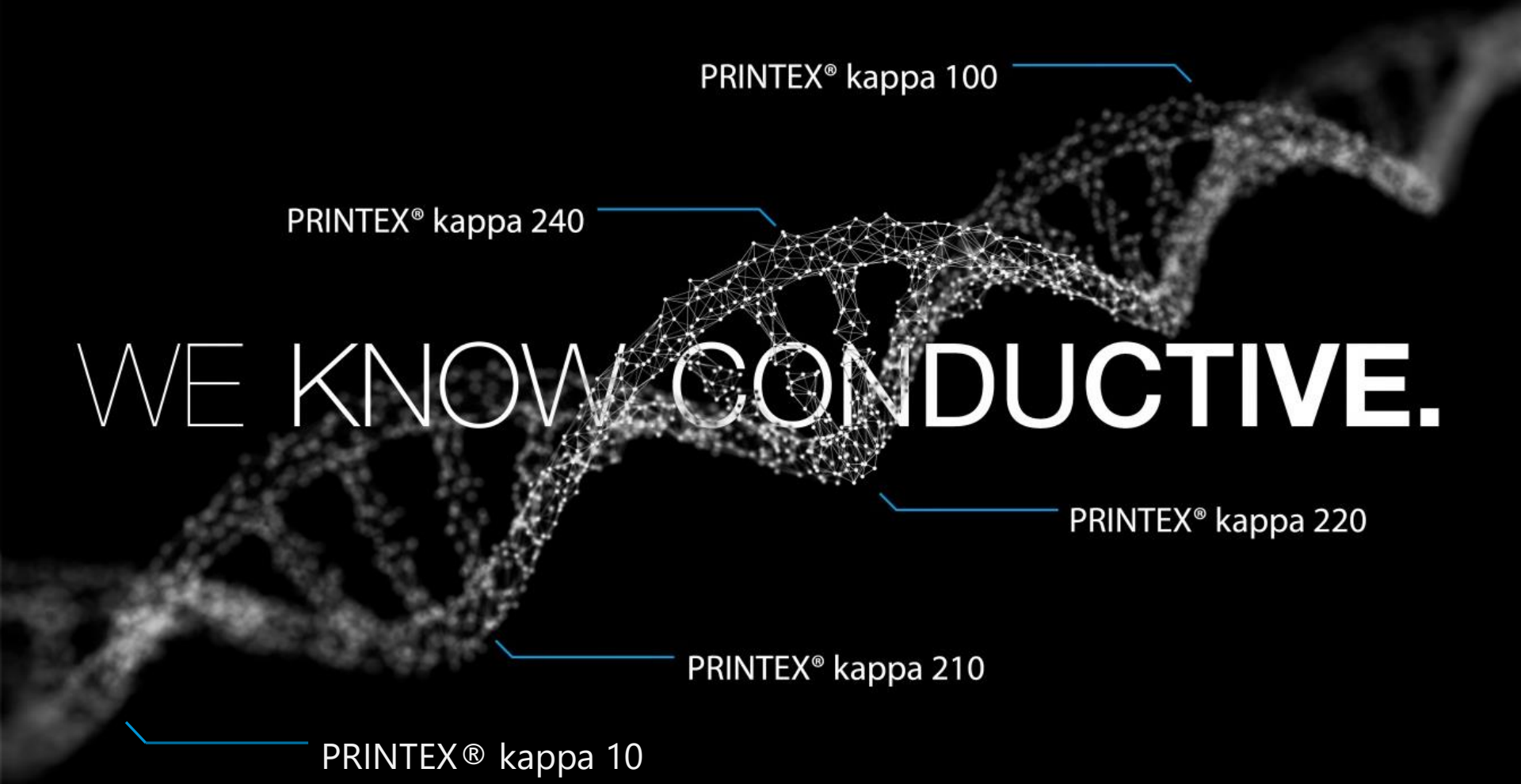
Orion Engineered Carbons



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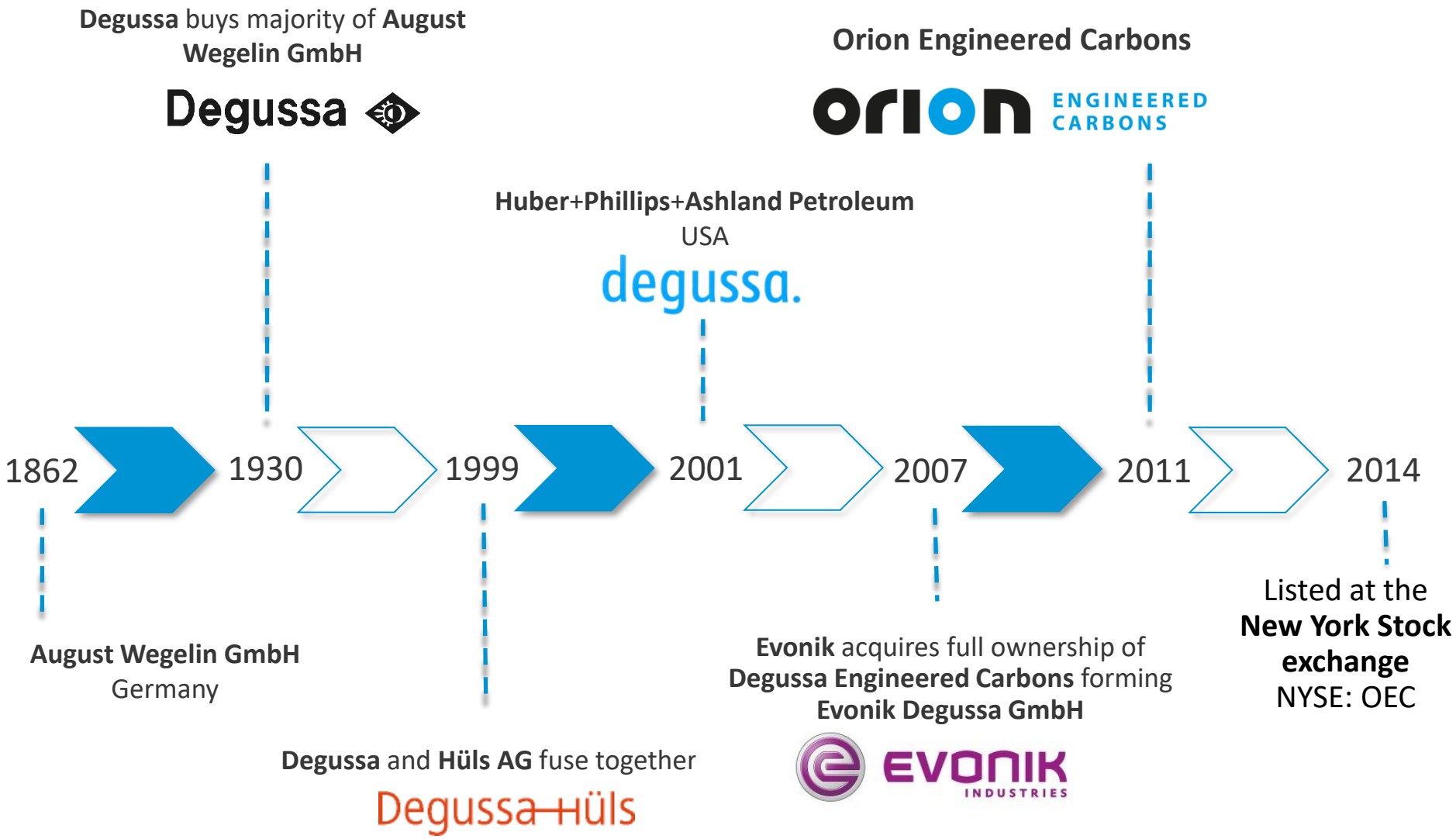
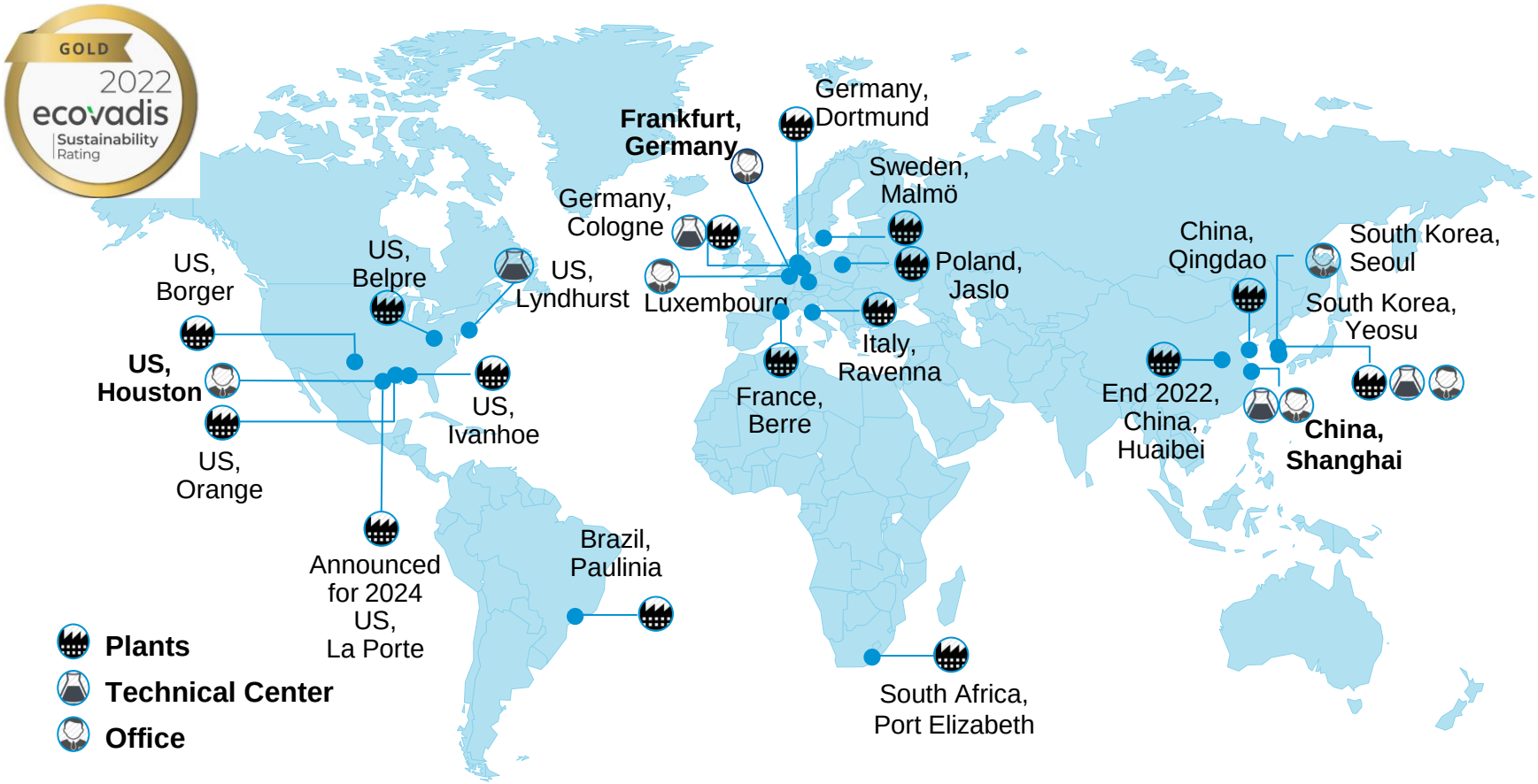
More than 150-year experience in Carbon Blacks

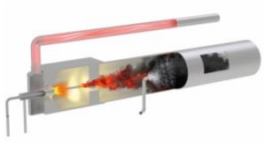
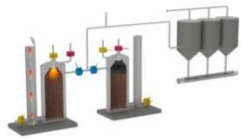
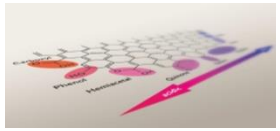


ORION Global Footprint

14 Production Sites – 4 Technical Centers – 1475 Employees –
2021: 1.55 bn US$ Sales – adj. EBITDA 148 mn USD – Sold Quantity of 964.300 tons
ECOVADIS – Gold rating (top 3% companies) and ISO 9001 and 14001 certified



Broadest process technology portfolio

	Furnace Black	Gas Black	Lamp Black	Acetylene Black	Thermal Black	Post-treatment
						
Rubber CB	Tire			Tire		
	MRG	MRG	MRG	MRG	MRG	
Specialty Carbon Black	Plastics	Plastics	Plastics	Plastics		
	Printing	Printing				Printing
	Coatings	Coatings	Coatings	Coatings		Coatings
	Sealants	Sealants		Sealants		Sealants
	Batteries (LAB)	Batteries (aLAB)	Batteries (LAB & aLAB)	Batteries (LiB & DryCell)		Batteries

LAB Lead-Acid Battery aLAB= advanced LAB; LIB Lithium Ion Battery; MRG=mechanical rubber goods

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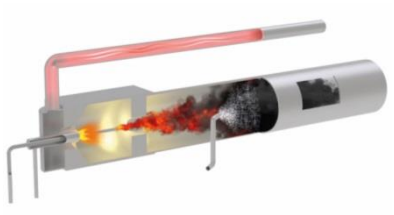
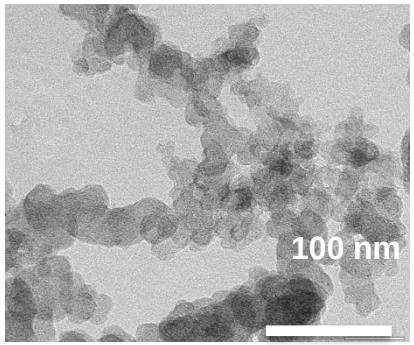
Broadest portfolio for different surface area and morphology for battery materials

Furnace Black Process

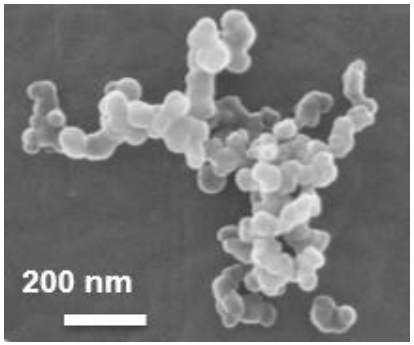




BET [m^2/g]	25 – 1150*
OAN [ml/100g]	40 - 420*

Easy to alter surface area/structure in a wide range

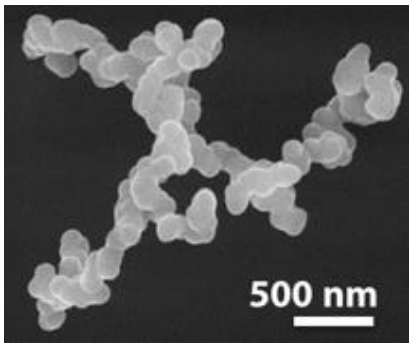
Gas Black Process



BET [m^2/g]	90 - 550
OAN [ml/100g]	110 - 200

Gas Black has small particles and high structure and slightly oxidized surface

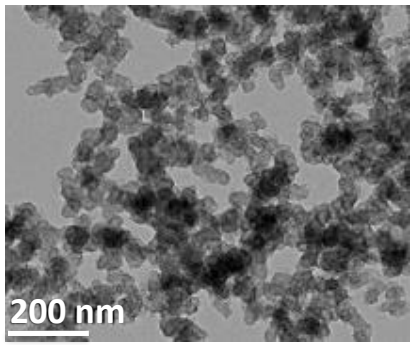
Lamp Black Process



BET [m^2/g]	30
OAN [ml/100g]	130 - 140

One unique grade, great for dispersion and with excellent purity

Acetylene Black Process



BET [m^2/g]	60-130
OAN [ml/100g]	>>220

Unique grades, Highest conductivity, extraordinary purity

New applications require advanced Lead Acid Batteries

New demands for batteries

- Fast Charging for e.g. Regenerative Breaking
- Idle-Start-Stop Functionality
- Maintenance Free and Long-Life due to Low Water Consumption
- Higher Endurance for Multiple Tasks in Hybrid Vehicles

Battery Performance Parameters needing to be enhanced by Modifications/Additives

- Dynamic Charge Acceptance (DCA)
- Cold Cranking
- Water Loss
- Cycle Life

Conductive Carbon Black enhanced negative electrode, which can significantly relieve the sulfation problem of negative electrodes at HRPSOC working condition.

More and more Carbon Black particles **facilitates the formation of small $PbSO_4$ particles** and restricts large $PbSO_4$ crystal growth.

High-surface area Carbon Black particles **have supercapacitive effect in NAM.**

HRPSOC=high rate partial state of charge; NAM=negative active material

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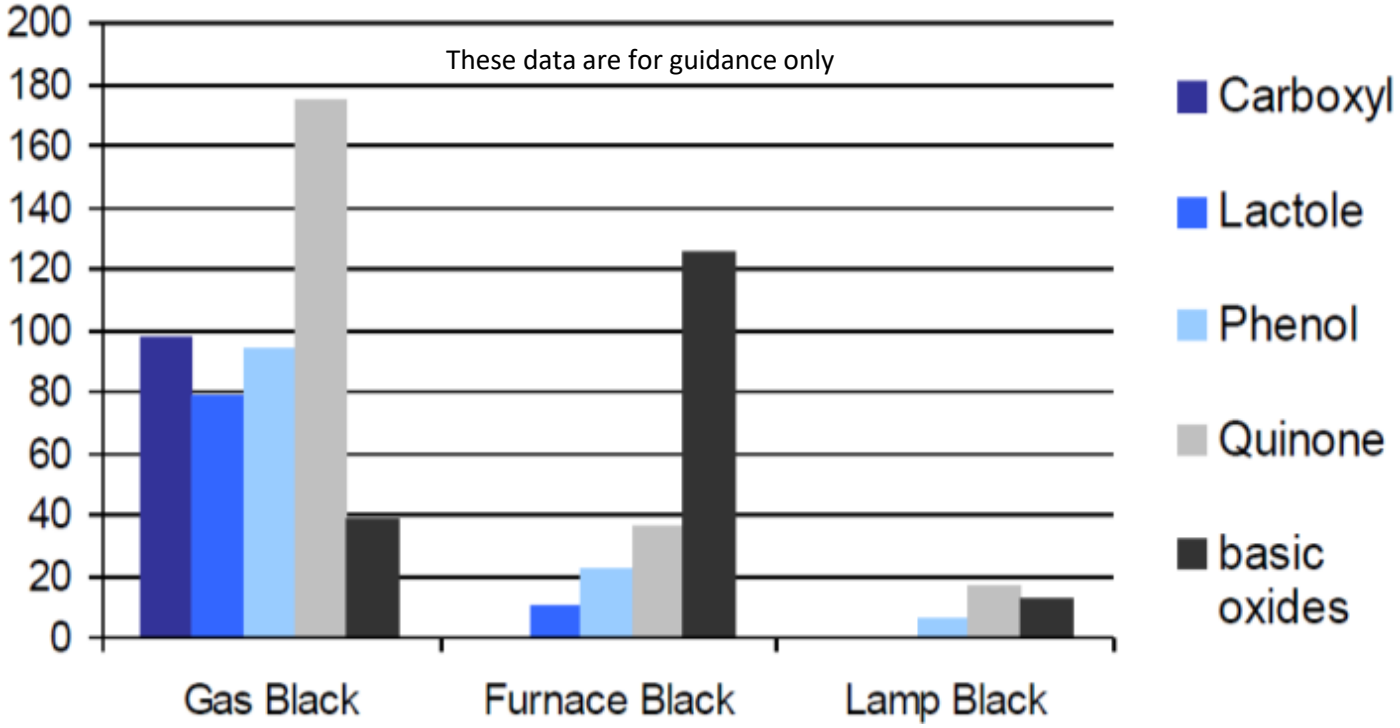
Orion controls Surface Chemistry

Surface group concentration on different Carbon Black (µmol/kg)



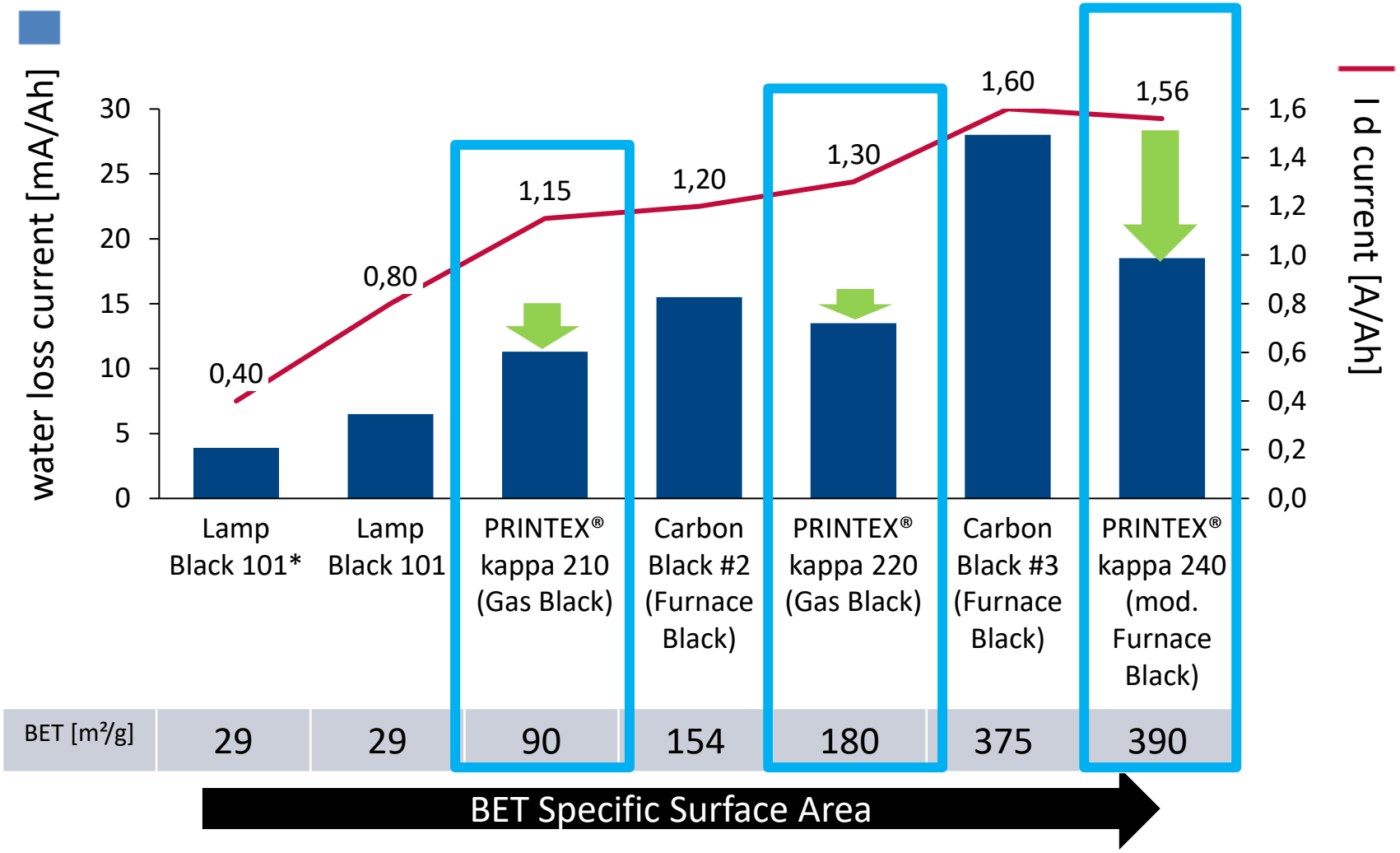
Volatile matter content of Carbon Black (weight loss at 950°C) :

Lamp Black /Acetylene Black : **< 0.7 wt.%**

Furnace Black: **1- 2 wt.%**

Gas Black or **Modified furnace black**: **3-20 wt. %**

Advantages of Surface Control



CB dosage 1.0 wt.% LO; *=0.2 wt.%; Cell 1st gen.

Reliable and high conductive carbon additives for LIB PRINTEX® kappa 100 and PRINTEX® kappa 10

Illustration different powdered and beaded Carbon Blacks

Production plant Cologne, Germany

Production plant Berre, France

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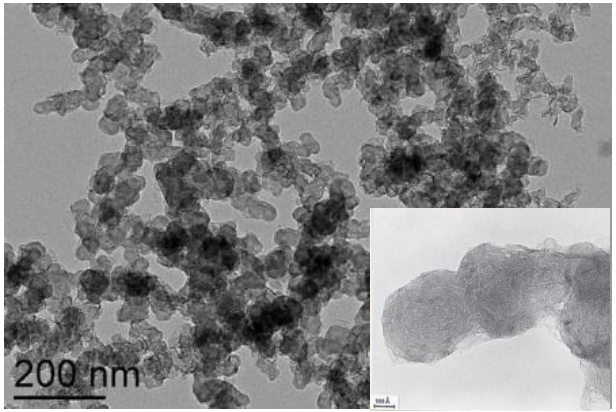
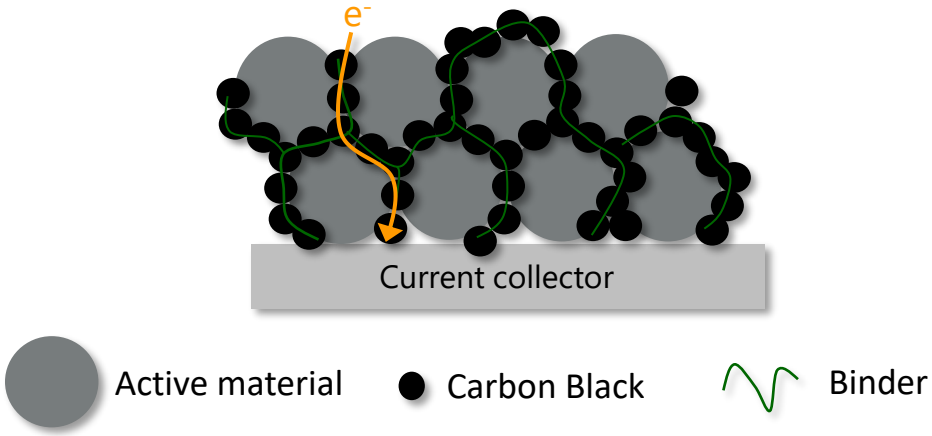
Where are conductive carbon blacks used?

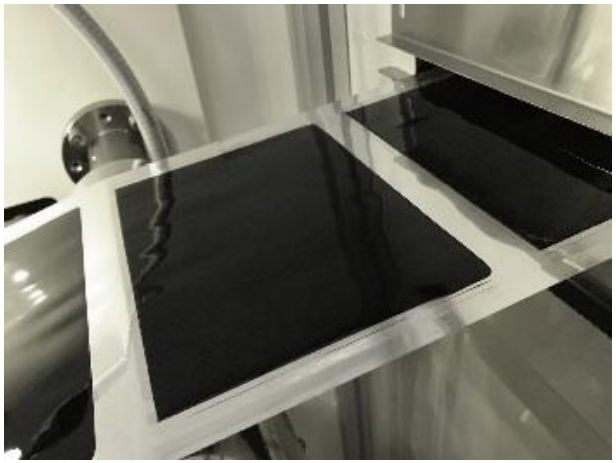
PRINTEX® kappa 100 or 10 are …

…used in small dosages as conductive carbon additive for cathode (1-3wt.-%) and anode (0.5-1wt.-%) formulations to ***lower internal resistance of the cells by forming a percolating network*** of conductive carbon black particles.



SEM micrograph showing fused graphitic structure of primary particles which are fused to larger aggregates





Picture of final wet cathode coating with conductive carbon additive

ORION's high quality Acetylene Black process technology: Benefits in your LIB

Clean feedstock and high quality process	Unique production process	High graphitization level
No side reactions /shuttle effect caused by impurities	High level long chain network structure	Very low moisture content
Low self-discharge	Easy to form a conductive network	High thermal and electrical conductivity
High cycle life	Easy to disperse during the slurry preparation	Good chemical stability at high voltage condition
		Higher energy and power density

LIB = Lithium-Ion Batteries

Sustainable Conductive Carbon Additive

$$nC_2H_2 \rightarrow 2C_n + nH_2$$

- Acetylene Black is formed by acetylene gas thermal decomposition in reactor
- Side product is hydrogen, which is released as water
- CO_2 emission is less than 200 kg per ton of Carbon Black compared to more than 5.000 kg of high conductive Furnace Blacks

Environment friendly processes

(Lowest CO_2 emission for a carbon black product)

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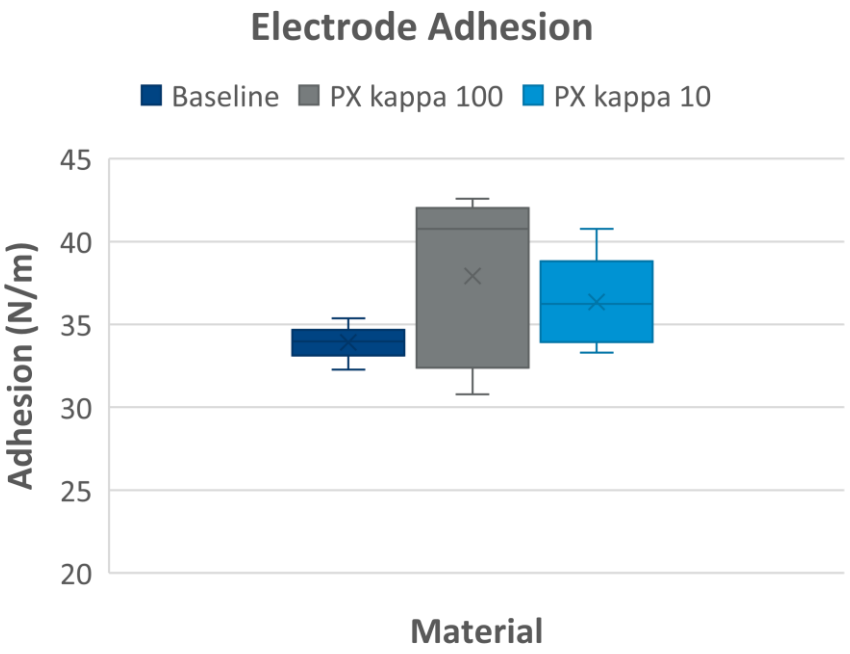
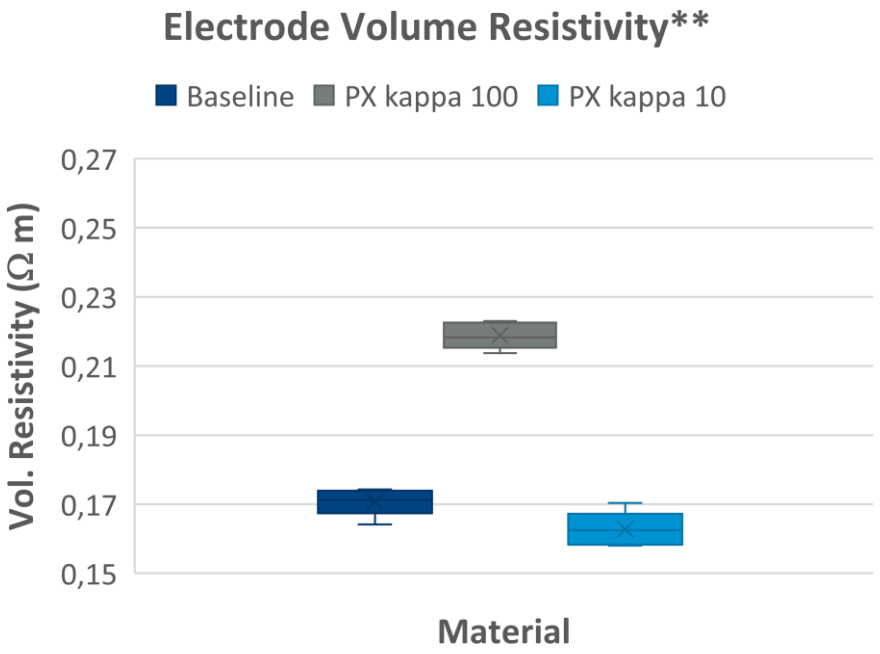
Performance in LFP electrodes

Formulation:

94% LFP | 3% Carbon black* | 3% PVdF



Good electrode adhesion with PRINTEX® kappa 100 and kappa 10



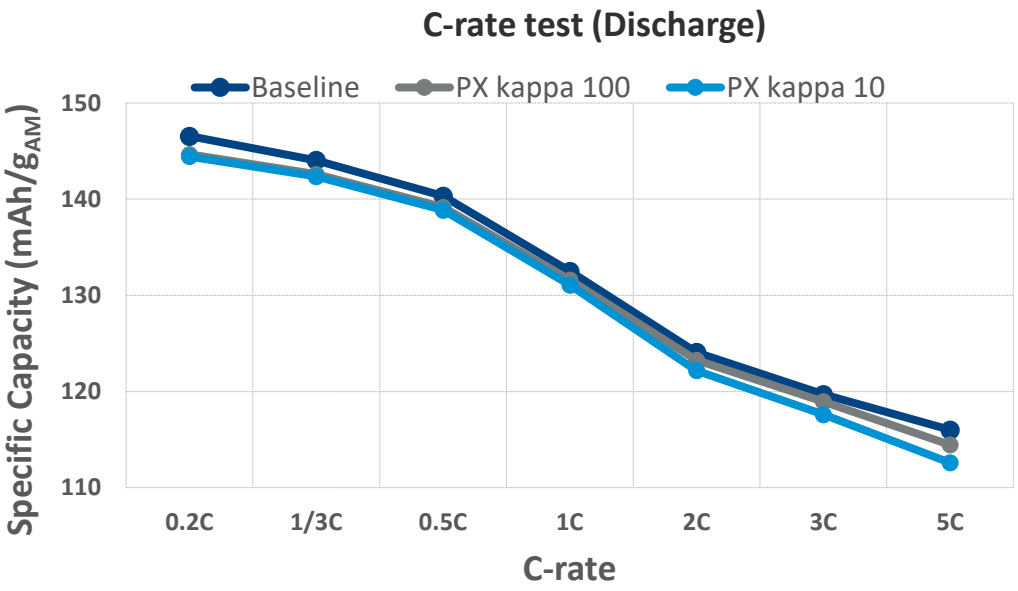
PRINTEX® kappa 10 has lower volume resistivity (VR) than the baseline

**** Double-side-coated electrodes**

Electrode loading = 152 g/m^2 // Electrode density = 2.1 g/cm^3

* PRINTEX® kappa 100 or kappa 10

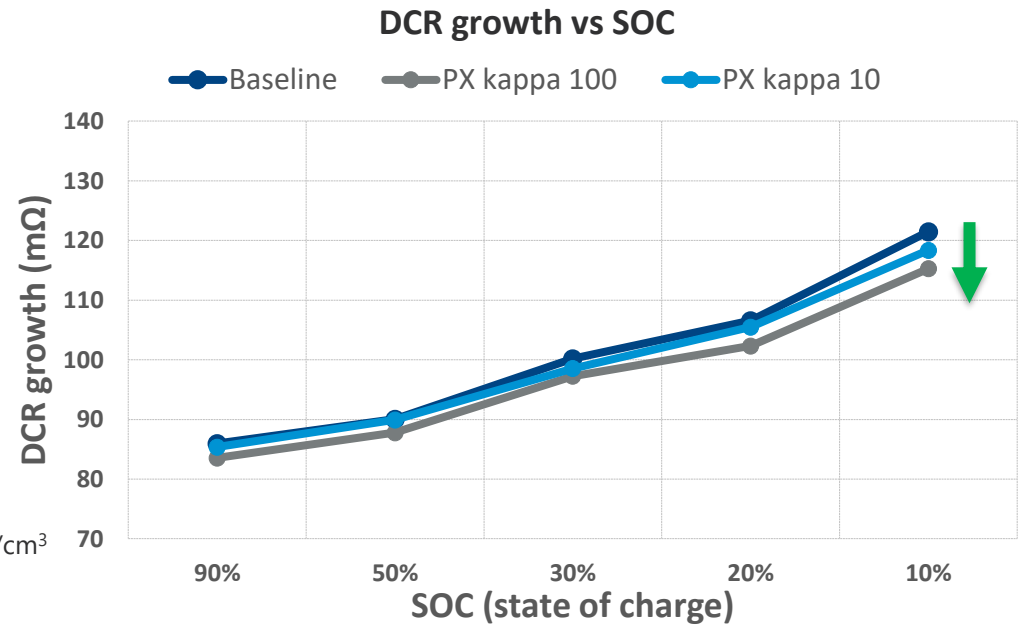
1.2 Ah Pouch cells with LFP electrodes



PRINTEX® kappa 100 and PRINTEX® kappa 10 have a **smooth capacity decay** at higher c-rates, indicating a **homogeneous** CB distribution in the electrode.

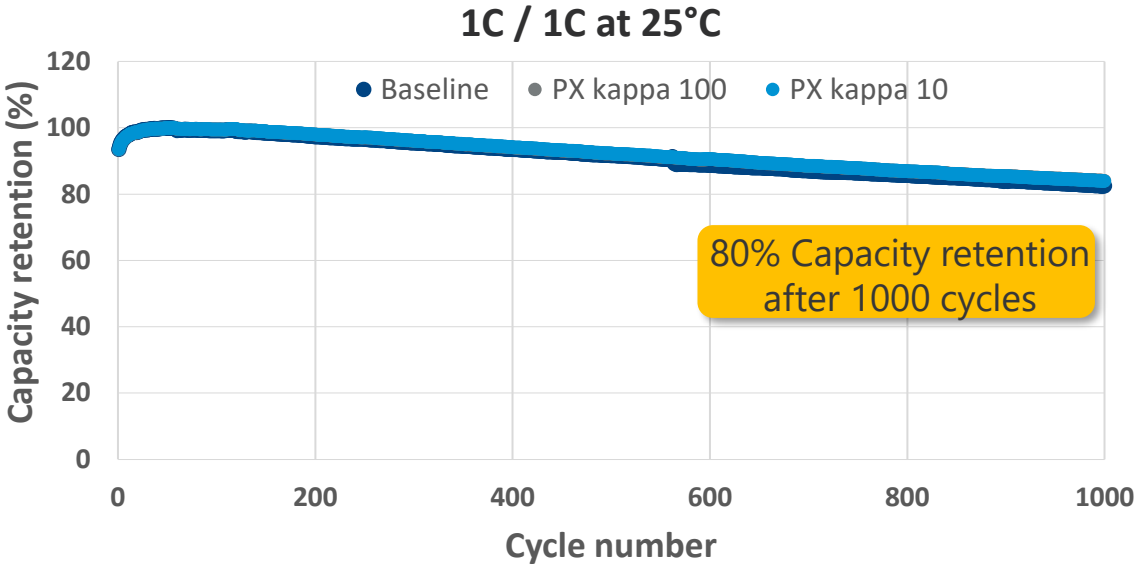
78% Capacity retention at 5C

PRINTEX® kappa 100 and PRINTEX® kappa 10 have a <u>slightly</u> **better DCR response** to the baseline at different SOC.



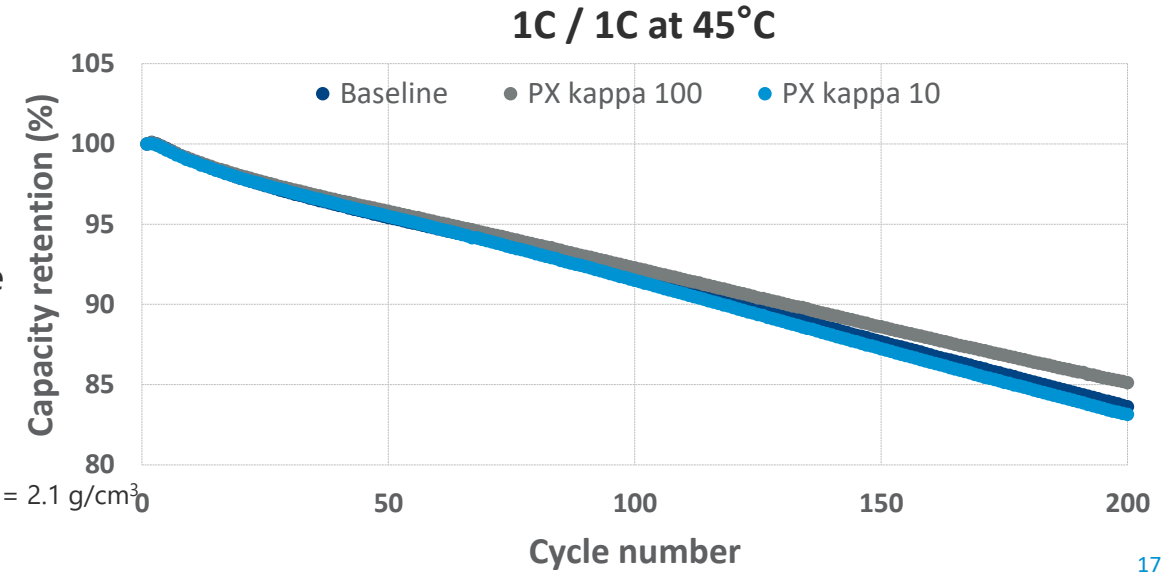
Cathode electrode loading = 152 g/m^2 and electrode density = 2.1 g/cm^3
Anode = 95.2% Graphite; 1% C, 1.5 % CMC, 2.3% SBR

Long term cycling at 25° and 45°C



After 1000 cycles, **PRINTEX® kappa 100 and PRINTEX® kappa 10** exhibit **80% capacity retention**

At high temperature long term cycling, **PRINTEX® kappa 100** shows an improve in **capacity retention.**



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Summary

Orion is a global leading supplier of high-quality conductive carbon additives for batteries with strong expansion plans

PRINTEX kappa 2xx series dedicated for aLAB to boost dynamic charge acceptance and controlled water loss

PRINTEX kappa 100 and 10 as sustainable and high-quality conductive carbon additive for lithium-ion batteries

Thank you for your attention

Visit us on booth 39

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