P2-$Na_{0.67}(Mn_{0.6}Fe_{0.25}Co_{0.15-x}Al_x)O_2$ as cathode material for Na-ion batteries

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Motivation

✓ $Na_{0.67}(Mn_{0.5}Fe_{0.25}\mathbf{Co_{0.25}})O_2$

Better performance with **Co** [1]

BUT Co → safety and cost issues

✓ Work: Reducing **Co** content and keep similar properties

Concept validated with $Na_{0.67}(Mn_{0.6}Fe_{0.25}\mathbf{Co_{0.15}})O_2$ [2]

Can we substitute Co by Al? [3]

Strategy

✓ **Synthesis by scalable** → solid state route

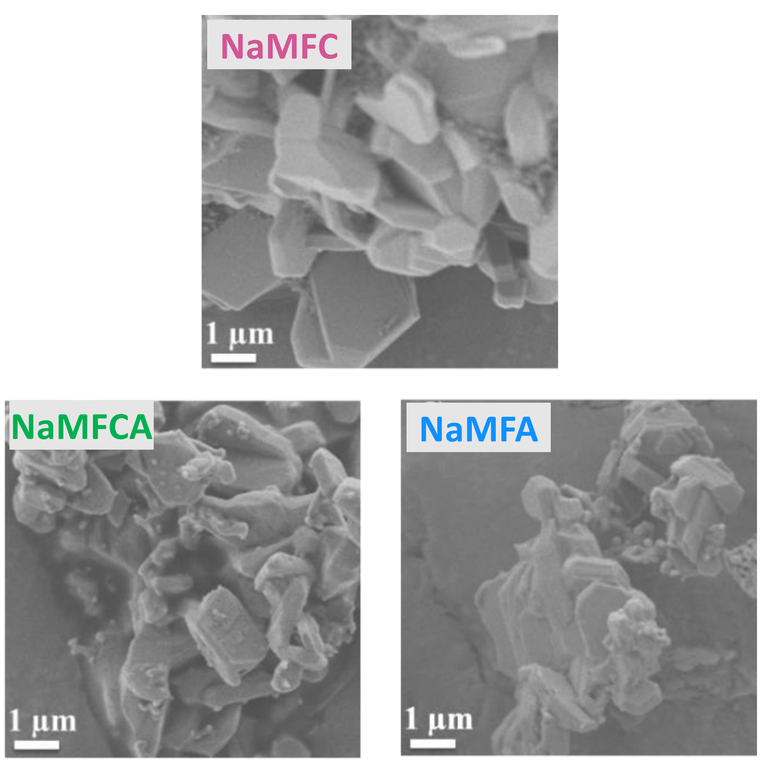
NaMFC [2]: $Na_{0.67}(Mn_{0.6}Fe_{0.25}\mathbf{Co_{0.15}})O_2$

Partial substitution → **NaMFCA** [3]: $Na_{0.67}(Mn_{0.6}Fe_{0.25}\mathbf{Co_{0.075}}\mathbf{Al_{0.075}})O_2$

Full substitution → **NaMFA** [3]: $Na_{0.67}(Mn_{0.6}Fe_{0.25}\mathbf{Al_{0.15}})O_2$

Materials characterization

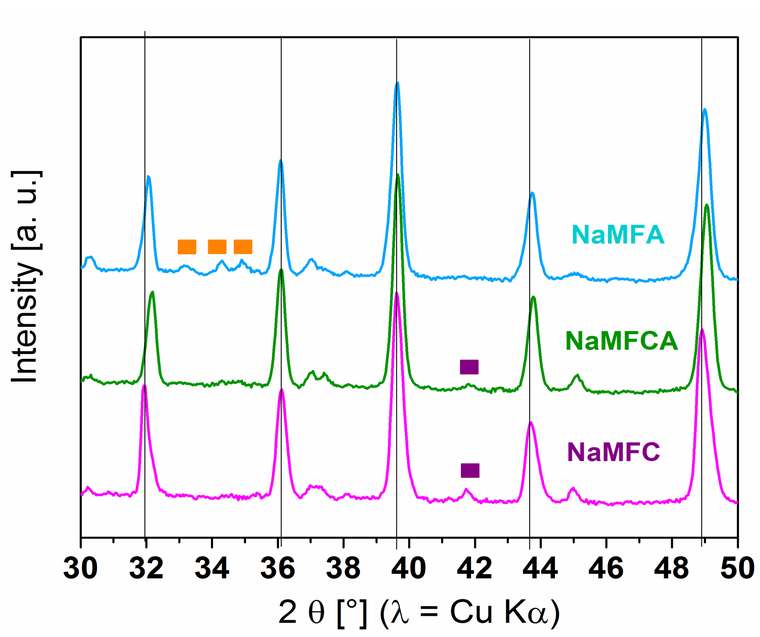
✓ SEM pictures of the materials



➢ Platelets shape particles for all materials

➢ Small spherical particles → impurity

✓ XRD patterns of the materials

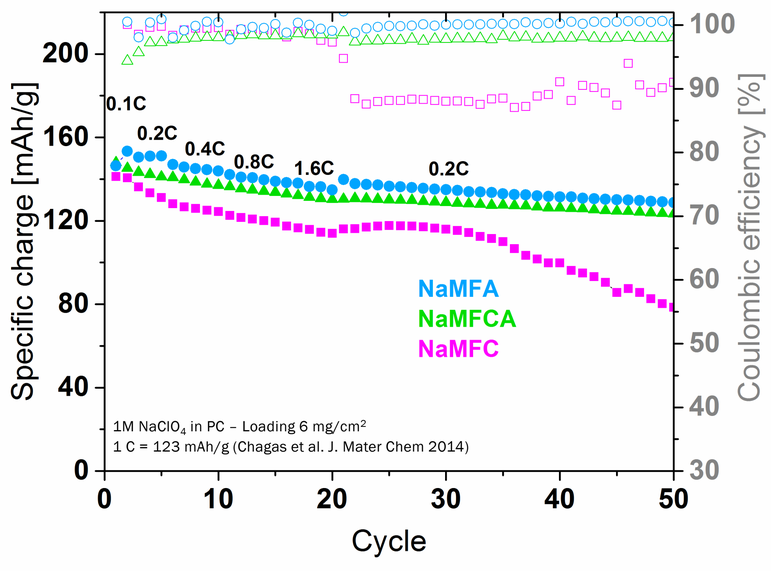


➢ P2 structure mainly kept but shift of some peaks → different cell parameters + occupation site

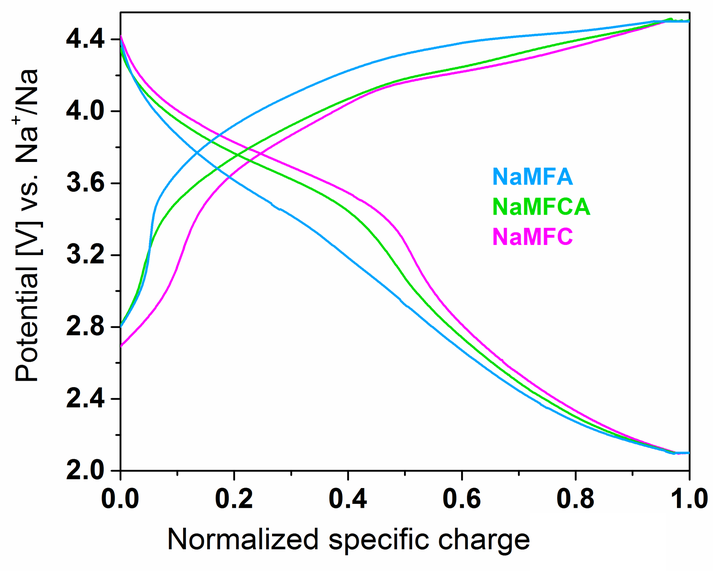
Successfull synthesis of NaMFCA and NaMFA compounds

Electrochemical performance

✓ Rate Performance



✓ Galvanostatic curves (1st cycle)



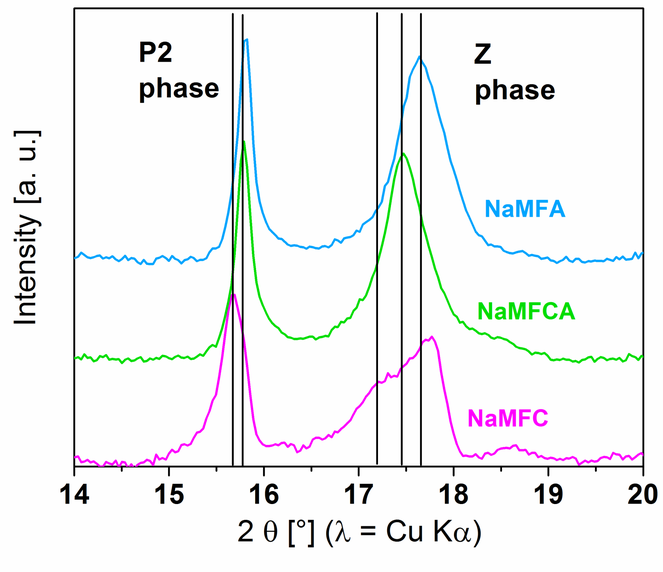
➢ Higher performance with Al containing materials

➢ Loss of~300 mV in discharge potential for NaMFA

Better performance with Al materials → Why?

Ex situ XRD

✓ XRD patterns → end of 1st charge



➢ Z phase better defined for Al containing materials

Stabilization Z phase with Al?

Conclusions

➢ Successfull substitution of **Co** by **Al** → Similar morphology and minor structural change (≠ cell parameters + occupation site)

➢ Better electrochemical performance for Al containing materials but lower discharge potential

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[1] L. Liu et al. Adv. Energy Mater. (2015) 1500944-1500949 [2] C. Marino et al. JPS submitted (2016) [3] C. Marino et al. Electrochem. Comm. submitted (2016)