ARMOR

INDUSTRY FOR PEOPLE

Primed Al/Cu foils to support the battery market evolution

NAATBatt 2019

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VP Operations

Who are we?

Mid-size industrial company

1922 established in Nantes, France
$300 M revenue (2018)
1850 employees

Expert in formulation and high precision coating

1.3 billion SQM of high precision coating produced annually
97 years of expertise in chemical formulation

Global mindset supported by local proximity

80 % turnover from export
26 manufacturing and logistics sites

En’ Safe® primed Al/Cu foils

- Aluminum or Copper foil with a primer
- Primer coating thickness: typically 1µm
- Improve the interface electrode / metal foil
- Range of 7 primers (different chemistry)

Wide product range required to cope with many applications

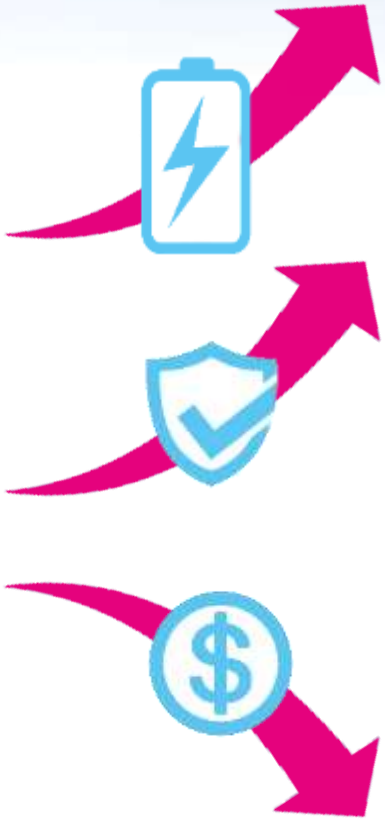
En' Safe® product range

Applications examples:

- Cathodes: NCA, NMC, LFP, LMO/LMNO, LCO
- Anodes: Silicon-based, LTO
- EDLC
- Lithium-Sulfur
- Lithium-ion 4.5 – 5.0V
- Lithium-capacitors
- Etc…

Battery technologies drivers

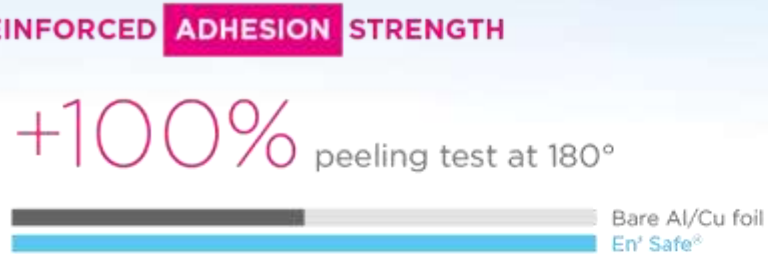
- Power and Energy Density
- Safety
- Cost



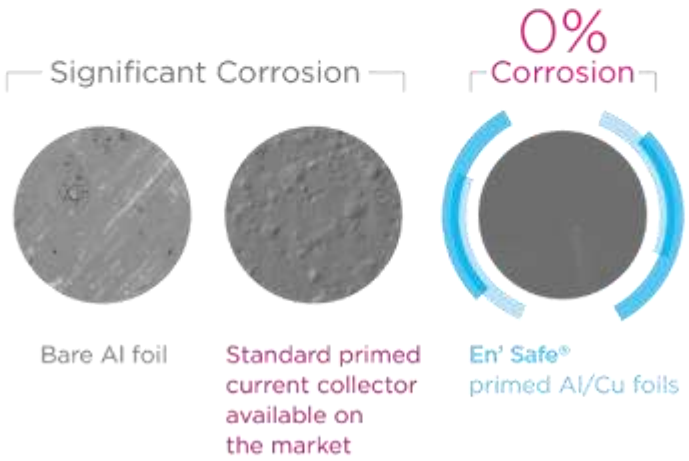
Optimized interface

REINFORCED **ADHESION** STRENGTH

+100% peeling test at 180°

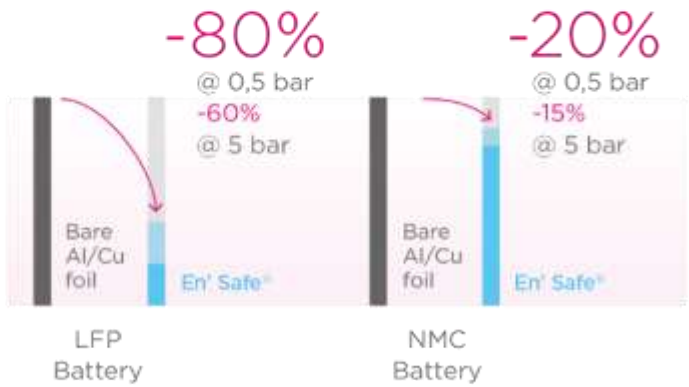


CHEMICAL BARRIER AGAINST **CORROSION**

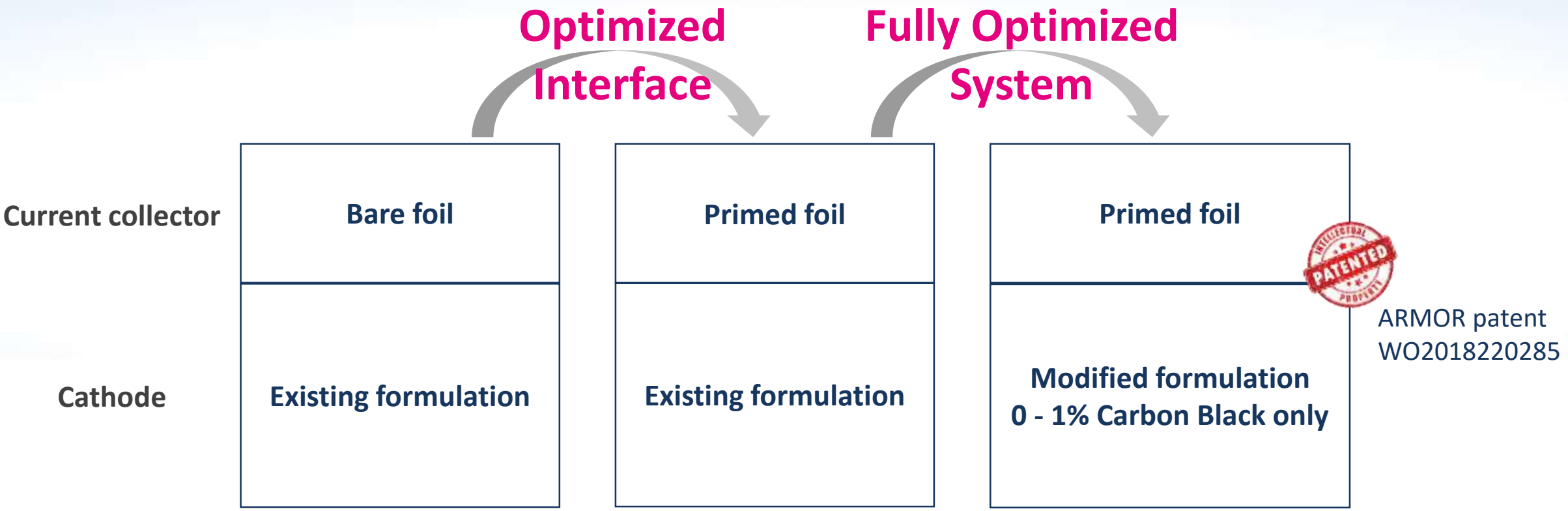


TRIPLE ACTION CURRENT COLLECTOR

LOWER INTERNAL **RESISTANCE**



Seeking for enhanced system performance



Fully optimized system

- En’ Safe® primed foil enables the reduction of Carbon Black in the electrode
  - 0% Carbon Black for LFP
  - 1% Carbon Black for NMC 532
- Excellent performance @ 5C (low impedance, no polarization, no capacity loss)
- Longer cycle life (typically +20%)

Wrap up - Savings ($$$)

- Bill Of Material (BOM) -> 0 to 1% Carbon Black instead of 3 to 5%
- Lower price per kWh -> Replacing passive material (Carbon Black) by active material
- Total Cost of Ownership (TCO) -> Thanks to a longer cycle life

Thank you for your attention !

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Auxiliary Slides – Reduction of Carbon Black

Systems tested

Cathode type	Electrode carbon content
LFP	E0 = 0 % Carbon Black
	E1 = 1 % Carbon Black
	E2 = 2 % Carbon Black
	E3 = 3 % Carbon Black
	E5 = 5% Carbon Black
NMC 532	

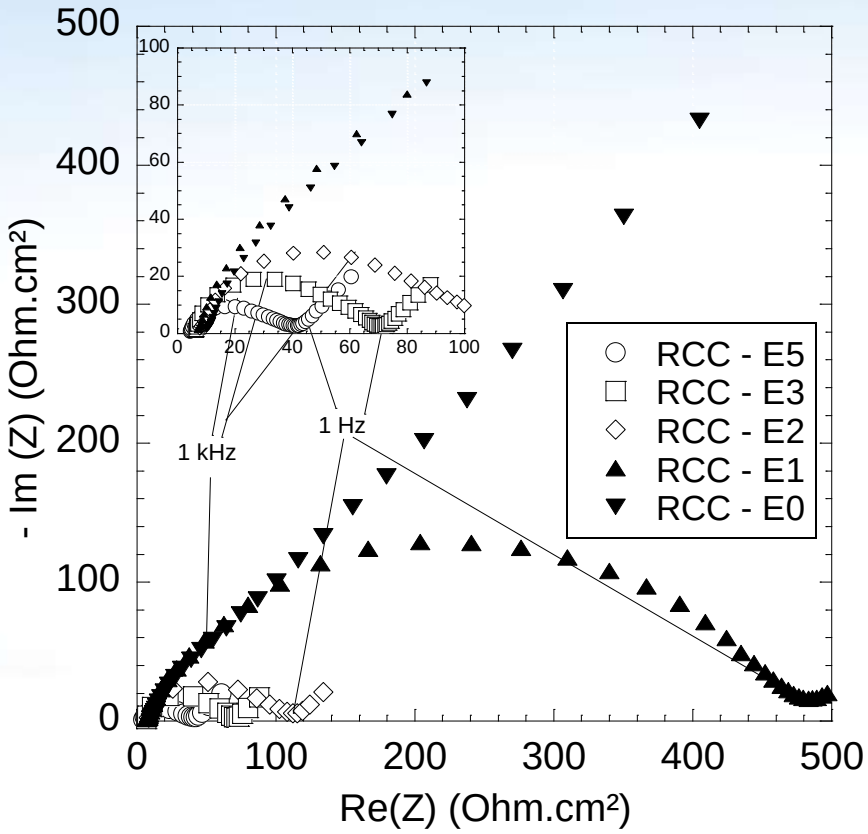
Test types

Topic	Test type	LFP	NMC 532
Impedance (especially for power app)	Electrochemical Impedance Spectroscopy (EIS)	X	
Power curves (especially for power app)	Rate capability 2,1V to 4,2V vs graphite C/5 to 5C	X	
Charge/discharge cycles (for cycle life)	Cycling @C and 2C	X	X
Specific capacity (especially for energy app)	Specific capacity @5C		X

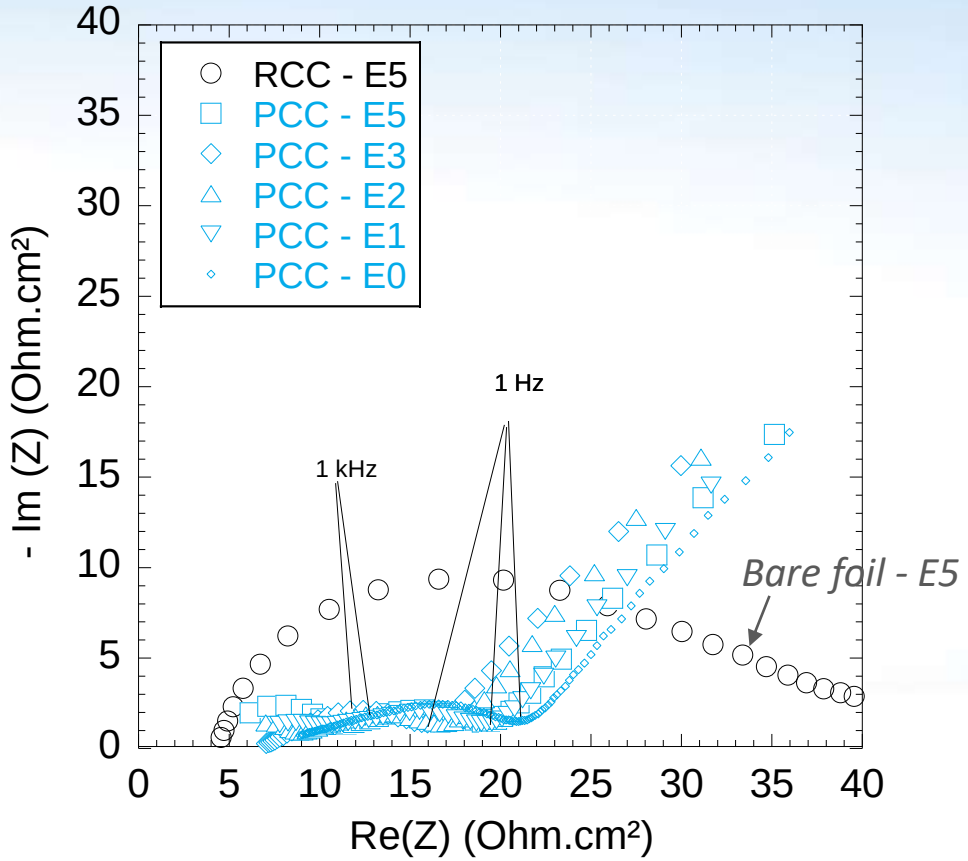
LFP cathodes

down to 0% Carbon Black

Electrochemical Impedance Spectroscopy (EIS) characterizations



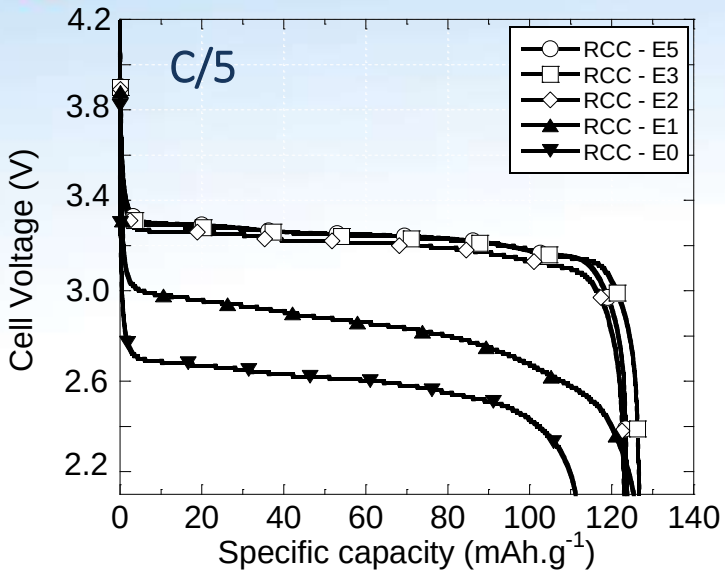
@ 50 % SoC (1 hour stand-by)
189 kHz - 10 mHz
ΔV = 5 mV

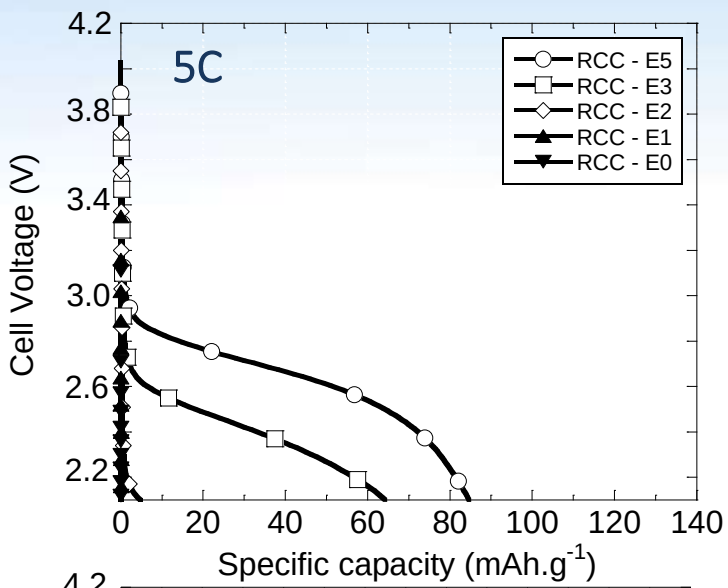


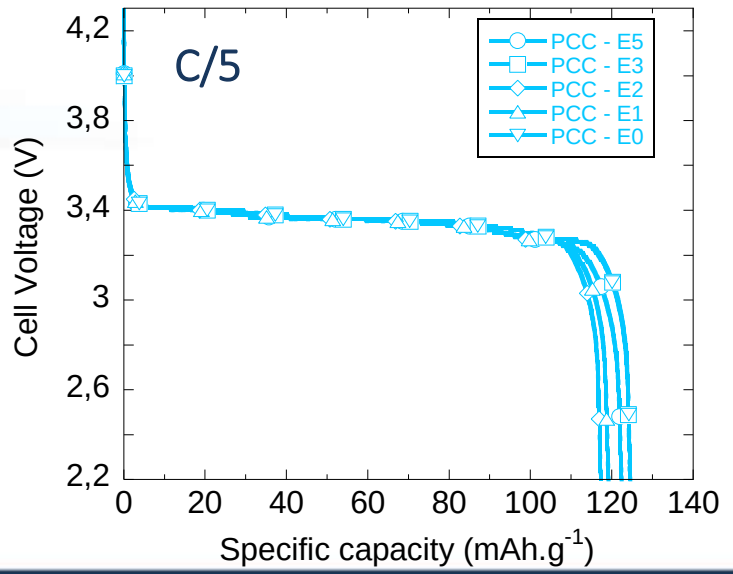
Bare Al foil
Huge impedance increase (from 40 to 2000 Ohm.cm²) when reducing electrode carbon content

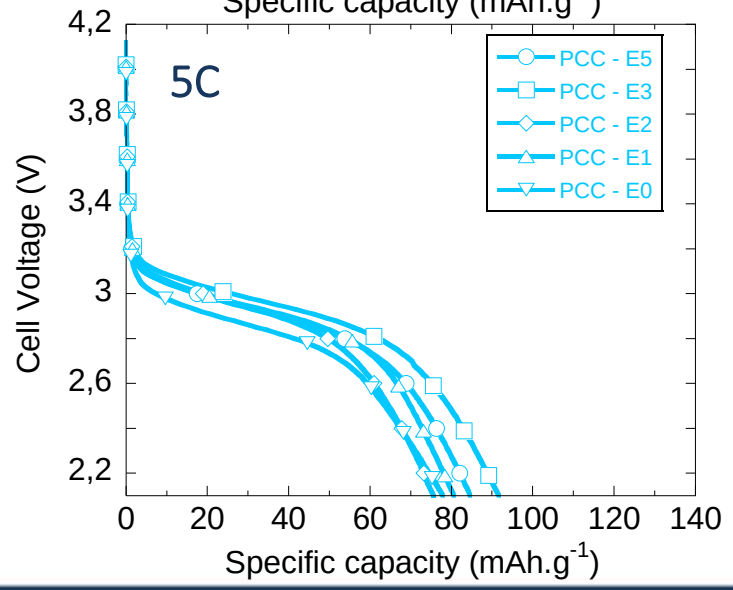
Primed Al foil
Very small impedance even with 0% Carbon Black in the electrode

Rate performance







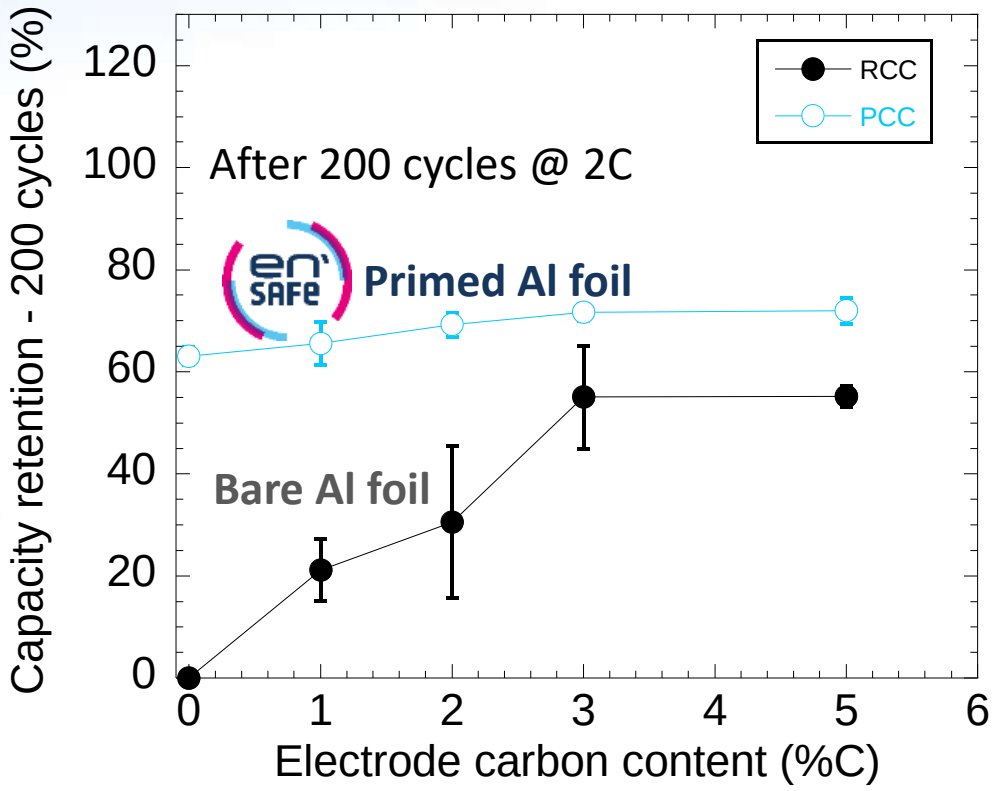


Bare Al foil
High polarization and huge capacity loss

Rate capability
2.1V to 4.2V vs Graphite
Previous charge at C/5
Discharge between C/5 and 10C

Primed Al foil
Almost no impact of electrode carbon content on capacity and polarization

Cycling



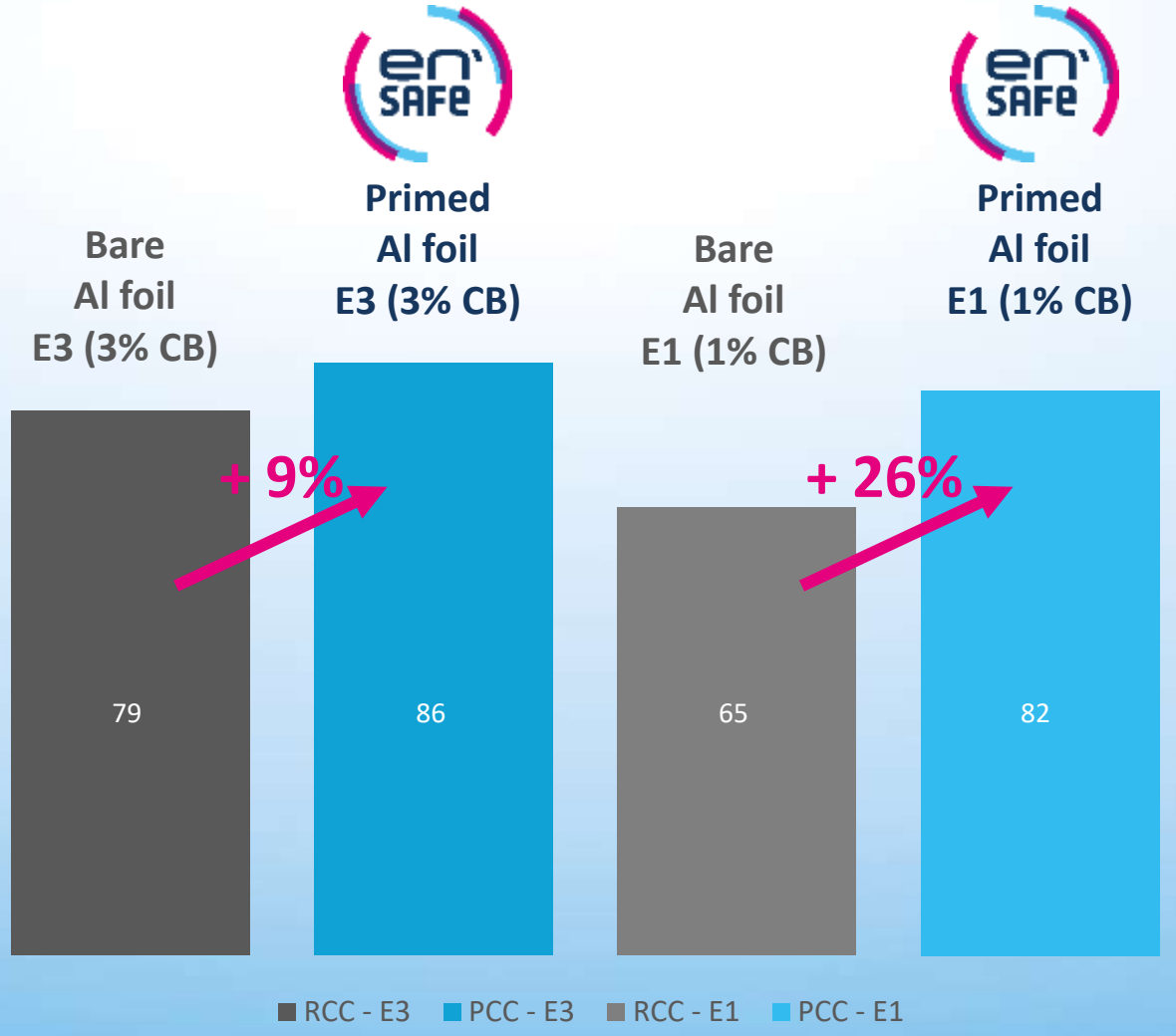
Bare Al foil:
Drastic loss of capacity retention by reducing electrode carbon content

Primed Al foil:
Low impact on capacity retention even with 0% Carbon Black in the electrode

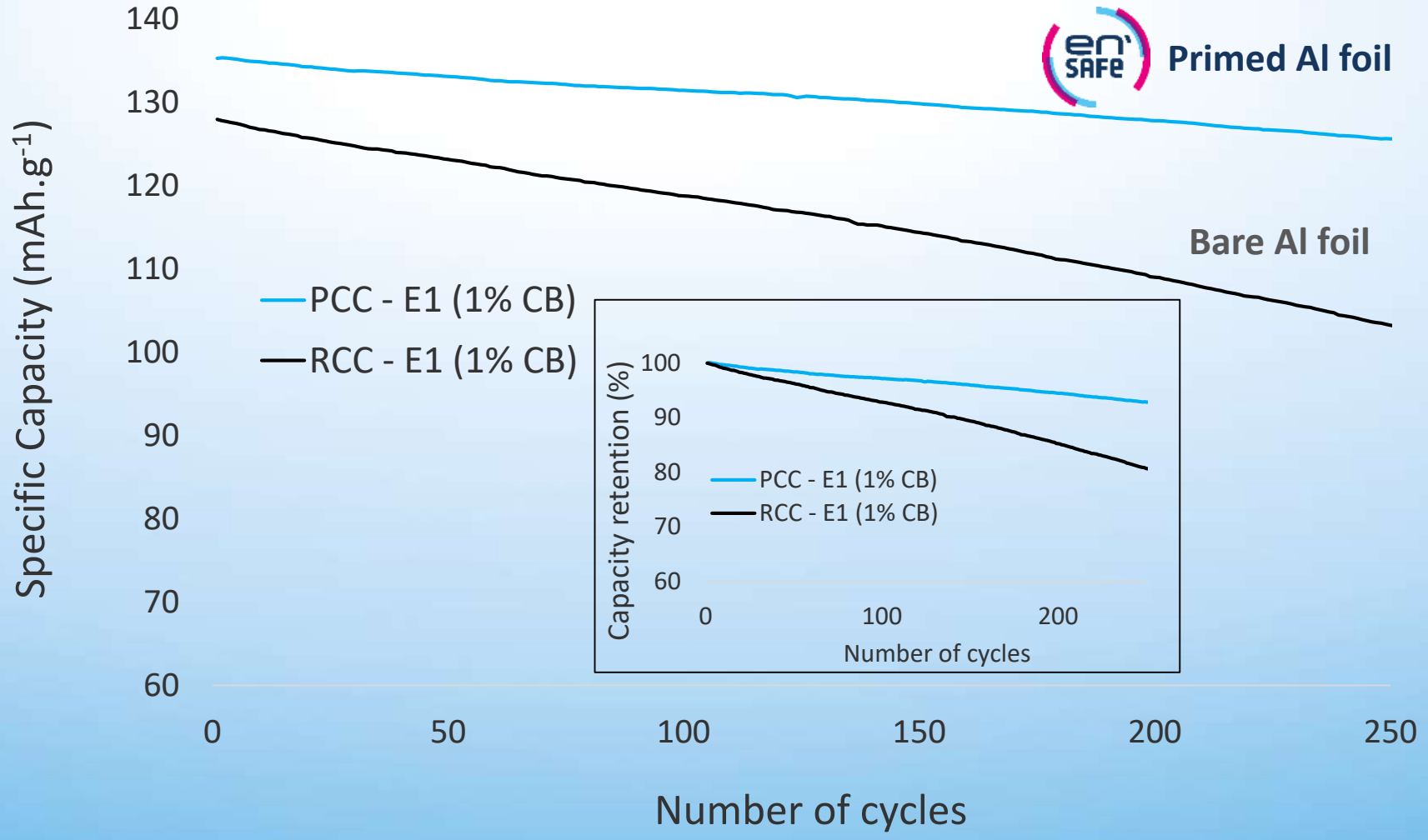
NMC 532 cathodes

down to 1% Carbon Black

Specific capacity (mAh.g^{-1}) @ 5C



Cycling @ C (1% Carbon Black in the electrode)

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SAFe
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