ELECTROCHEMISTRY LABORATORY

BATTERIES

Electrode engineering of graphite/silicon electrodes

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Motivation / Targets

- develop carbon based anode material with specific charge > 450 mAh/g by addition of small amounts of silicon
- compatibility with common industrial processes
- understand influence of different electrode components

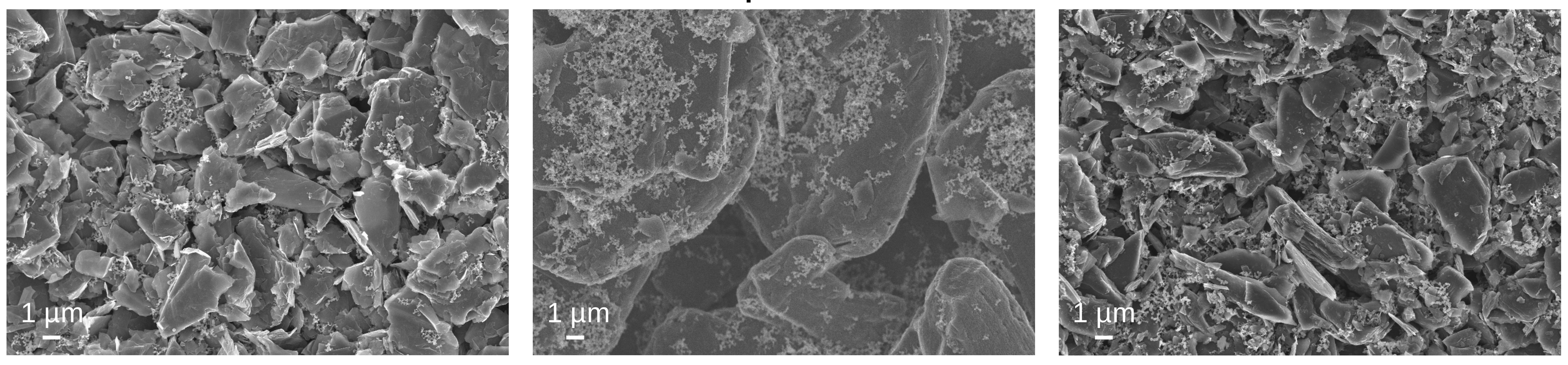
Experimental

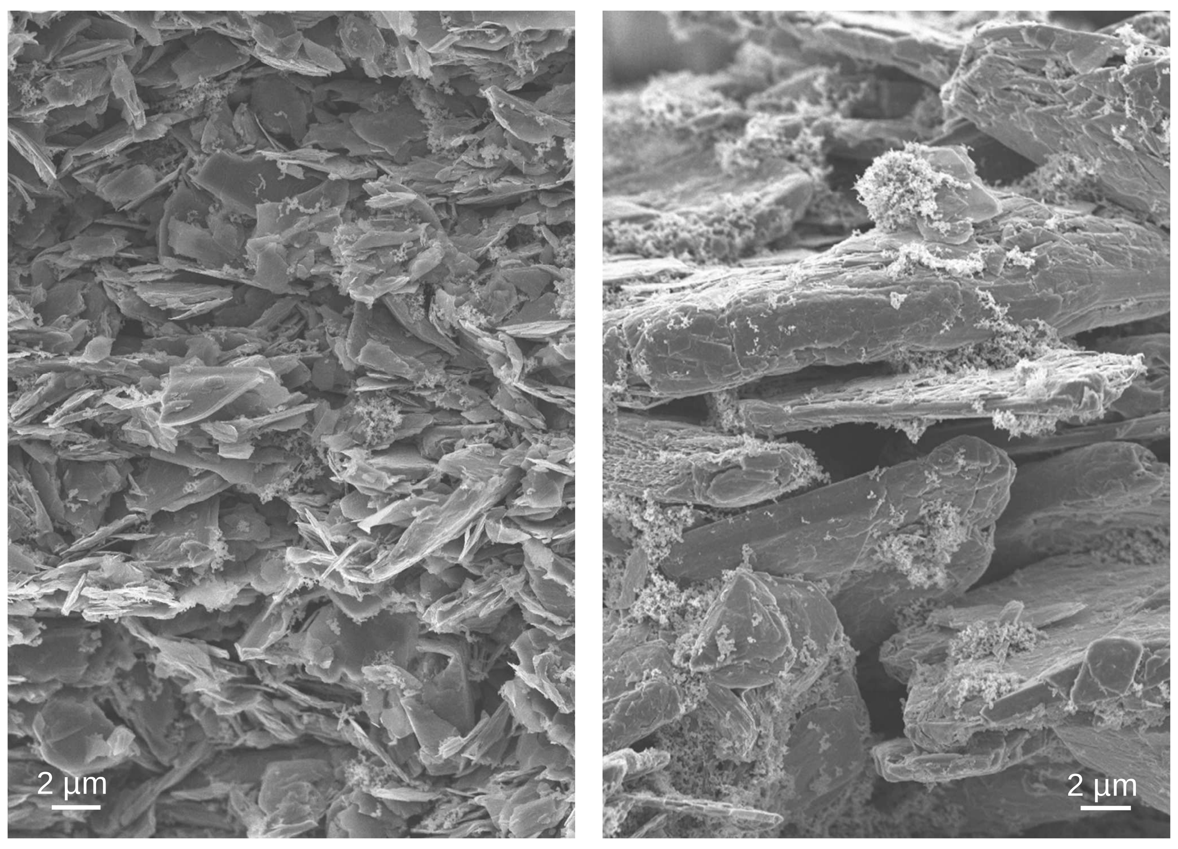
- 4.75 wt% Si, 90.25 wt% intercalating carbon, 1 wt% SuperC65, 4 wt% binder
- for comparison: 95 wt% intercalating carbon, 1 wt% SuperC65, 4 wt% binder
- 20 mA/g first cycle, following 50 mA/g between 5 mV and 1.5 V vs. Li^+/Li
- 1M $LiPF_6$ in EC/DMC 1:1 (w:w) unless stated otherwise

Morphology

graphite KS6 + Si | graphite SLP30 + Si | fine coke + Si

top view

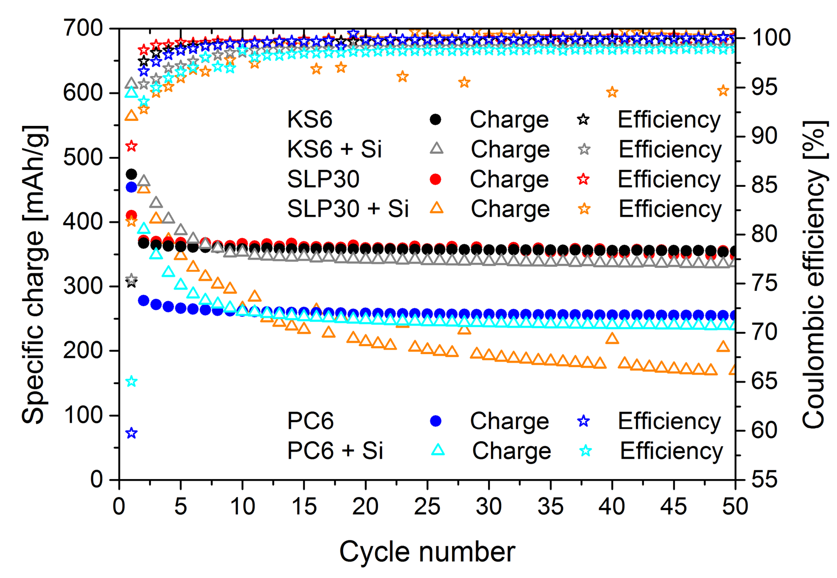




cross-sectional view

- macroscopically homogeneous
- agglomerates of Si nanoparticles and carbon black
- larger particles & higher aspect ratio for SLP30 than KS6 → preferred orientation of SLP30 parallel to substrate
- electrodes with PVDF shown, electrodes with CMC/PAA exhibit the same morphology

Role of carbon material

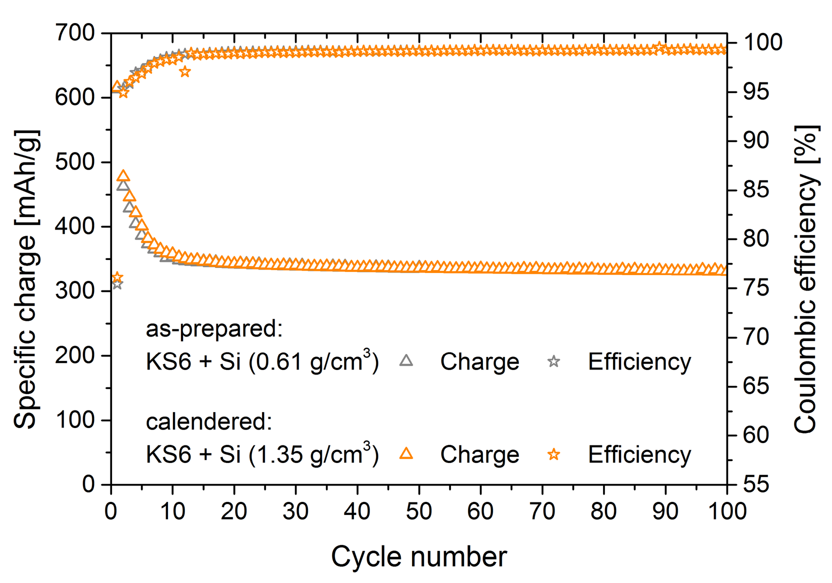


electrodes with PVDF binder

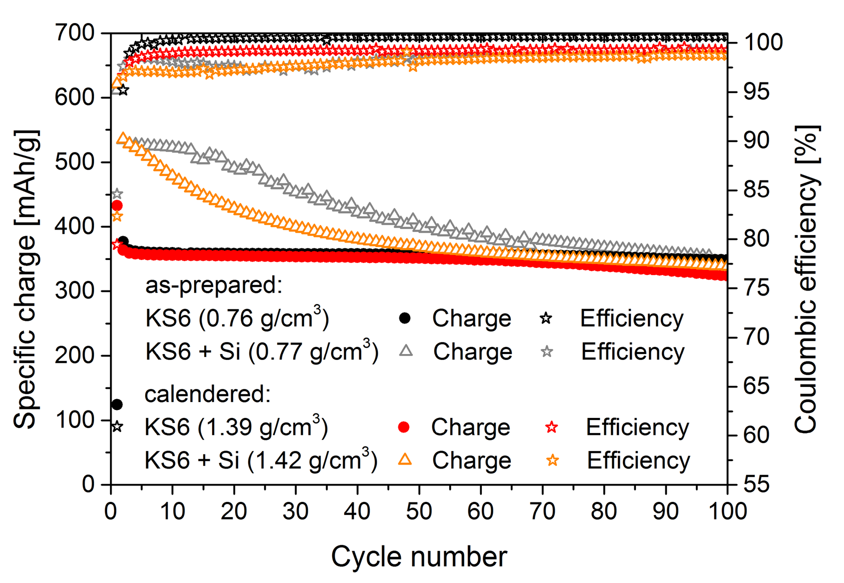
- carbon/Si electrodes: only carbon contributes towards specific charge after ~10 cycles
- for SLP30/Si electrodes, cycling of graphite part is negatively affected by presence of Si

Electrode density

PVDF binder:



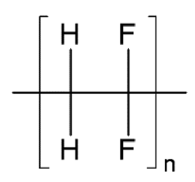
CMC/PAA binder:



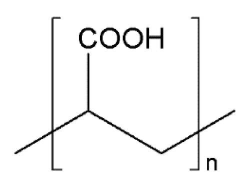
- ➢ densification of electrode does not affect cycling behaviour
- ➢ faster charge fading with densified electrodes containing Si

Binder influence

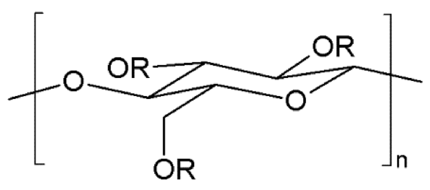
PVDF



PAA

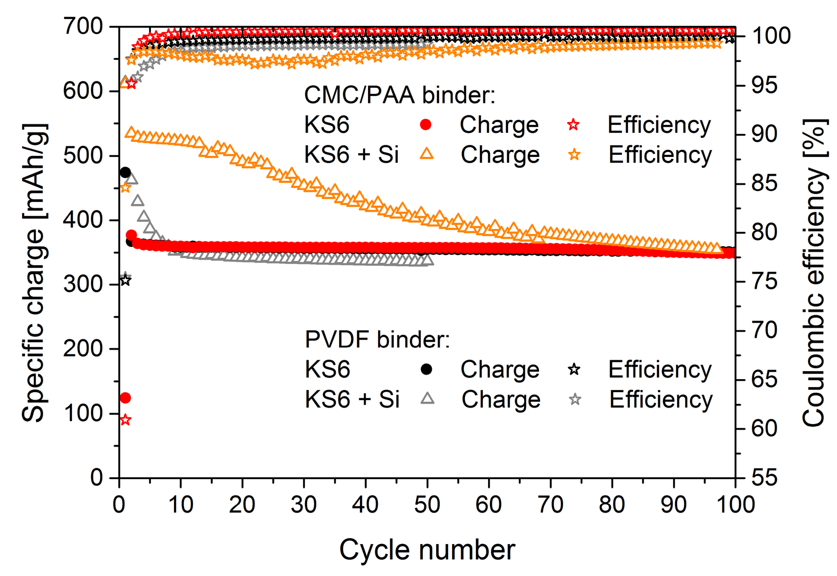


CMC

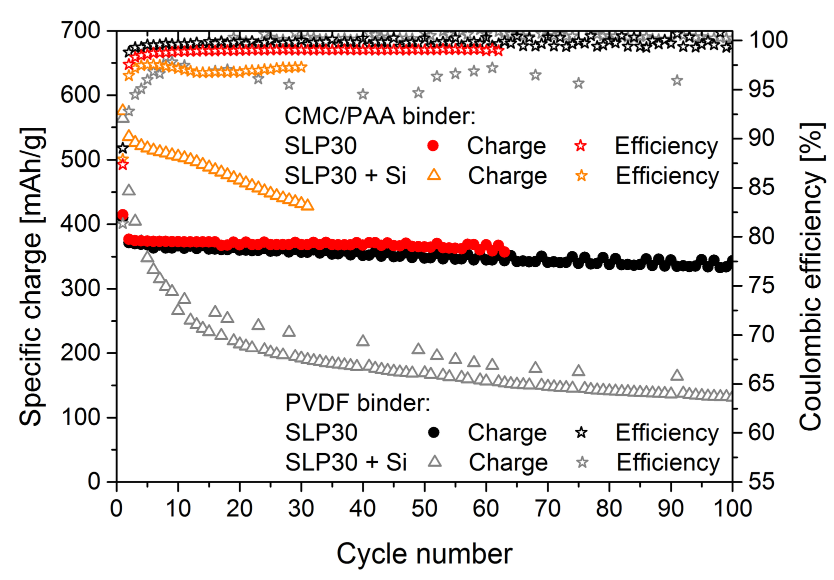


R = H or CH_2COOH

KS6 based electrodes:

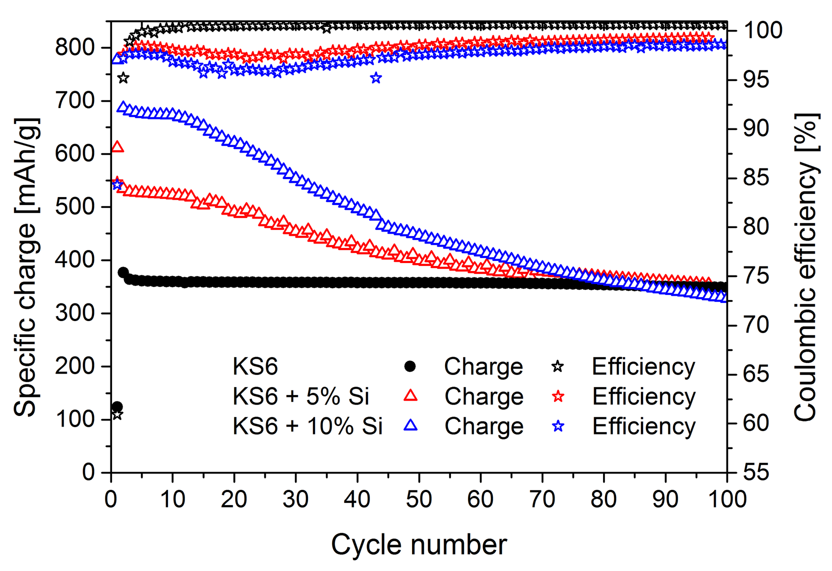


SLP30 based electrodes:



- ➢ using CMC/PAA: improved cycling stability for both KS6 and SLP30 based electrodes containing Si

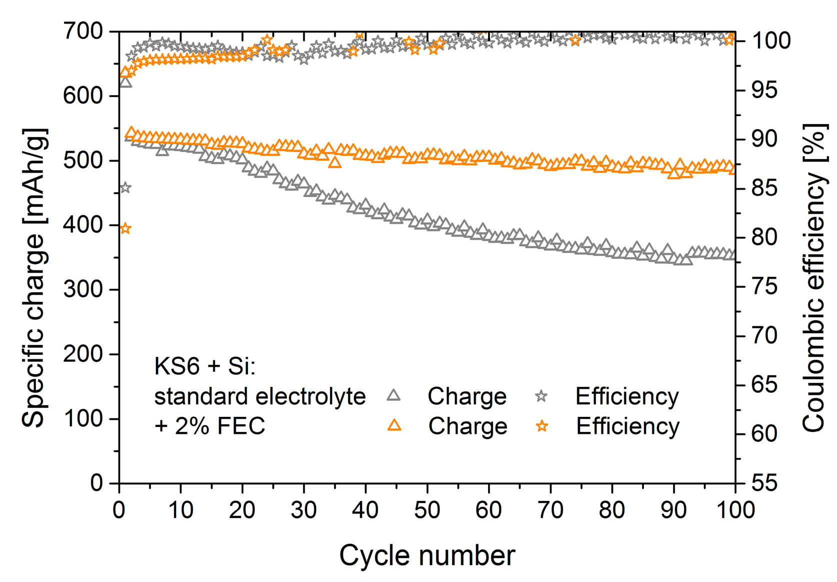
Graphite/Si ratio



electrodes with CMC/PAA binder

- first cycles: higher specific charge with 10 % Si in active material
- stronger fading with 10 % Si in active material

FEC electrolyte additive



electrodes with CMC/PAA binder

- enhanced cycling stability in presence of fluoroethylene carbonate (FEC) additive with 90 % capactiy retention from 2nd to 100th cycle

Conclusions

- KS6: best of the different types of intercalating carbon for combination with Si
  - better cycling stability than SLP30 based electrodes
  - compared to PC6, less Si is needed to obtain same specific charge
- binder and electrolyte have strong influence on cycling stability

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