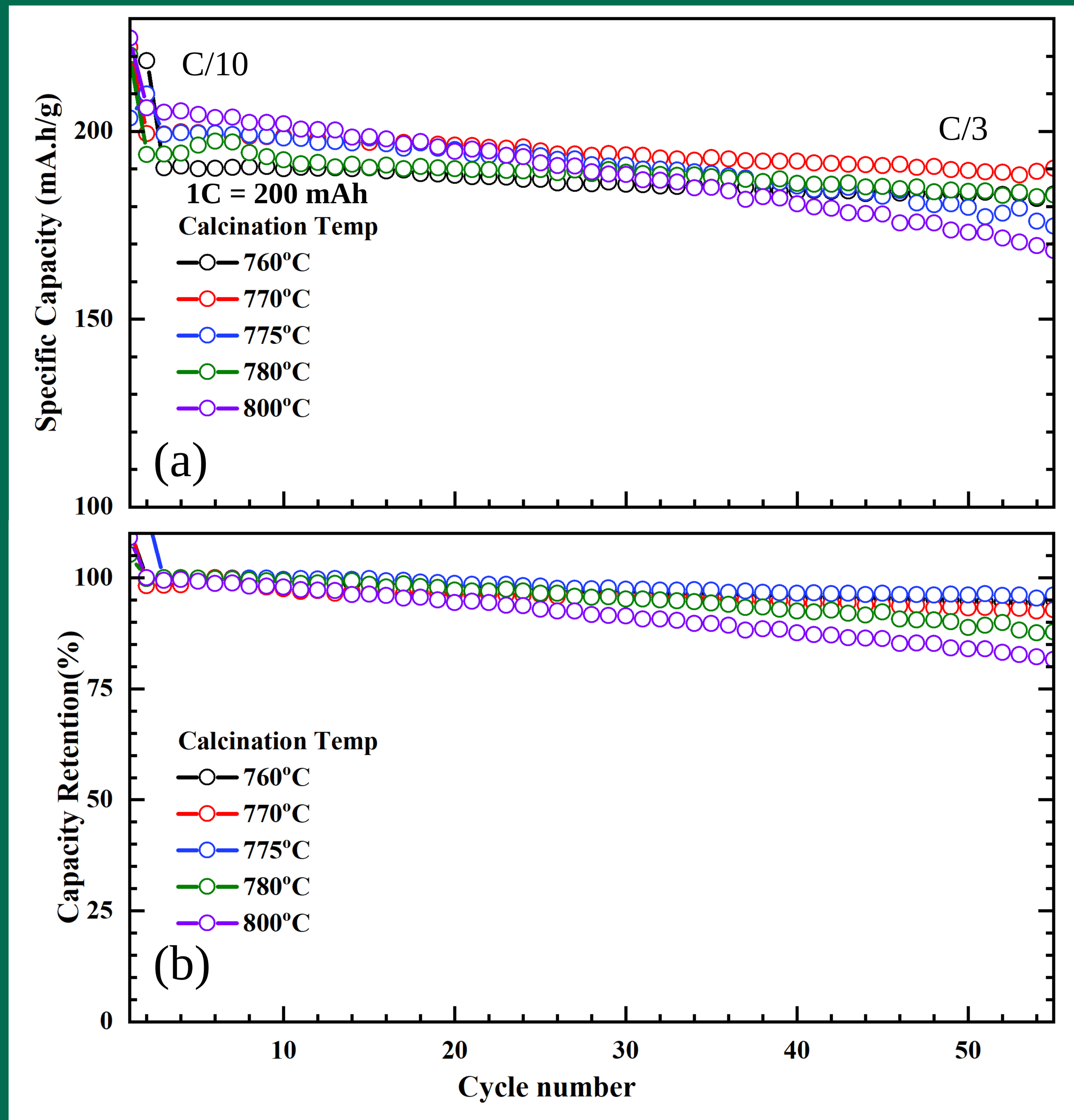


Figure 5. (a) Sample heated at 800 °C shows greatest specific capacity while 760 °C has the lowest indicating that greater heating temperature plays a role in initial capacity (b) Graph of capacity retention indicates that the 800 °C has the greatest capacity fading over many cycles while 770 and 775 °C have a strong retention

Table 1.
Lattice parameters of $LiNi_{0.85}Mn_{0.075}Co_{0.075}O_2$ calculated by Rietveld refinement method at different temperatures.

$LiNi_{0.85}Mn_{0.075}Co_{0.075}O_2$	*a* (Å)	*c* (Å)	Unit cell volume (Å³)	Rwp
NMC-760	2.8729(0)	14.203(7)	101.52(5)	2.305
NMC-770	2.8712(3)	14.205(7)	101.42(2)	4.515
NMC-775	2.8719(2)	14.199(9)	101.42(9)	2.257
NMC-780	2.8722(6)	14.197(5)	101.43(5)	3.102
NMC-800	2.8729(3)	14.198(8)	101.49(2)	2.889

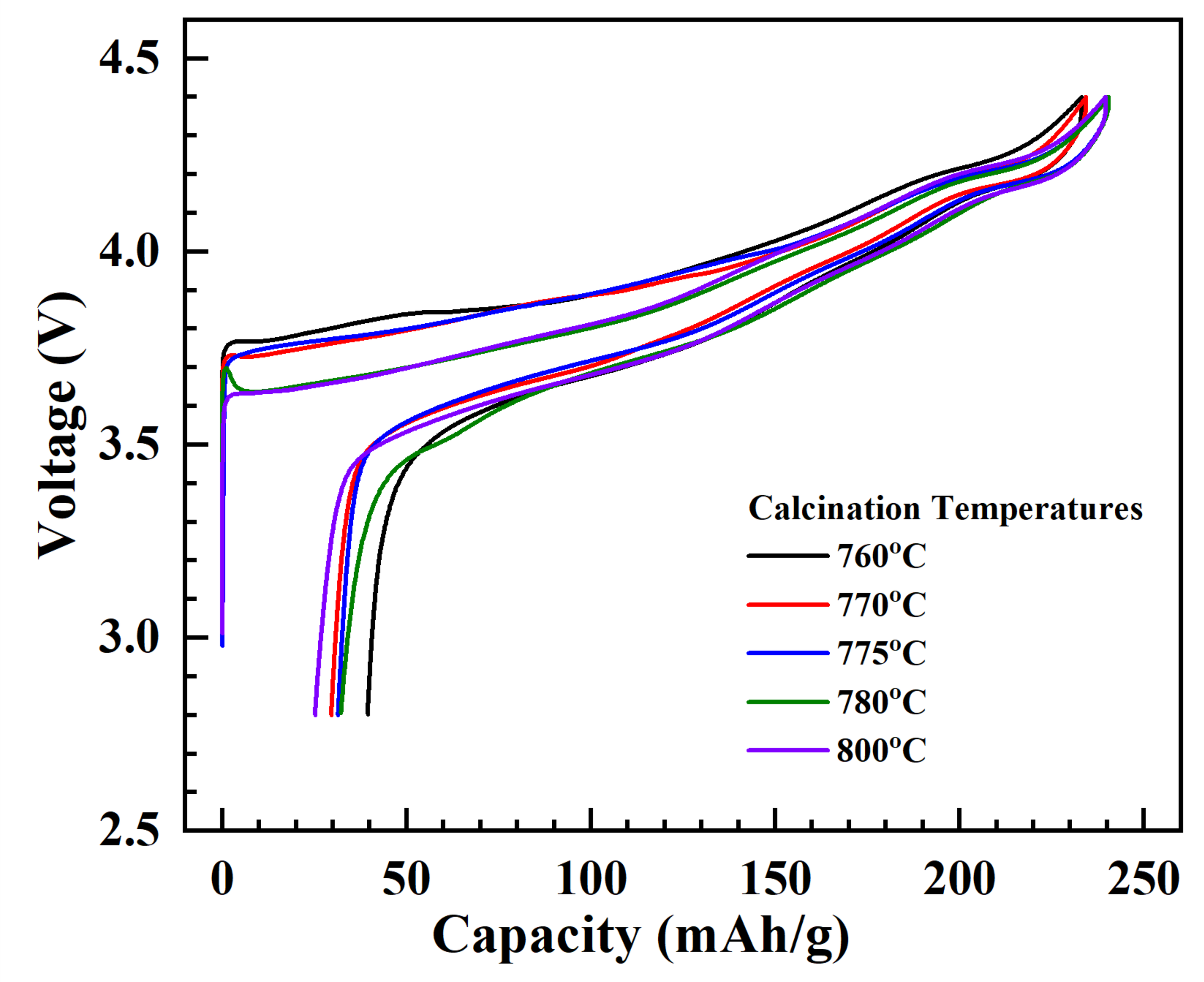


Figure 6. Sample heated at 800 °C shows the best first cycle with a irreversible capacity loss of approximately 25 mAh/g, pattern is shown with the rest of the samples having greater irreversible capacity loss with decrease of calcination temperature.

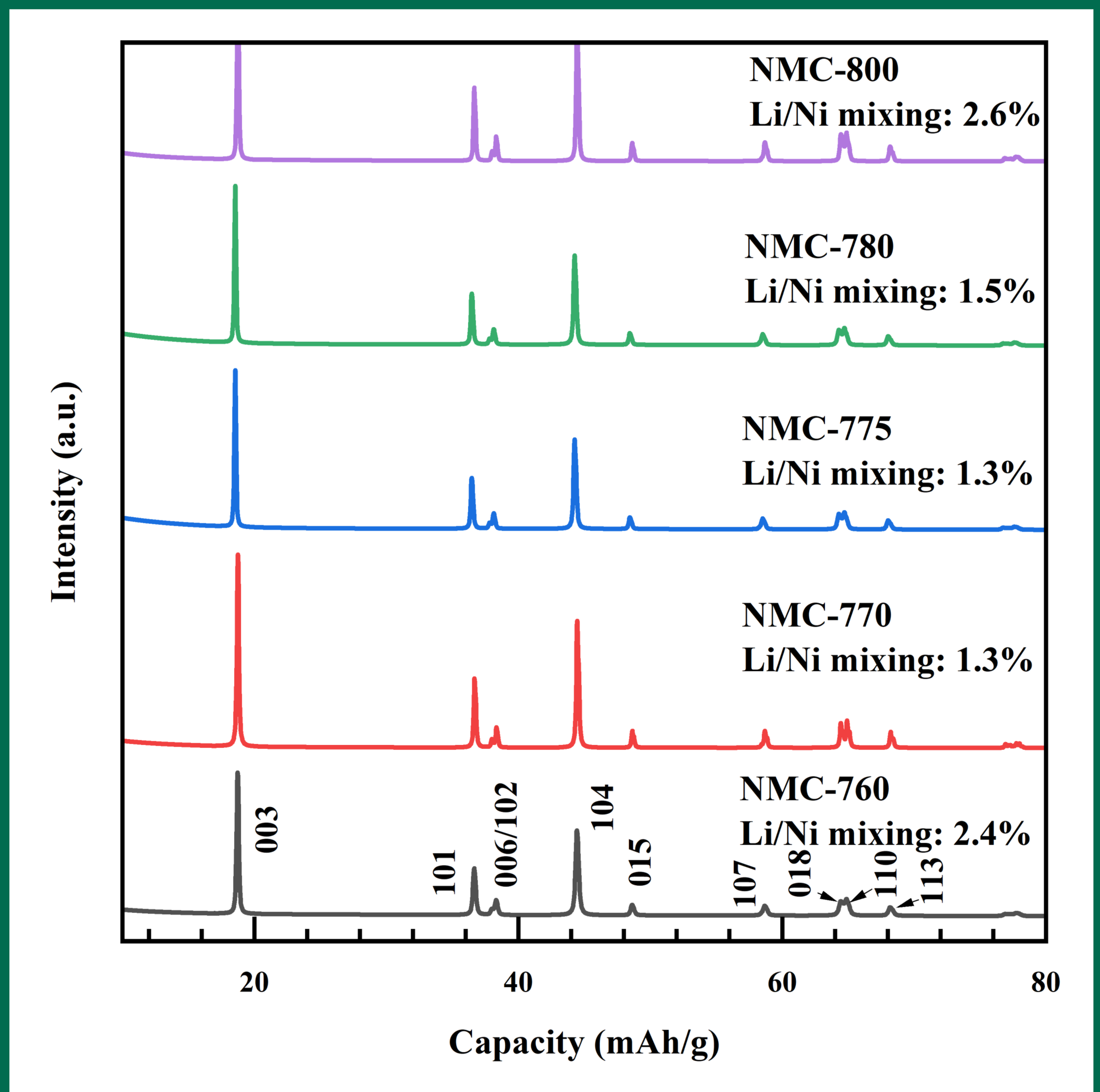


Figure 7. Li/Ni mixing decreases and increases with heating temperature.

Electric vehicles that use NMC

Results:

Cell volume as well as Li/Ni mixing decreases as calcination temperatures increase until after 775 °C where it increases again.

Sample heated at 770°C showed a strong initial capacity while retaining that capacity over many cycles while others like 800 °C had the strongest initial capacity but a major trade-off was high-capacity fade.

Conclusion:

Choosing the proper synthesis temperature for the cathode material is important to obtain the best performance in the overall Lithium-ion battery

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BINGHAMTON UNIVERSITY
STATE UNIVERSITY OF NEW YORK

BATTERY 500 CONSORTIUM