PAUL SCHERRER INSTITUT

ELECTROCHEMISTRY LABORATORY

BATTERIES

$CuSbS_2$ *vs.* Sb_2S_3 as negative electrode for Li-ion and Na-ion batteries

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Motivations

✓ Previous work: $MSnS_2$ (M = Cu, Fe) as anode for Li-ion and Li-S [1]

↪ Greater than 500 mAh/g for Li-ion due to M

✓ Sb *vs.* Sn→ Sb better performance in Na-ion batteries [2]

↪ $MSbS_2$ (M = Cu) exploration for Na-ion batteries

[1] C. Villevieille et al. J. Electroch. Soc. 162 **2015** A284-A287) [2] *A. Darwiche et al J. Am. Chem. Soc.*134 (2012) 20805

Strategy

No transition metal

Sb_2S_3

vs. Li [3] → 2 step $Li_2S + Li_3Sb$

vs. Na [4] → 2 step $Na_2S + Na_3Sb$

VS.

With transition metal

$CuSbS_2$

vs. Li [5] → Conversion

vs. Na → **?**

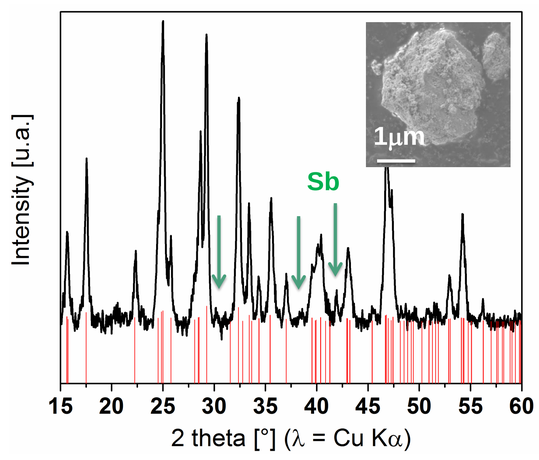
Conversion reaction? Role of transition metal Li vs. Na?

[3] C. park et al. J. Mater Chem. 20 (2010) 1097 [4] *H. Hou et al. ACS Applied Mater. Interfaces 7* (2012) 19362 [5] Z. Zhang et al. Int. J. Electrochem. Sci. 8 (2013) 10059

Syntheses and characterization

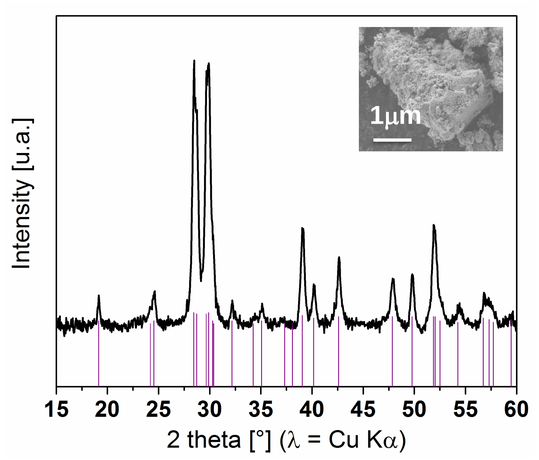
✓ **Syntheses** → Mechanosynthesis (particle size 1-10 μm)

✓ **Sb_2S_3**



➢ Minor Sb impurity

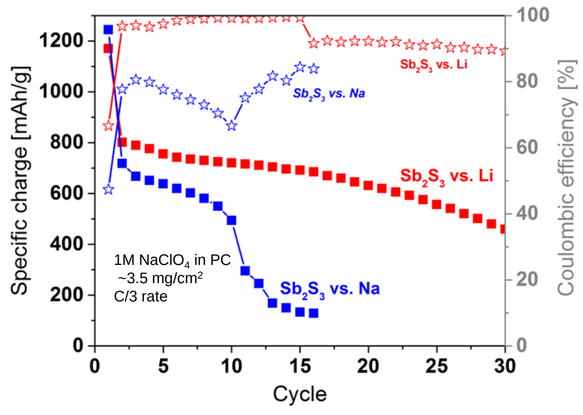
✓ **$CuSbS_2$**



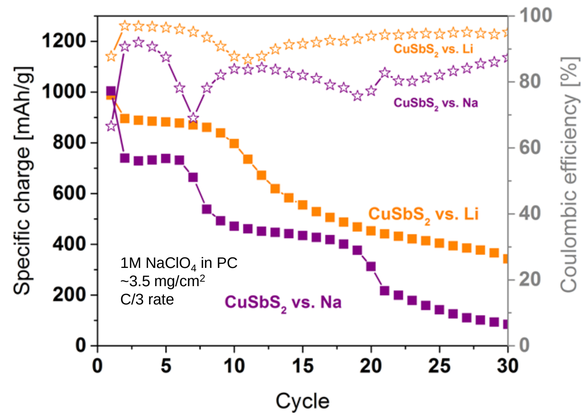
➢ No impurity

Electrochemical performance

✓ **Sb_2S_3**



✓ **$CuSbS_2$**



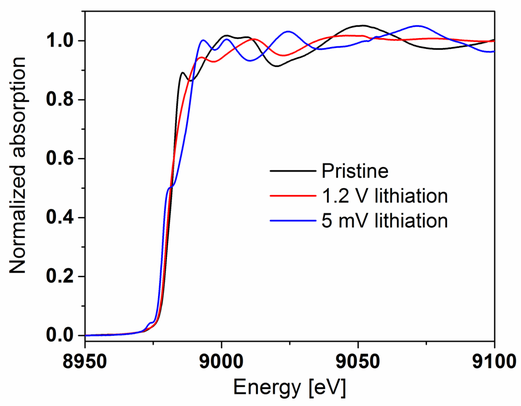
➢ 1th - 7th cycles → $CuSbS_2$ better than Sb_2S_3 → **Interest Cu**

➢ After 7th cycles → Fading more important vs. Li for $CuSbS_2$

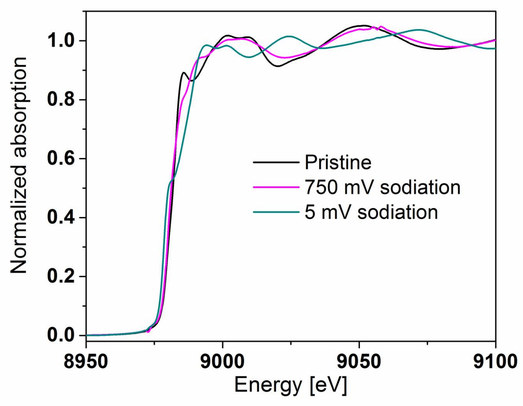
Ex situ XANES $CuSbS_2$

✓ Operando XRD → Amorphization → **Use XAS @ Cu K-edge**

✓ **1st lithiation**

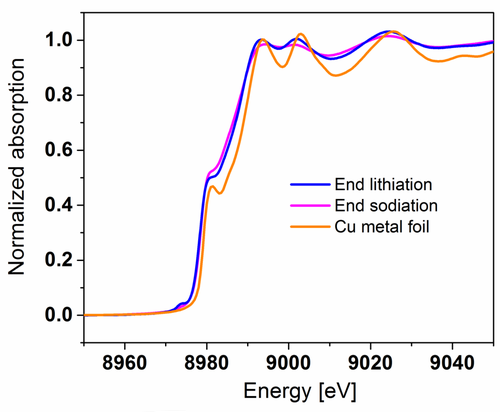


✓ **1st sodiation**



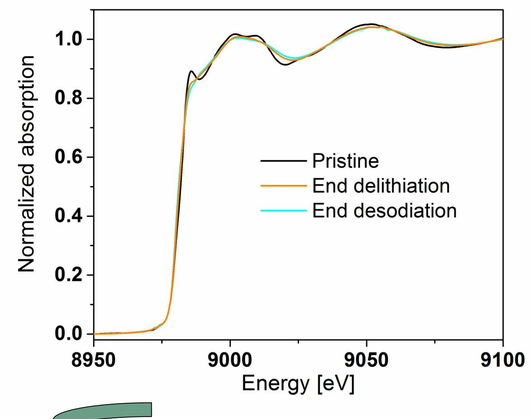
↪ XANES evolution along lithiation / sodiation → Not 2 step mechanism

✓ **End discharge**



↪ Cu metal

✓ **End charge**

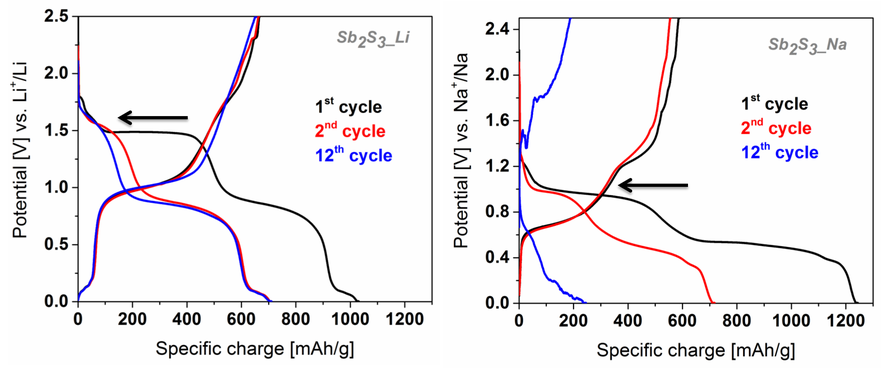


↪ «$CuSbS_2$» reformed

Conversion: $CuSbS_2$ + xNa → Cu + Na_xSb + Na_yS ←→ «$CuSbS_2$»

Investigations on further cycles

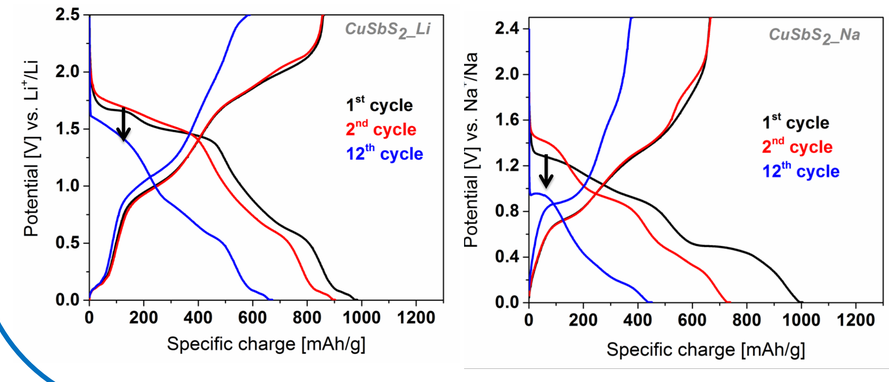
✓ **Sb_2S_3**



➢ 2 potential plateaus → 2 step mechanism

↪ Sb or S can react independently

✓ **$CuSbS_2$**



➢ Higher polarization

↪ Loss of contact? Electrolyte decomposition?

Conclusions

- **Successful syntheses of Sb_2S_3 and $CuSbS_2$**
- **Interest of Cu → better σ → efficient until 7th - 10th cycles**
- **Evidence of conversion mechanism vs. Na**
- **Different fading mechanism for Na compared to Li in $CuSbS_2$**

Acknowledgments This work is financially supported by the SCCER Heat and Electricity Storage. The authors thank M. Nachtegaal, Super XAS beamline at SLS synchrotron and P. Novák

Storage
Swiss Competence Centers for Energy Research