# Effect of synthesis on cathodes for sodium-ion batteries: correlation between morphology, structure and electrochemical performances

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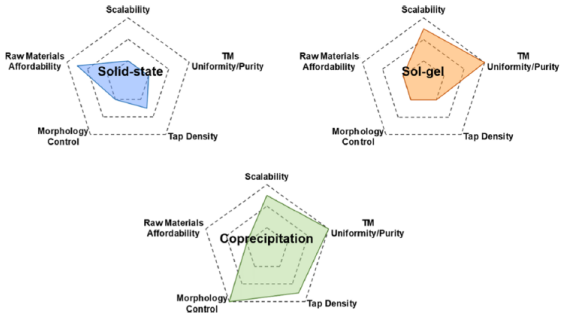
## 1. STARTING POINT:

Among all the cathodic materials tested in Sodium-Ion Batteries (SIBs) the most widely studied are layered sodium-based oxides, of general formula $NaxMO_2$, where M is a transition metal, for their good performances and similarity with the lithium-ion cathodes.

Hydroxide coprecipitation is the synthesis route employed industrially for the synthesis of lithium-based layered oxides, but what about sodium one's?

## 2. SYNTHETIC ROUTES: PRO'S AND CON'S




Different synthesis can have an influence on the production cost and on the characteristics of the final cathodic material, even affecting the electrochemical performances [1]

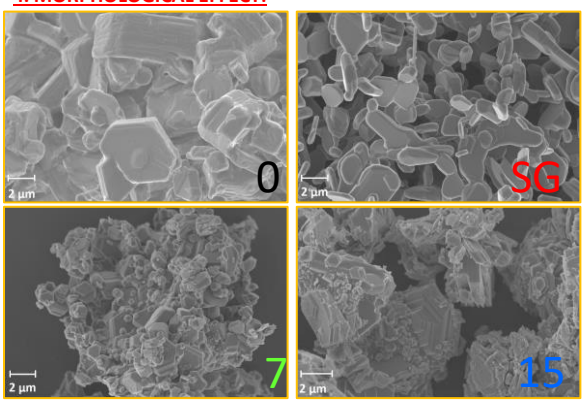
## 3. THE SYSTEM:

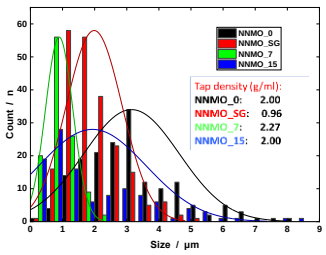
The cathodic material $Na_{0.67}Mn_{0.67}Ni_{0.33}O_2$ (NNMO) have been synthesized with four different methods:

- SOL-GEL with citric acid and ethylene glycol **NNMO_SG**
- COPRECIPITATION **NNMO_0**
- COPRECIPITATION with $NH_3$ as complexing agent and a constant pH value during the process [2] **NNMO_7**, **NNMO_15***

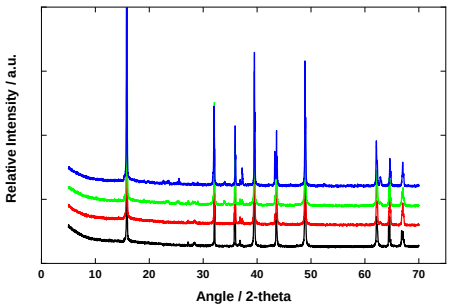
* 7 or 15 is referred to the duration, in hours, of the synthesis

## 4. MORPHOLOGICAL EFFECT:



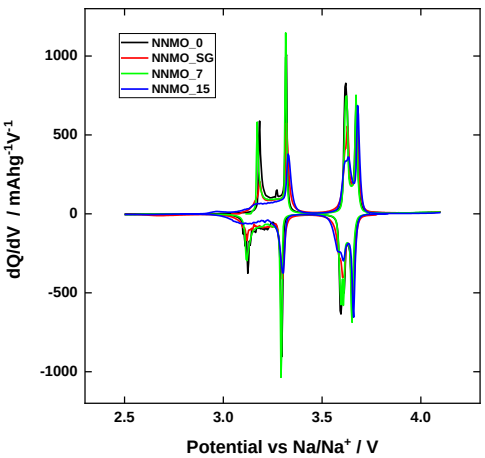



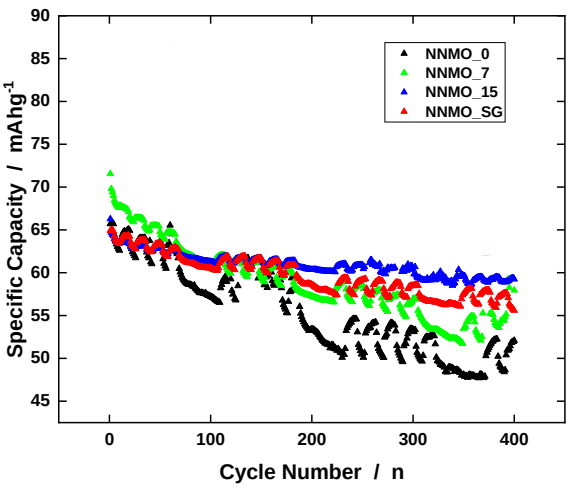

Differences found in the particle size and shape. NNMO_7 and NNMO_15 present regular particles, showing the growth directions.
Even the size distributions are different, parameter that affects the tap density of the final powders.




Small differences in the XRD peaks intensity or position shows that the synthesis path has effects on the cell parameters

## 5. ELECTROCHEMMICAL DIFFERENCES:




**OPERATING MEAN VOLTAGE:**
**NNMO_0 : 3.369 (c) 3.476 (a)**
**NNMO_SG : 3.423 3.488**
**NNMO_7 : 3.379 3.464**
**NNMO_15 : 3.407 3.500**
**(c) = cathodic, (a) = anodic**

Potentiodynamic Cycling with Galvanostatic Acceleration analysis (PCGA) showed that the de-sodiation/sodiation process occurs with different reaction mechanisms, as it can be seen from the different peak position/shape, things that influence also the average mean voltage of the electrochemica process.

Long cycling Galvanostatic Charge with Potential Limitation (GCPL) showed that the four samples has a different capacity ritention, in particular NNMO_15, the best samples has a retention of 90% after 400 cycles, whereas NNMO_0, the worst sample has only 75%

## 6. CONCLUSIONS AND FUTURE PERSPECTIVES:

- The data presented showed a strong effect of the synthesis path on the morphological, structural and electrochemical performances.

- Future steps will be the investigation of the XRD patterns of the four different powders, to obtain the cell parameters of the different samples and to correlate the electrochemical differences to the structural data.

- Future steps will be also about investigating new techniques for the synthesis, in order also to characterize different morphologies.

## 7. BIBLIOGRAPHY:

[1] J. Lamb, A. Manthiram, Chem. Mater. 2020, 32, 8431−8441
[2] H. Li, J. Li, X. Ma, J. R. Dahn, Journal of The Electrochemical Society, 2018, 165, 5, A1038