PAUL SCHERRER INSTITUT

ELECTROCHEMISTRY LABORATORY

BATTERIES

$Na_{0.67}(Mn_xFe_yCo_z)O_2$ as positive electrode for Na-ion batteries

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Storage
Swiss Competence Centers for Energy Research

Motivations

✓ $Na_{0.67}(Mn_{0.5}Fe_{0.5})O_2$ vs. $Na_{0.67}(Mn_{0.5}Fe_{0.25}Co_{0.25})O_2$

→ Higher rate performances with Co [1-3]

✓ Co → **safety** and **cost**

→ Can we **reduce Co content**?

[1] L. Liu et al. Adv. Energy Mater. (2015) 1500944-1500949 [2] N. Yabuuchi *et al Nature Mater.* 11 (2012) 512-517
[3] V. Duffort et al. Chem. Mater. 27 (2015) 2515-2524

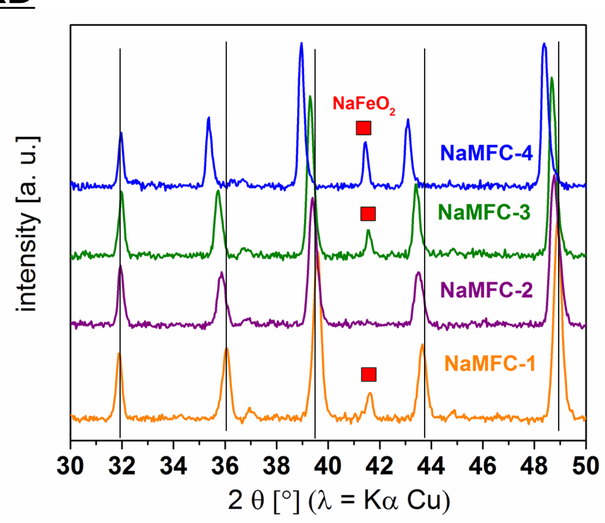
Strategy

✓ **Synthesis of 4 compounds** → solid state route @ 900° C (12 h)

High Co	High Mn / Low Co	High Fe / Low Co	No Co
$Na_{0.67}(Mn_{0.5}Fe_{0.25}Co_{0.25})O_2$ NaMFC-1	$Na_{0.67}(Mn_{0.6}Fe_{0.25}Co_{0.15})O_2$ NaMFC-2	$Na_{0.67}(Mn_{0.5}Fe_{0.35}Co_{0.15})O_2$ NaMFC-3	$Na_{0.67}(Mn_{0.5}Fe_{0.5})O_2$ NaMFC-4

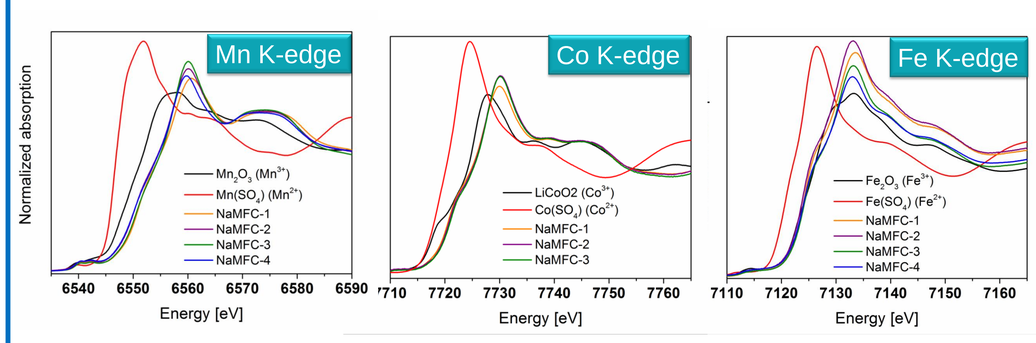
Characterization

✓ **XRD**



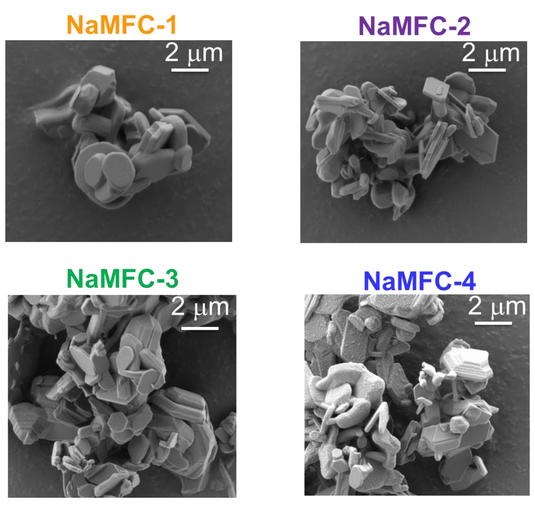
➢ Minor $NaFeO_2$ impurity
➢ Shift to lower 2θ →higher lattice parameters

✓ **XANES**



➢ Mainly Mn (IV), Co (III), Fe (III)

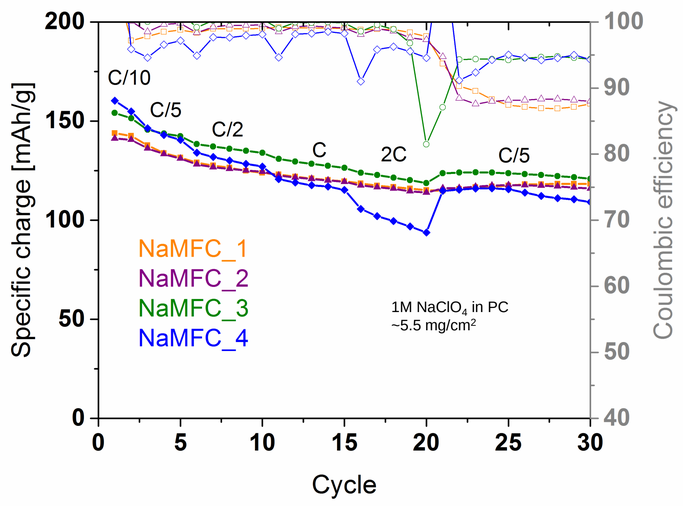
✓ **SEM**



➢ Platelet particles ~0.5 µm thick

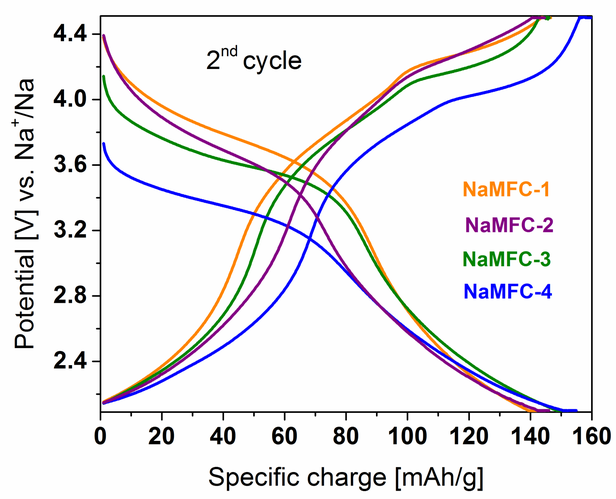
Electrochemical performances

✓ **Rate performances**



➢ Similar performances than NaMFC-1

✓ **Galvanostatic curves**

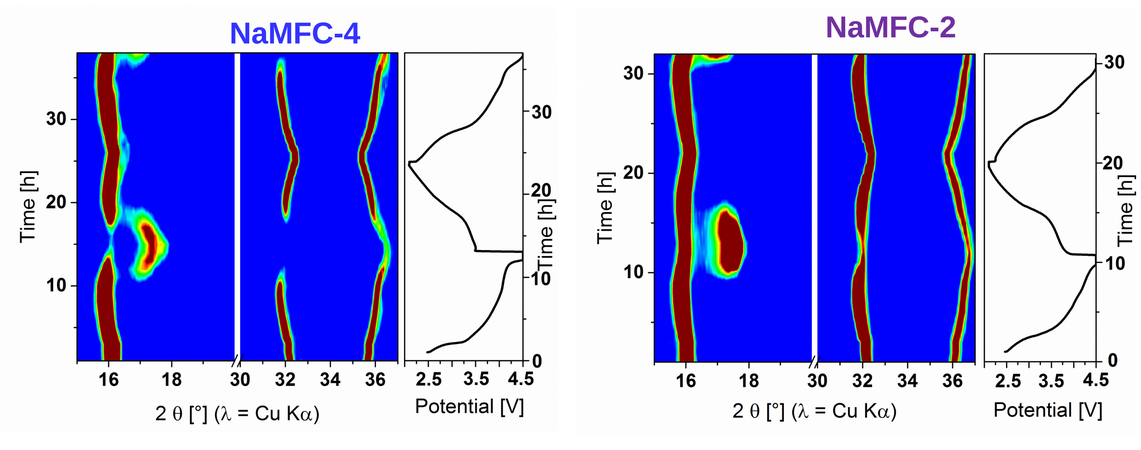


➢ Limited loss in discharge potential for low Co content samples

Co content can be reduced in NaMFC-1

First cycle study

✓ **Operando XRD**



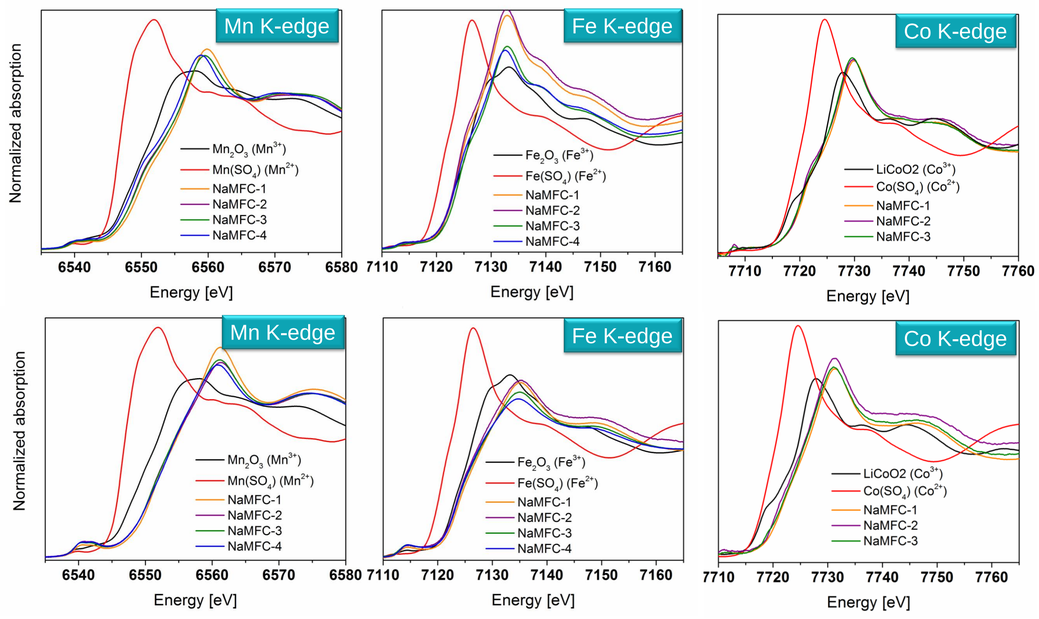
➢ Similar mechanism

No change for low Co

✓ **Ex situ XANES**

End 1st discharge

End 2nd charge



Mn (IV) + ε Mn (III)
Fe (III)
Co (III)

End 1st cycle

Mn (III) + ε Mn (IV)
Fe (III)
Co (III)

End 2nd charge

Mn (IV)
Fe (IV) + ε Fe (III)
Co (IV) + ε Co (III)

Conclusions

➢ **Successful syntheses of lower Co-NaMFC compounds**
➢ **Similar electrochemical performances and limited loss in potential**
➢ **No difference in the first cycle reaction mechanism**

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