PAUL SCHERRER INSTITUT

ELECTROCHEMISTRY LABORATORY

BATTERIES

# *Full cells HE-NMC vs. graphite: an interfacial study*

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## Properties and challenges

- **HE-NMC layered oxide** ( $xLi(Ni,Co,Mn)O_2 + yLi_2MnO_3$): specific charge of ~**220 mAh/g vs. $Li^+/Li$** in the range of [2.5 V – 4.8 V] with **LP30***

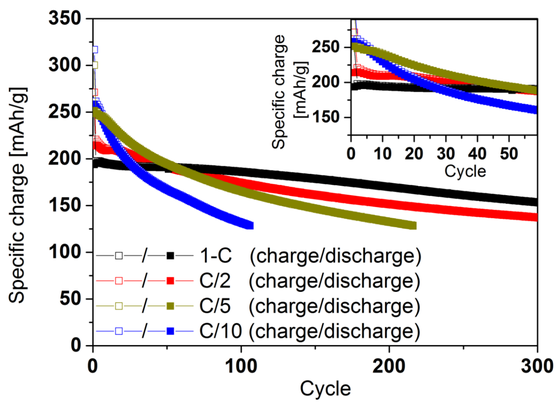
- Study of the full-cell interfaces

- Effect of the **dissolved transition metals** (Ni, Co, Mn) on the passivation layer

- **Role of FEC⁺ and VC# additives** on the electrochemical performances

*LP30 : electrolyte → ethylene carbonate (EC): dimethyl carbonate (DMC) (1:1 w/w), 1M $LiPF_6$
⁺FEC: fluoroethylene carbonate #VC: vinylene carbonate

## HE-NMC *vs.* graphite



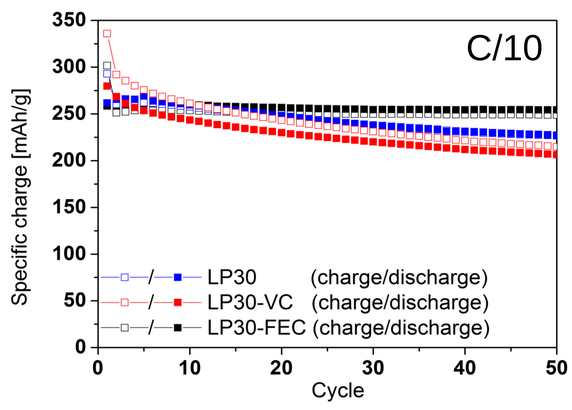

**LP30** used as electrolyte

- Two trends:
  - **Slow rate (C/10):** → **50 % loss** after 100 cycles
  - **Fast rate (1-C):** → **10 % loss** after 100 cycles

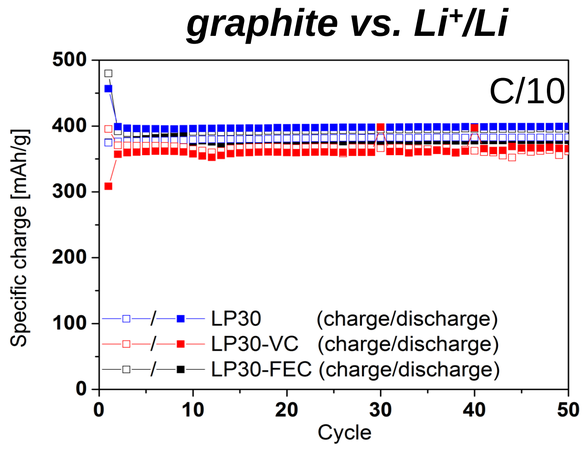
- **100 mAh/g** at **C/2** rate after **600 cycles**

## Additive effect: half cell

***HE-NMC vs. $Li^+/Li$***




***graphite vs. $Li^+/Li$***

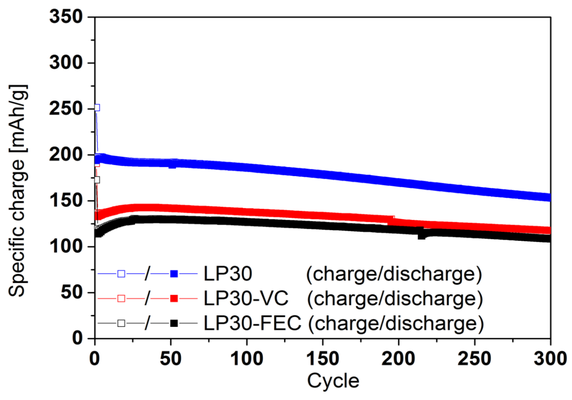



- **FEC** → better performance
- **VC** → loss in performance

- No improvement with the help of additives at C/10 rate

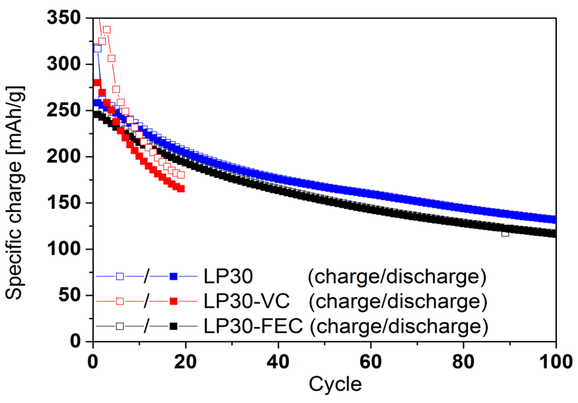
## Additive effect: HE-NMC *vs.* graphite

***1-C rate***




- **FEC or VC:** better stability but with lower performance than without additive

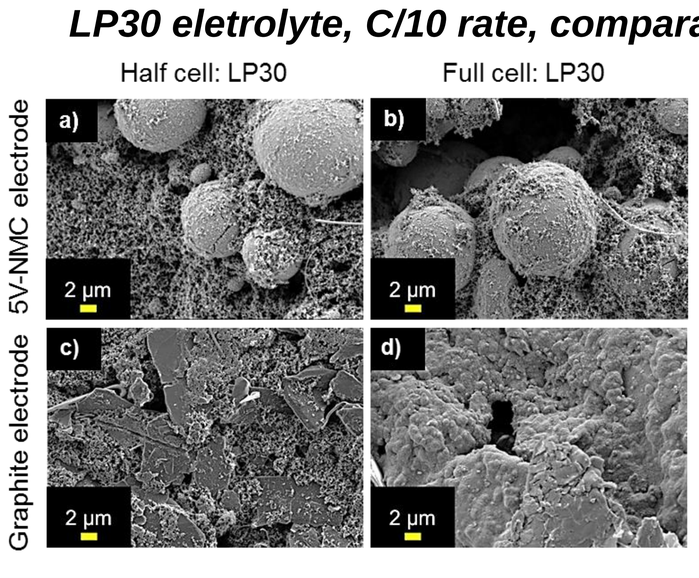
***C/10 rate***




- **VC:** hard to cycle the full-cell configuration
- **FEC:** no improvement

## *Post mortem* SEM analysis: HE-NMC *vs.* graphite

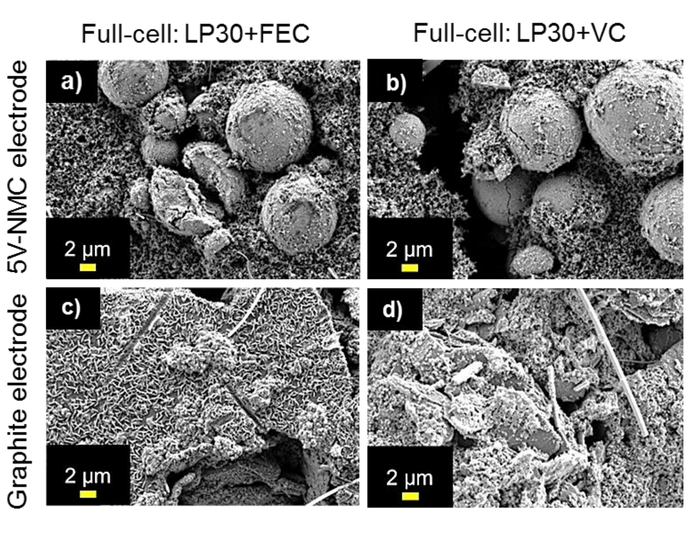
***LP30 eletrolyte, C/10 rate, comparaison half/full cell***




- **HE-NMC: cracks** → $O_2$ release and/or structural reorganization

- **Graphite: great passivation layer** at the graphite surface in **full cell** → limited lithium diffusion

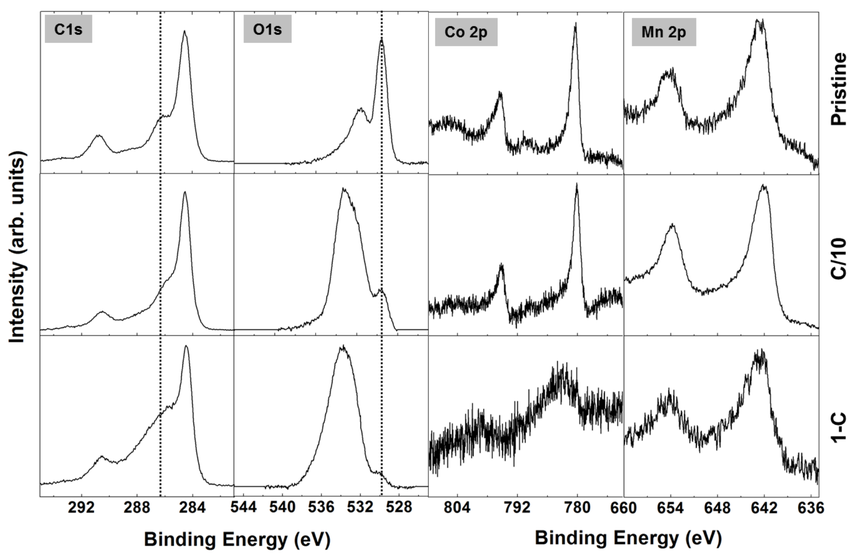
***Additive FEC or VC, C/10 rate***




- **HE-NMC: more cracks** and **thicker SPI** (Solid Permeable Interface)

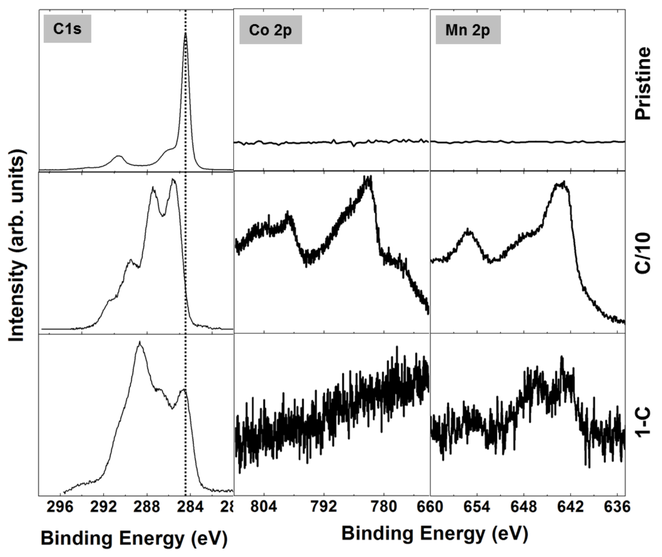
- **Graphite:** important **surface modifications** in full cell:
  - **FEC**: presence of «sticks» on the sheets
  - **VC**: thick «polymer» covering all the sheets

## *Post mortem* XPS analysis: HE-NMC *vs.* graphite with LP30




***HE-NMC electrode:***

- **Thicker SPI** at 1-C rate




***Graphite electrode:***

- Presence of **transition metals** at the **graphite surface**

- **Thicker SEI** (Solid Electrolyte Interphase**)** at C/10 rate

## Conclusion

- **Uncorrelated behavior** between half and full cells
- **Migration** of **transition metals** from the positive to the negative electrode
- **Change** of the **full-cell electrochemistry** with the **an additive**

→ **Need** of **full-cell studies** to fully **understand** the **behavior of HE-NMC** material

Scan me !

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