Application of *in-situ* dilatometry to investigate the effect of single-walled carbon nanotubes on the performance of Ni-rich cathodes

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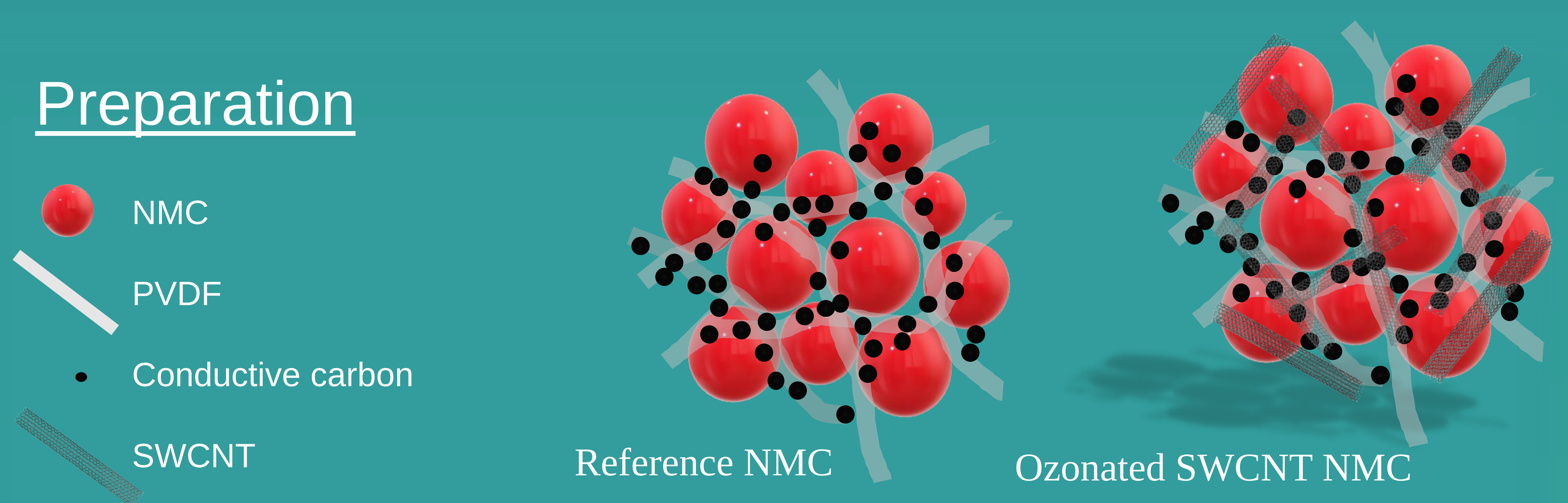
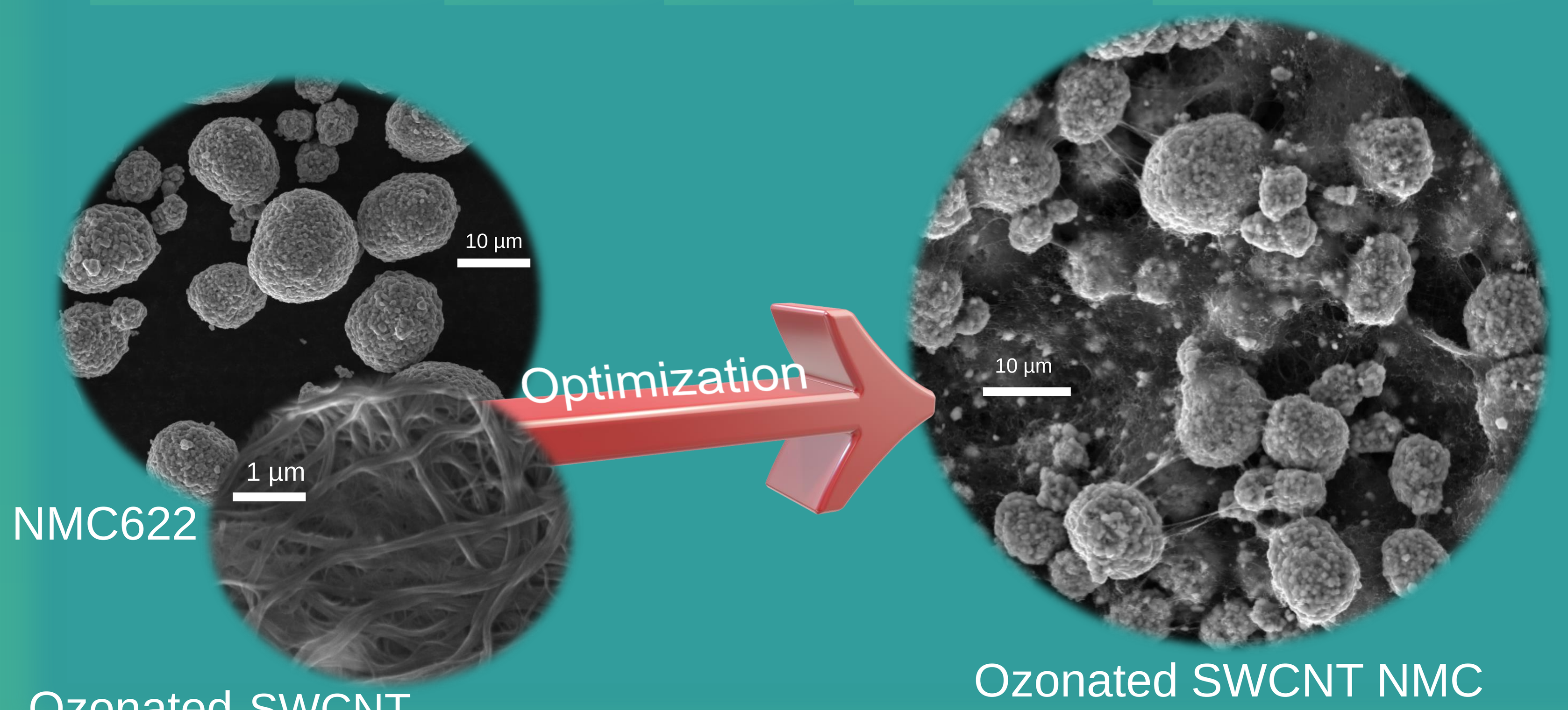
Abstract

- Enhancing lithium-ion batteries (LiBs) cycle life is essential from both economic and sustainability perspective.
- In this work, ozonated long single walled carbon nanotubes (SWCNTs) are utilized to improve electrical conductivity of a $LiNi_{0.6}Mn_{0.2}Co_{0.2}O_2$ (NMC622) positive electrode along with enhancement of the mechanical strength, power density and cycling stability.
- Volume change caused by Li (de-)insertion analyzed by nano-resolution dilatometry and differential analysis of dilatometry.

Preparation

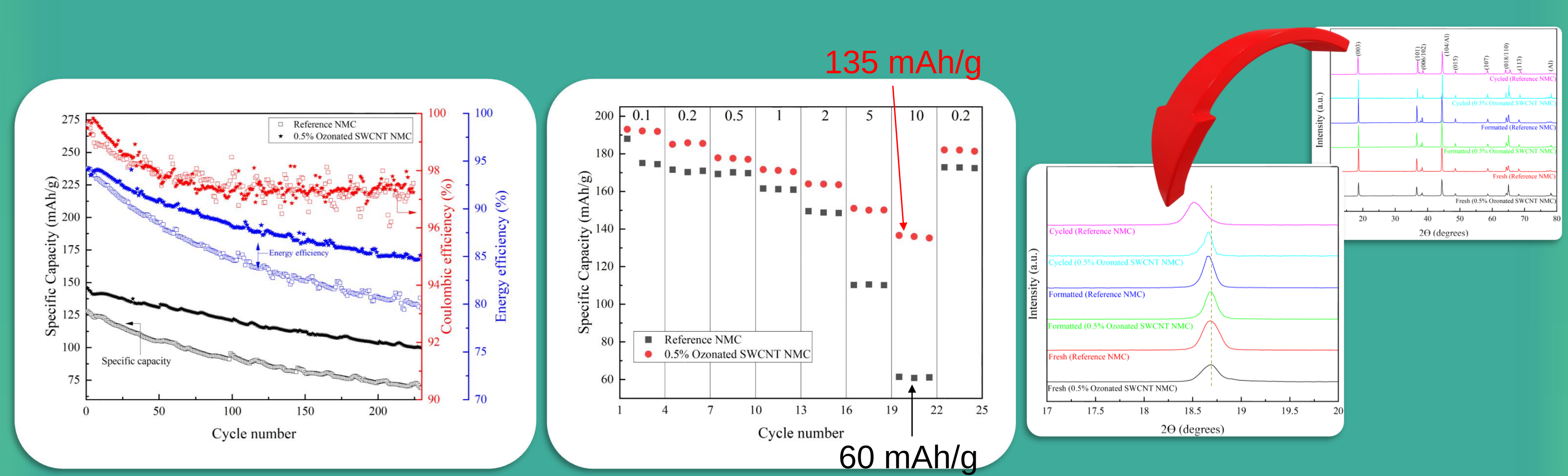


Sample name	NMC 622	Binder	Conductive additive	
			Carbon	Ozonated SWCNT
Reference NMC	95 wt. %	3%	2 wt. %	0 wt. %
SWCNT NMC	95 wt.%	3%	1.5 wt. %	0.5 wt. %



Galvanostatic cycling

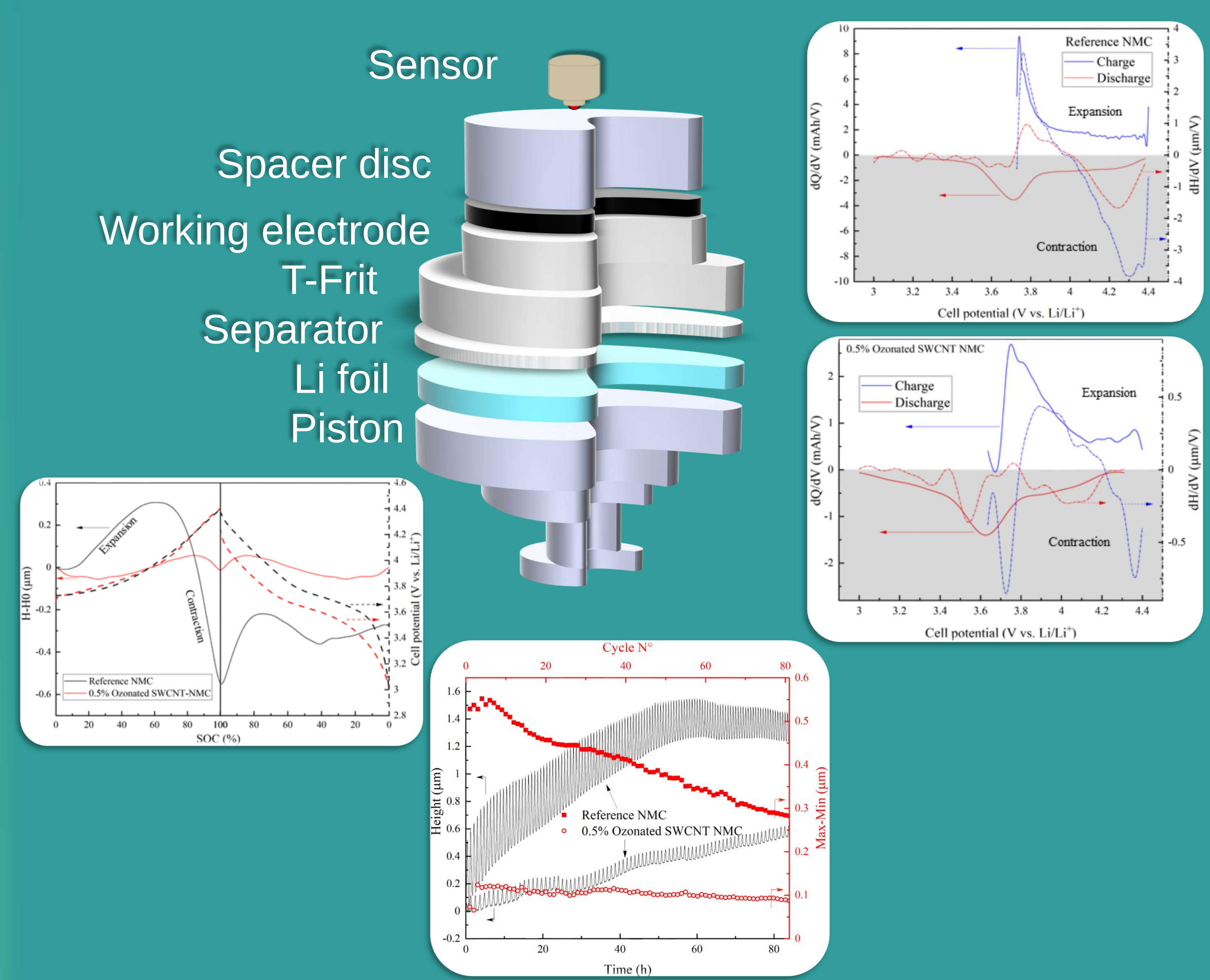
- Capacity retention of 69% compared to 56% after 250 cycles for the Ozonated SWCNT NMC and the reference NMC samples, respectively.
- Higher energy efficiency of the Ozonated SWCNT NMC sample at higher cycle numbers.
- The 0.1C rate capacities for the reference and ozonated-SWCNT NMC samples are 185 mAh/g and 193 mAh/g, respectively.



- The (003) reflection at 18.69° for the fresh samples show an apparent shift to smaller values, to 18.52° and 18.65° for the cycled Reference NMC and 0.5% Ozonated SWCNT NMC electrode, respectively. The smaller shift for the SWCNT sample suggest that the SWCNTs delay the increase in the lattice parameters caused by ageing.

Dilatometry

- *In-situ* electrochemical dilatometry: Working electrode (W.E.) thickness measurement during electrochemical performance in nanoscale.
- Stiff glass frit blocks movements caused by counter electrode
- Spacer disk transfers the movement of the W.E. to the sensor unit.



- Dilatometry results show that the SWCNTs prevent the severe contraction of the NMC622 at higher potentials while the dH/dV analysis reveals that the SWCNTs cause a 200 mV positive shift in electrode contraction threshold potential.
- Long-term cycling results show that the Reference NMC electrode dilation is ~5 times higher than that of the Ozonated SWCNT NMC sample in the early cycles and still ~3 times higher after 80 cycles due to higher capacity loss in the Reference NMC sample.

Conclusion

- Electrochemical results show that SWCNTs improve cells performance significantly compared to the Reference NMC electrode with conventional carbon black conducting additive at a large range of current densities.
- Overall, SWCNTs are concluded to diminish the composite electrode structural changes preventing loss of electronic paths within the electrode porous structure and thus increasing the cycling stability and efficiency and reducing overpotentials.

References

Mousavihashemi, Seyedabolfazl, Katja Lahtinen, and Tanja Kallio. Electrochimica Acta (2022): 140093.

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