

Toward Greener Lithium-Ion Batteries: Water-Based Processing of NMC Cathodes

Driélle Müller[a,b,c,*], *Cédric Vandenabeele*[a,b], *Nathalie Job*[c], *Stéphane Lucas*[a,b]

[a] *Laboratoire d'Analyse par Réaction Nucléaires (LARN), Namur Institute of Structured Matter (NISM), University of Namur, 61 Rue de Bruxelles, 5000 Namur, Belgium*
[b] *Innovative Coating Solutions (ICS), 10, Rue Jean Sonet, B-5032 Isnes, Belgium*
[c] *Department of Chemical Engineering – Nanomaterials, Catalysis, Electrochemistry (NCE) University of Liège (B6a), 4000 Liège, Belgium*

E-mail: drielle.mullerdasilva@unamur.be

The transition toward more sustainable lithium-ion battery manufacturing requires replacing toxic organic solvents used in electrode fabrication with environmentally benign alternatives such as water. While aqueous processing is already well established for anodes, its application to nickel-rich cathode materials remains challenging due to their high reactivity with water, which leads to surface degradation, lithium leaching, and performance loss [1,2]. This PhD project investigates the physicochemical mechanisms governing the interaction between layered NMC cathode materials and water during electrode processing, with a focus on NMC532. Particular attention is given to the role of slurry composition, binder chemistry, and pH evolution in controlling lithium stability and electrode performance. Systematic pH measurements reveal that aqueous processing induces alkalinization through surface-limited and equilibrium-limited lithium leaching mechanisms, whose relative contributions depend strongly on material concentration and chemical environment. The influence of different binders is examined, highlighting that xanthan gum-based formulations moderate pH evolution differently from conventional water-soluble binders such as CMC, suggesting a binder-dependent control of lithium leaching pathways. Electrochemical testing shows that while optimized aqueous processing can achieve performance comparable to conventional PVDF/NMP routes for NMC532, the same strategies are not directly transferable to more reactive NMC811 materials. Overall, this work provides mechanistic insight into water-based cathode processing and outlines pathways toward greener lithium-ion battery manufacturing compatible with high-energy cathode materials.

References

[1] Busà, C., Belekoukia, M. & Loveridge, M. J. Electrochimica Acta 366, 137358 (2021).
[2] Jung, R. et al..J. Electrochem. Soc. 165, A132 (2018).