

Critical Evaluation of Pulsed Current Charging Effects on the Performance of Commercial Sodium-Ion Batteries

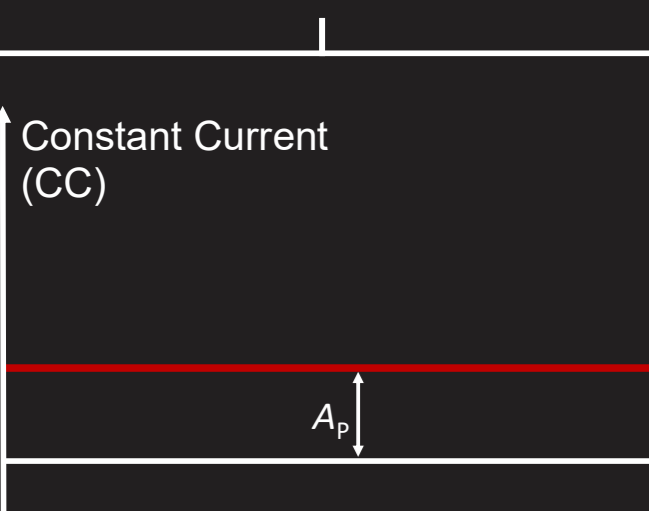
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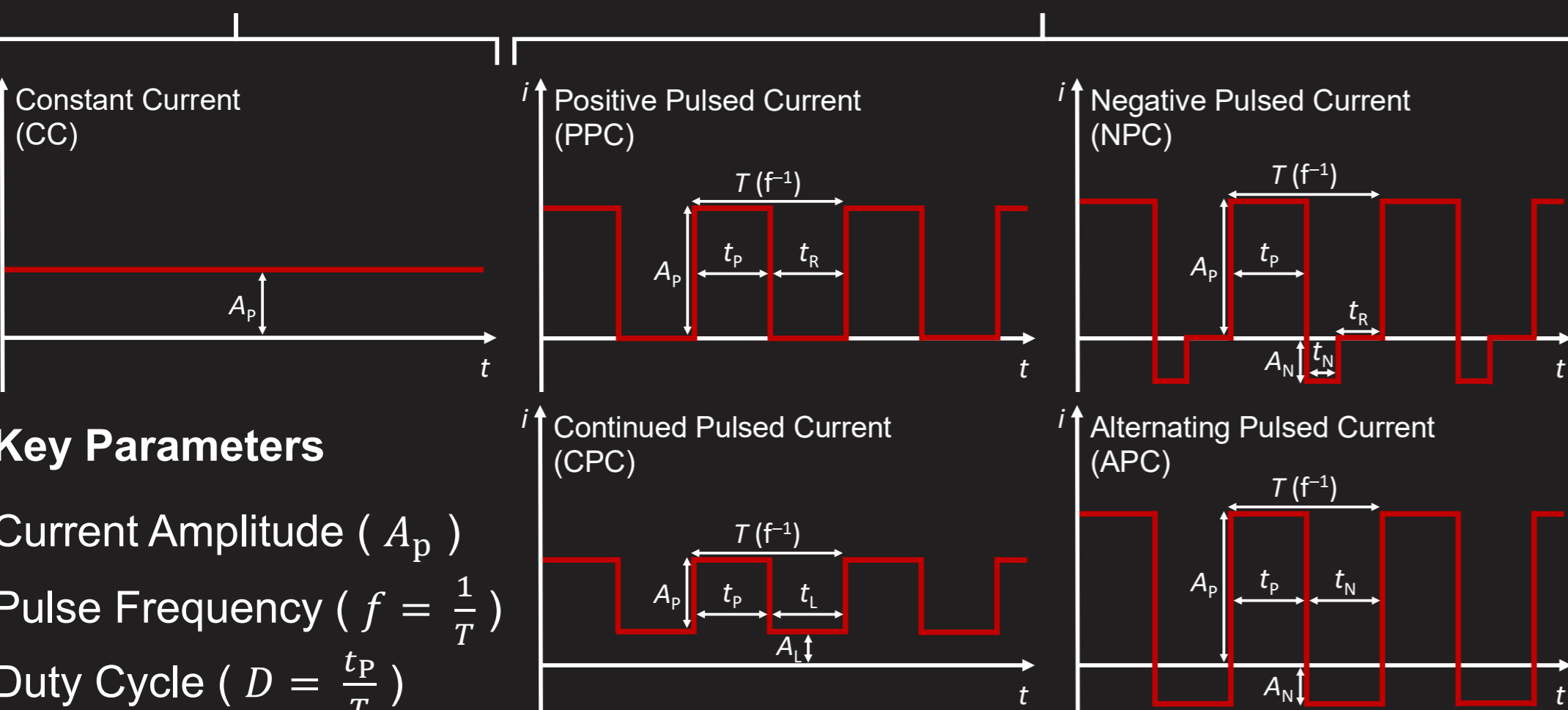


Introduction

Constant Current



Pulsed Current



Key Parameters

Current Amplitude (A_p)
Pulse Frequency ($f = \frac{1}{T}$)
Duty Cycle ($D = \frac{t_p}{T}$)

Results and Discussion

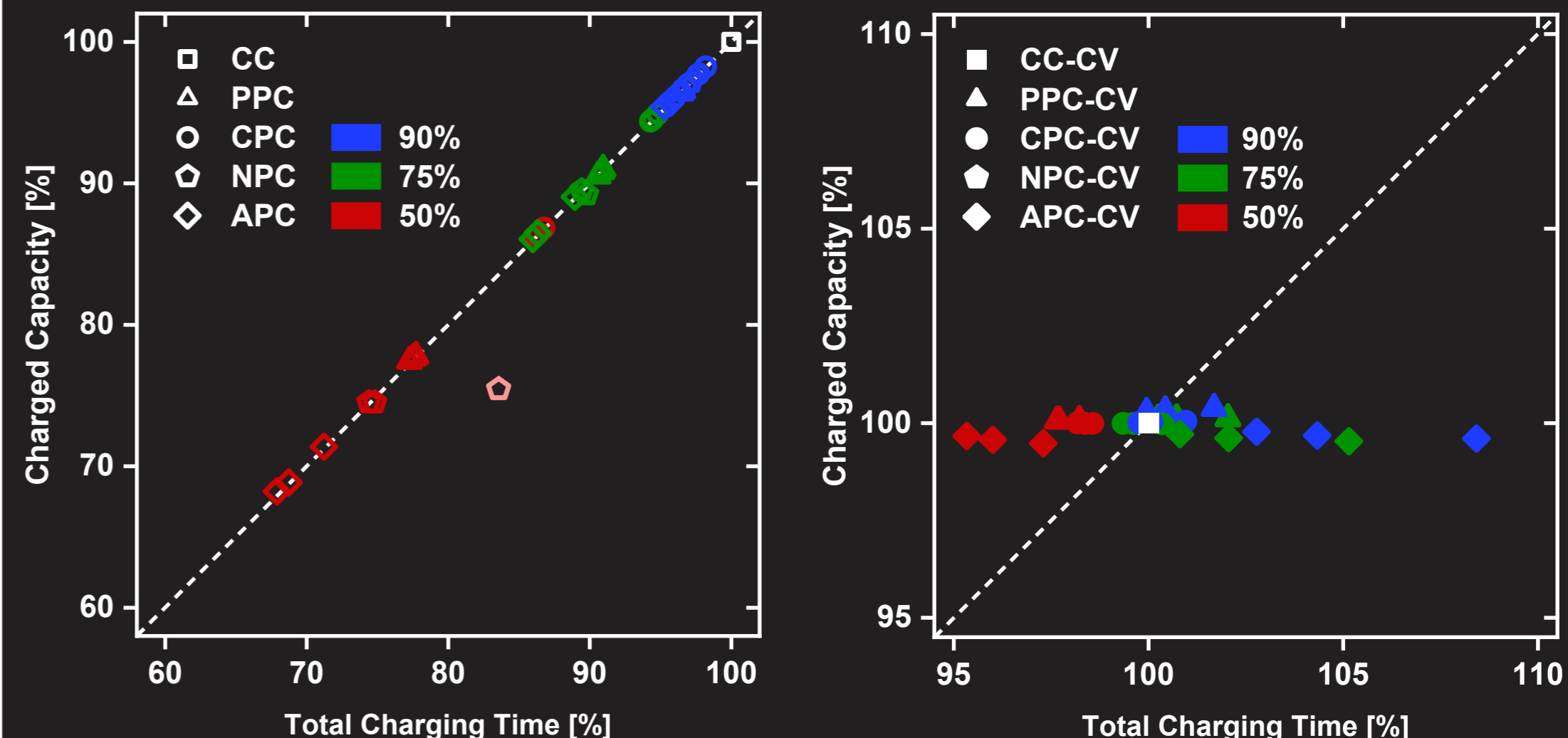
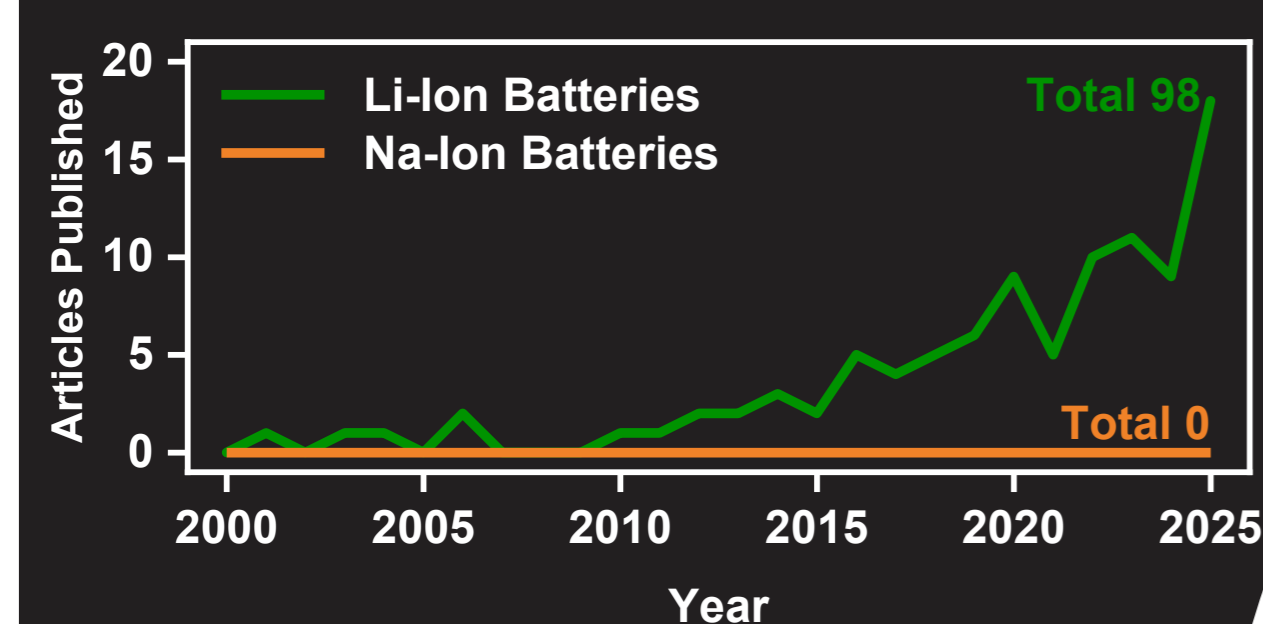


Fig. Charged capacity to charging time ratio as a function of current mode, duty cycle and pulse frequency without (left) and with (right) a subsequent constant voltage step.

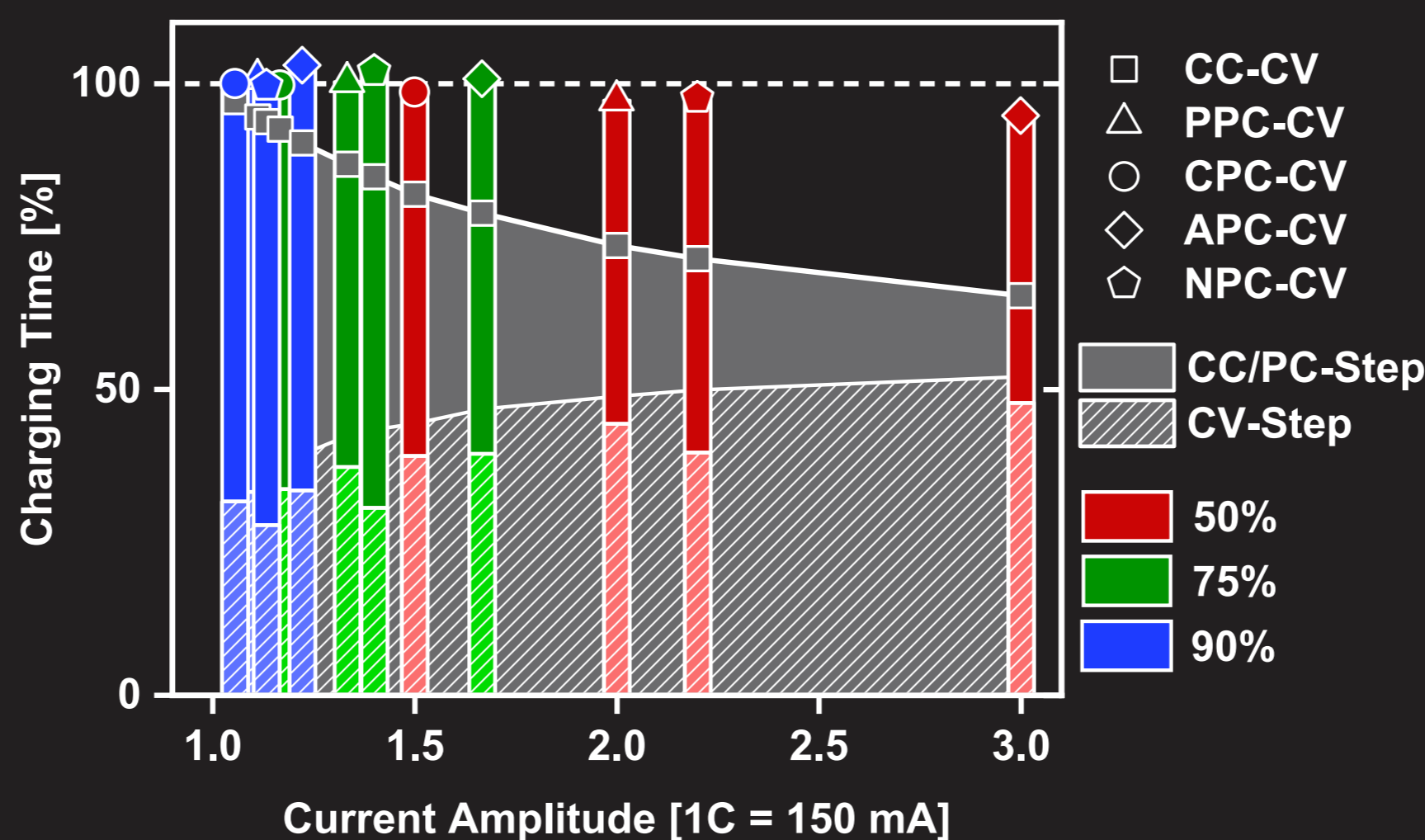
Publications on Pulsed Current Charging



Pulsed Current Charging for Sodium-Ion Batteries?

Conclusions

PC charging offers no fast-charging enhancement for sodium-ion batteries!



Larger current amplitude of PC charging results in increased overpotential without reducing the constant voltage duration.

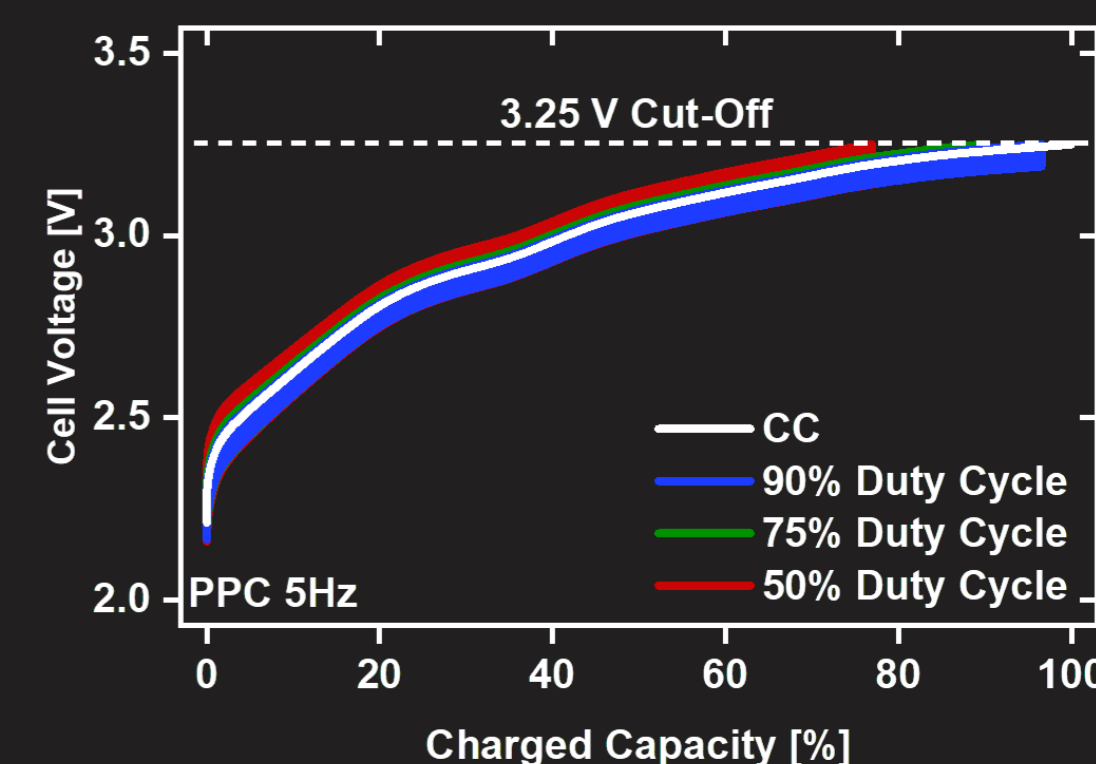
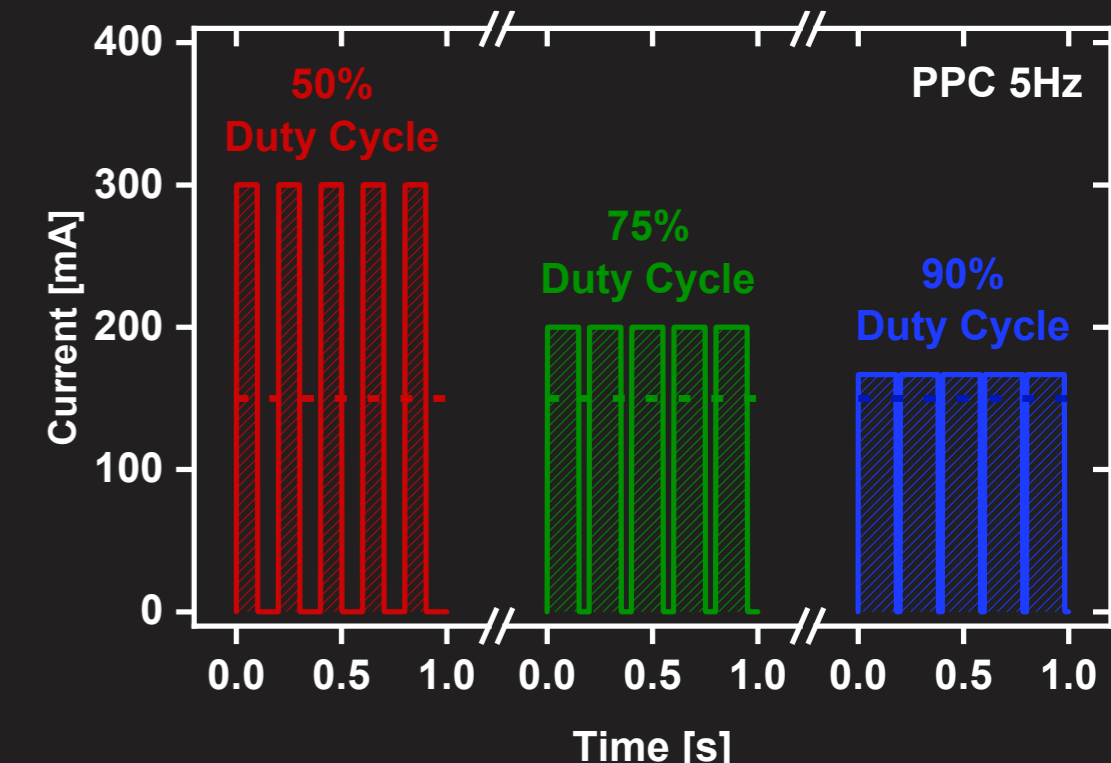


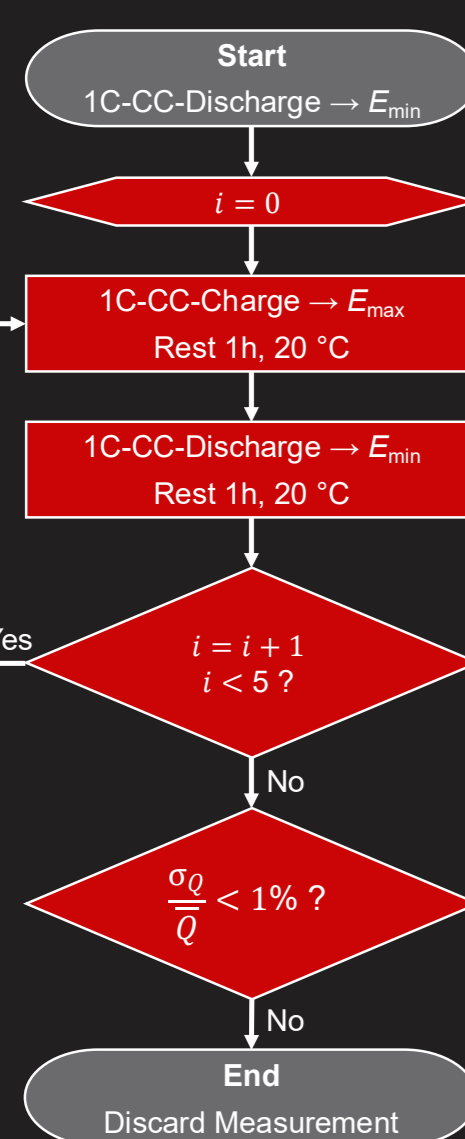
Fig. Current profile of the PPC protocol at 5 Hz as a function of duty cycle (top) with the corresponding voltage profile (bottom).

Methodology

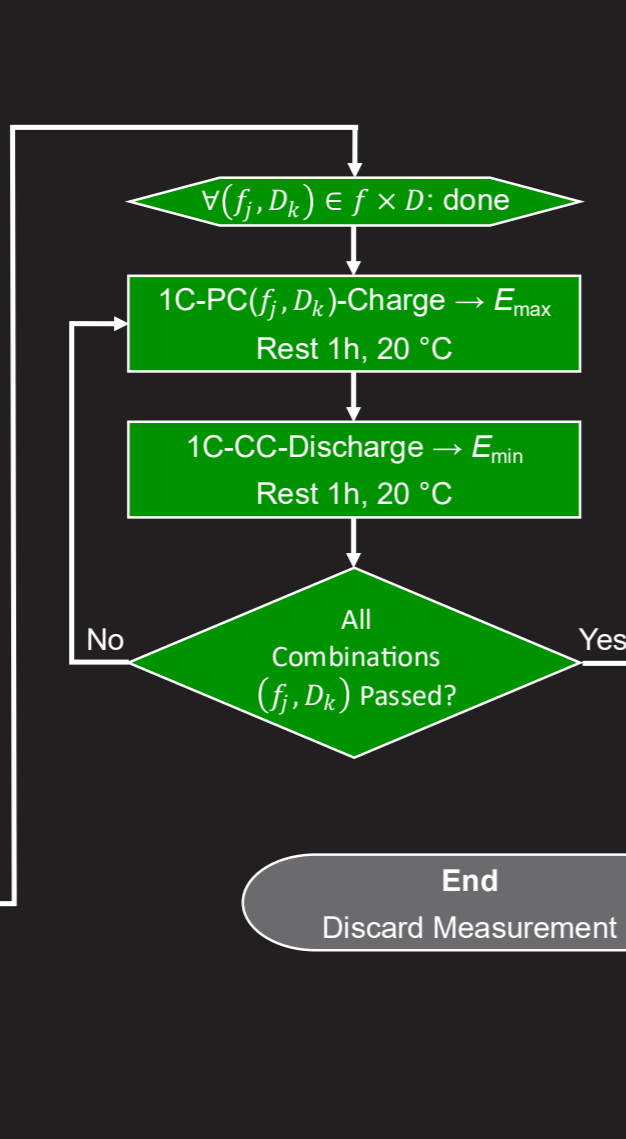
Pos. Electrode: NFPP
Neg. Electrode: Hard Carbon
Current Collector: Aluminum
Electrolyte: 1M NaPF₆ in 2G
Separator: Celgard
Voltage Range: 1.50 to 3.25 V
Nominal Voltage: 2.85 V
Nominal Capacity: 150 mAh
Internal Resistance: 195 mΩ

Fig. Characteristics of the investigated sodium-ion pouch cell.

Stability Check



PC Charging Test



Data Verification

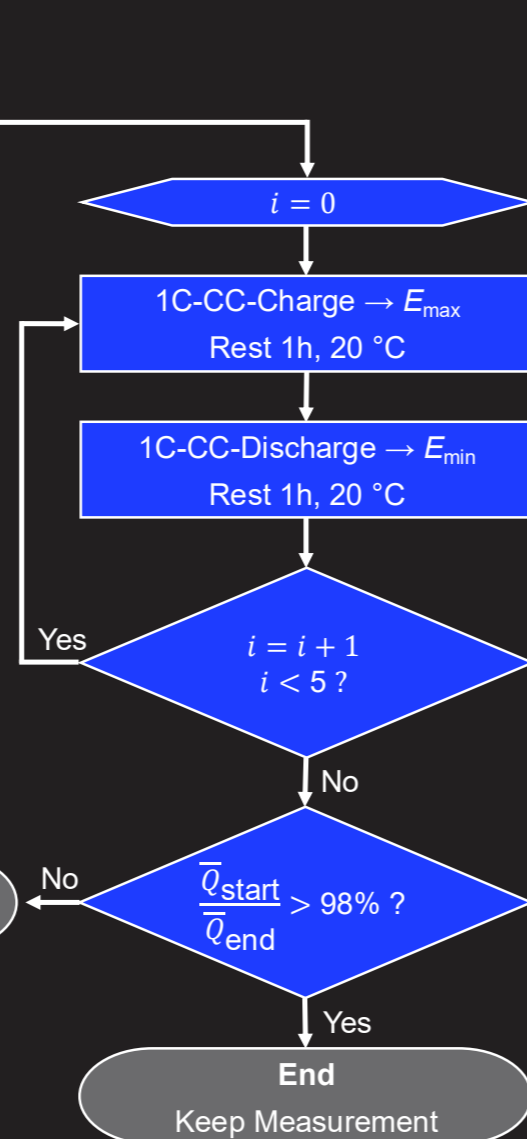


Fig. Measurement protocol for investigating the effect of PC protocols for fast-charging.

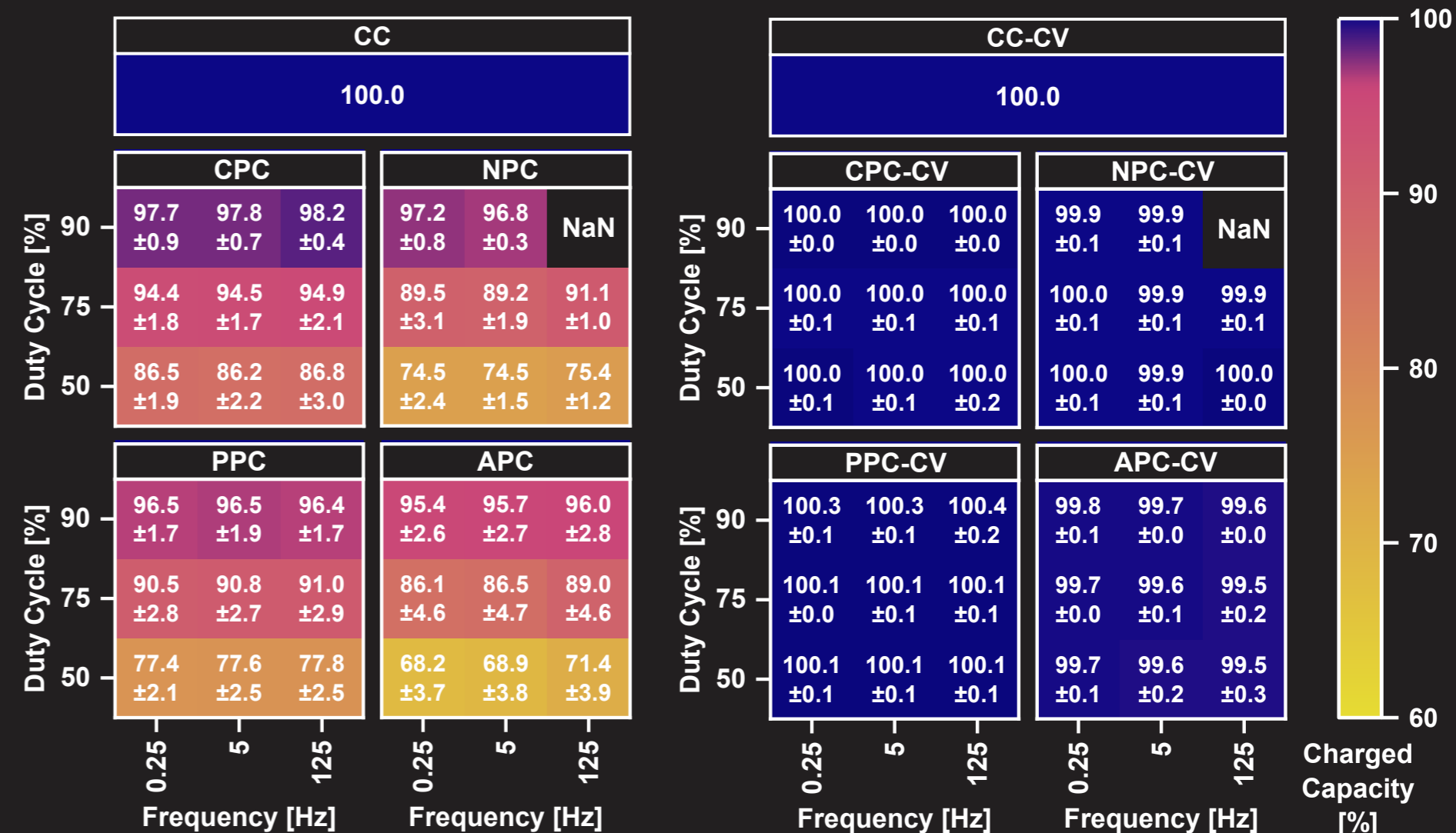


Fig. Capacity retention as a function of current mode, duty cycle, and pulse frequency without (left) and with (right) a subsequent constant voltage step.

Experimental

All measurements were conducted using commercial dry pouch cells consisting of Na₄Fe₃(PO₄)₂P₂O₇ (NFPP) and hard carbon as the positive and negative active electrode materials, respectively. The cells were dried under vacuo at 120 °C for 24 hours, transferred to an Ar-filled glovebox, filled with 1 mL of 1M NaPF₆ in diglyme (2G) and vacuum sealed at -90 kPa gauge pressure. Charged and discharge measurements were conducted at an average current of 150mA (1C) with the current amplitude of the pulsed current charging protocols corrected for the applied current mode and duty cycle. All measurements were repeated with three independent cells.

Acknowledgements



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