BONDERITE

CONDUCTIVE COATINGS: ENABLING DRY BATTERY CELL MANUFACTURING

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Henkel

Henkel Adhesive Technologies

WELCOME!

Dr. Jacob Turner
Senior Chemist, Henkel

HOW DO CONDUCTIVE ELECTRODE COATINGS OPTIMIZE THE PERFORMANCE OF DRY COATED BATTERIES?

HENKEL ADHESIVE TECHNOLOGIES

THE BATTERY SHOW NORTH AMERICA

DR. JACOB TURNER, SR. CHEMIST
THE BATTERY SHOW | OCT. 8, 2024

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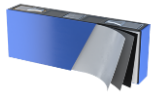
HENKEL E-MOBILITY SOLUTIONS

KEY TECHNOLOGIES FOR BATTERY SYSTEMS

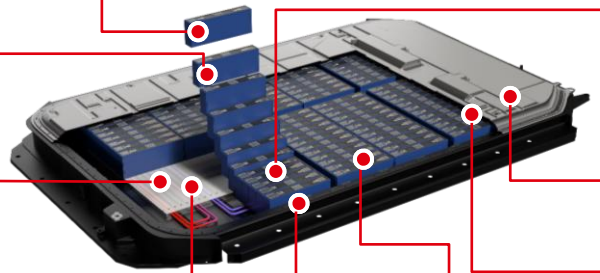
Battery Conductive Coatings



Battery Dielectric Coatings

Battery Safety Pottings

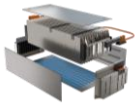
Battery Safety Pads



Thermal Gap Fillers

Battery Safety Coatings

Thermally Conductive Adhesives



Structural & Debonding Adhesives

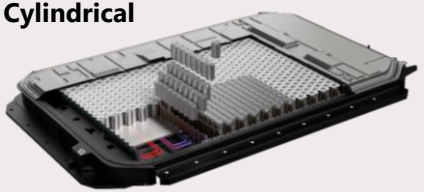
Battery Cell Assembly Adhesives

Top Cover Gaskets

APPLICABLE TO VARIOUS BATTERY TYPES

Pouch

Cylindrical



Prismatic

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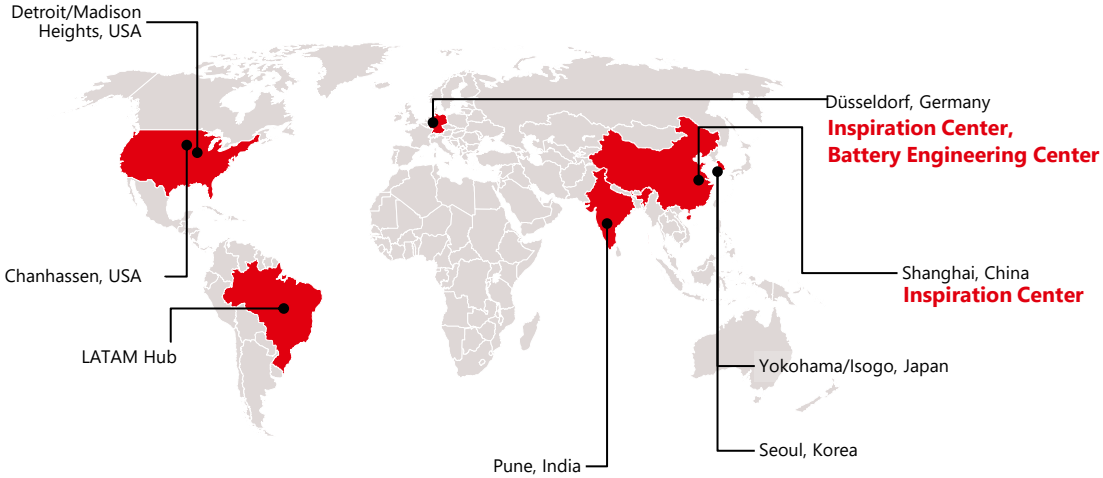
AUTOMOTIVE COMPONENTS BUSINESS

GLOBAL FOOTPRINT

8 Innovation Hubs	~200 Scientists	~100 Thermal & Battery	~400* Patents	+200M€ Invest
Automotive Expertise	**Multi-Technologies**	**Solutions Experts**	**Automotive Applications**	**Inspiration Centers Düsseldorf/Shanghai**



* Active patent families

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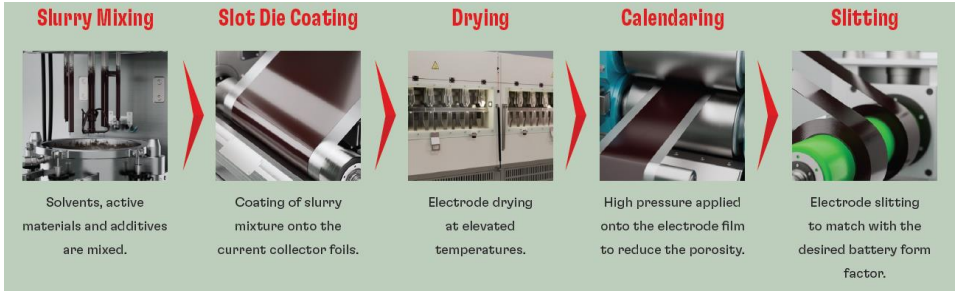
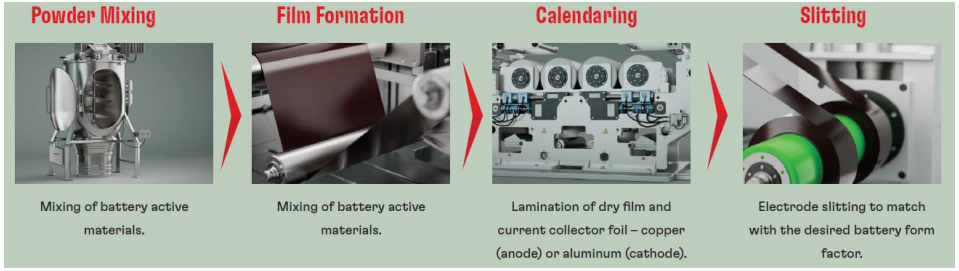
ELECTRODE MANUFACTURING
WET VS. DRY COATING

ELECTRODE MANUFACTURING | WET & DRY PROCESS

Wet process



Dry process



Factory layout
-20% *reduction in production footprint*

No use of NMP
No *drying and solvent recovery*

CAPEX
-35% *reduction in manufacturing invest*

Energy and CO_2
-30% *reduction in energy demand*

Performance
Thick *electrodes and ASSB possible*

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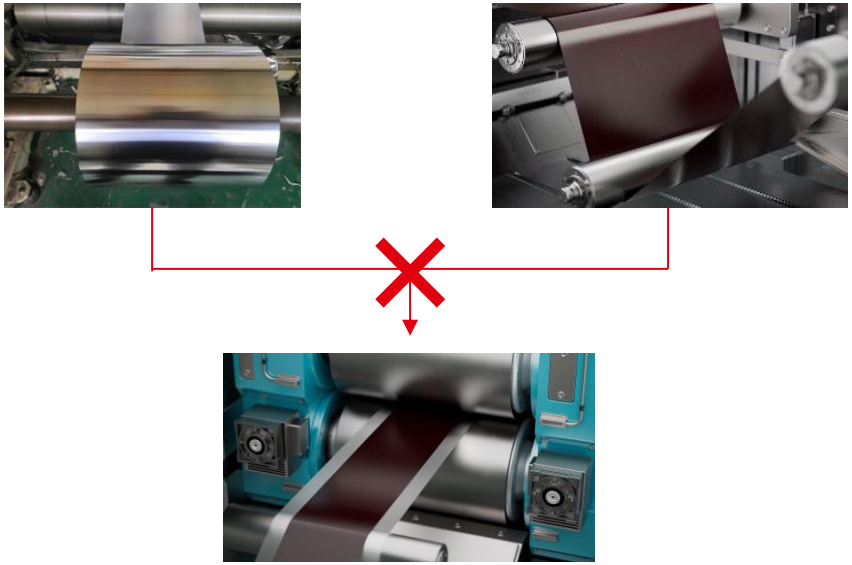
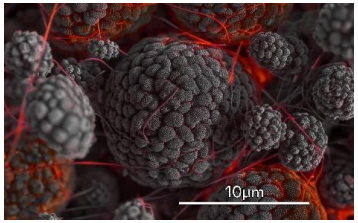
DRY ELECTRODE MANUFACTURING | CHALLENGES



No adhesion between dry film and current collector foil

Resistance rise, capacity fading, processing issues, …



- Dry film typically consists of active materials, carbon additives and fibrillized PTFE.
- In contrast to wet processing, binder cannot interact with aluminum or copper foil surface.

Current collector foil surface modification required!

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CONDUCTIVE ELECTRODE COATING
FOR THE BEST INTERFACIAL MATERIAL CONTACT

PHYSICAL
ADHESION PROMOTION
- Increased affinity & contact area

ELECTRICAL
ENHANCED CONDUCTIVITY
- Increased conduction channels

ELECTROCHEMICAL
ANTI-CORROSION
- Reduced oxidation & dissolution

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HENKEL'S CONDUCTIVE COATING LEGACY

Trusted partner in tailored carbon coatings for >100 years

1920s
Cathode Ray Tubes

Aquadag

1980
Alkaline Batteries

Bonderite S-FN EB-020

2005
Super Capacitors

Bonderite S-FN EB-012

2015
LFP Batteries

Bonderite S-FN 15000
Bonderite B-CC 2200

2020
Dry Coated Batteries

Bonderite B-CC 1020

2025
SSB, LiS, …

Future developments

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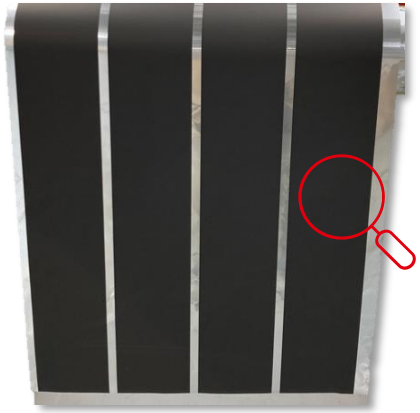
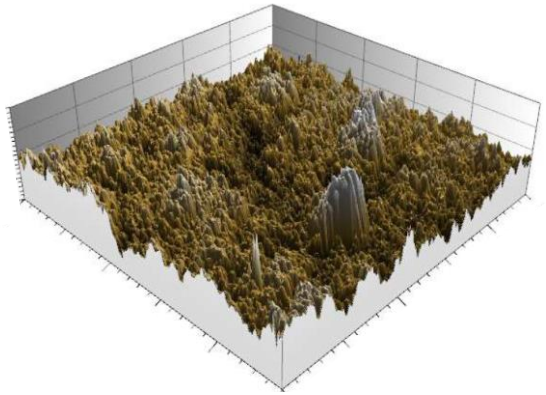
CONDUCTIVE COATINGS | GENERAL UNDERSTANDING

Conductive coatings:
Dispersions of carbons and resin on metal foils



Surface view



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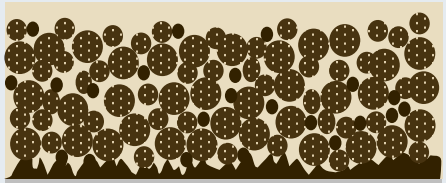
ADHESION PROMOTION | WET ELECTRODE PROCESSING

Carbon coated foil

Current Collector

Carbon coated copper or aluminum foils as substrate for anode / cathode manufacturing.

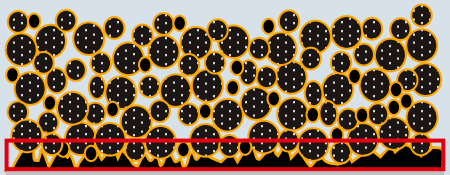
Slot-die coating



Current Collector

Slot-die coating of dispersed active materials, carbons and binder onto the current collector.

Drying



Current Collector

Improved adhesion and conductivity between current collector and active materials through conductive coating.

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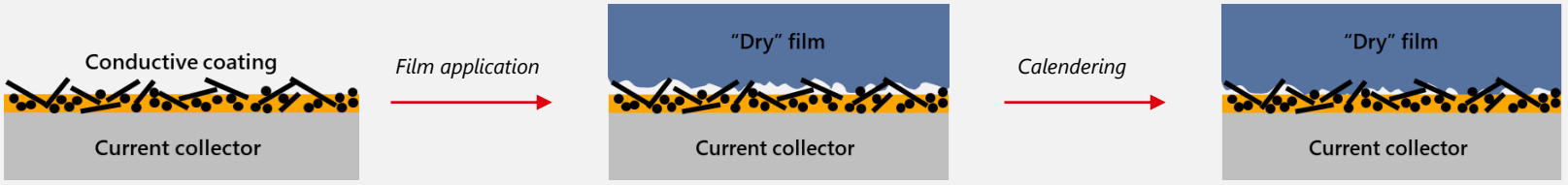
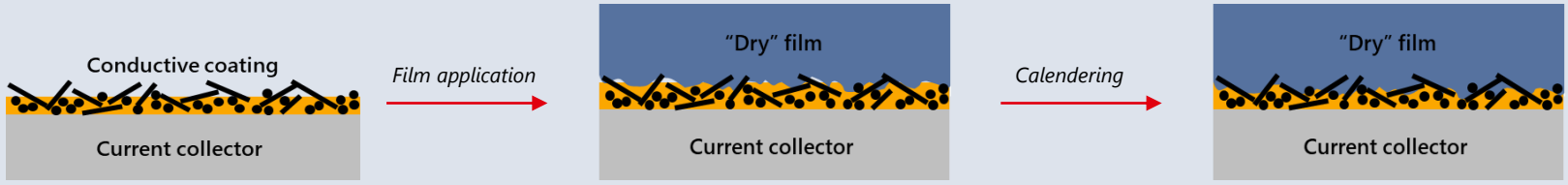
DRY BATTERY PROCESSING | HENKEL'S "ACTIVE" COATING CONCEPT

"Passive" conductive coating systems



Dry film forced to adapt to *conductive coating*

Henkel's "active" conductive coating systems



Conductive coating designed to adapt to *dry film*

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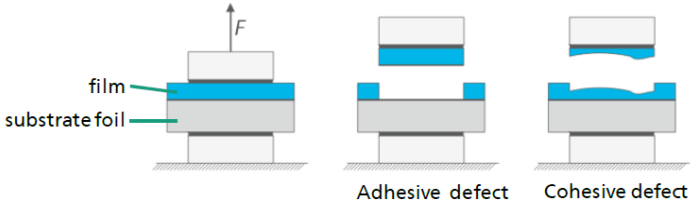
TECHNICAL INSIGHTS
ADHESION CHARACTERISTICS

Dry electrode sheet production and validation with Henkel BCCs

Stamp pull-off test



Technical Information

Electrode chemistry

Dry Electrode:
CAM: 95wt% NMC 622
Carbon: 4wt% Super C65
Binder: 1wt% PTFE
Loading: 30 mg/cm²

Carbon coatings:
Active coating: Bonderite B-CC 1020
Passive coating: Reference material

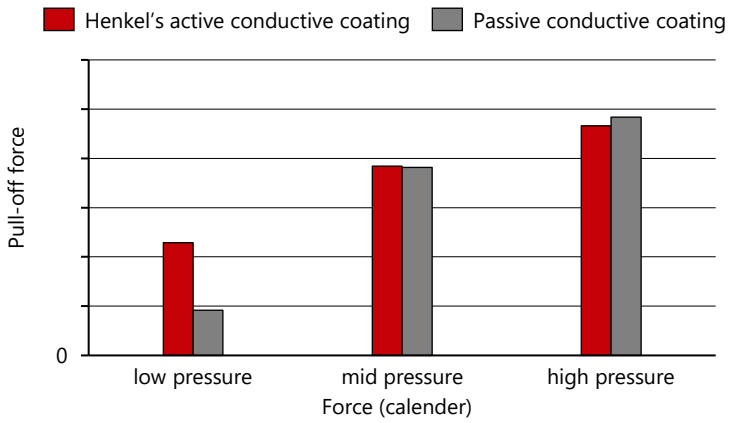
Process conditions calendar

Temperature variation:
Pressure: 40 kN
Temperature:
RT, 50, 80, 110, 130 °C

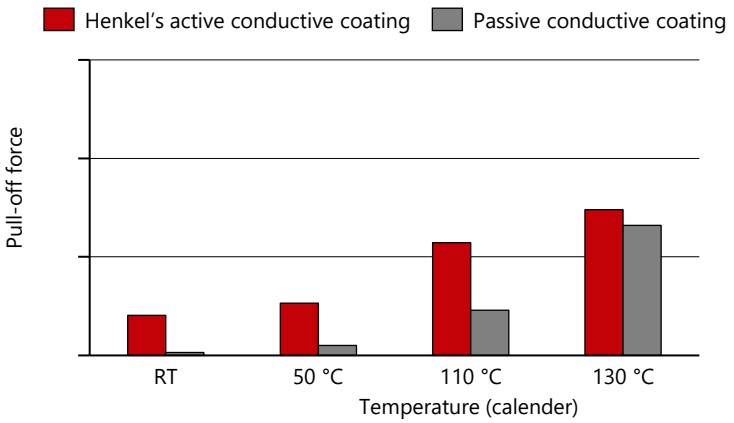
Pressure variation:
Temperature: 110 °C
Pressure: 40, 80, 120 kN

TECHNICAL INSIGHTS & HENKEL'S BENEFIT
ADHESION CHARACTERISTICS OF DRY COATED ELECTRODE

Lamination pressure variation



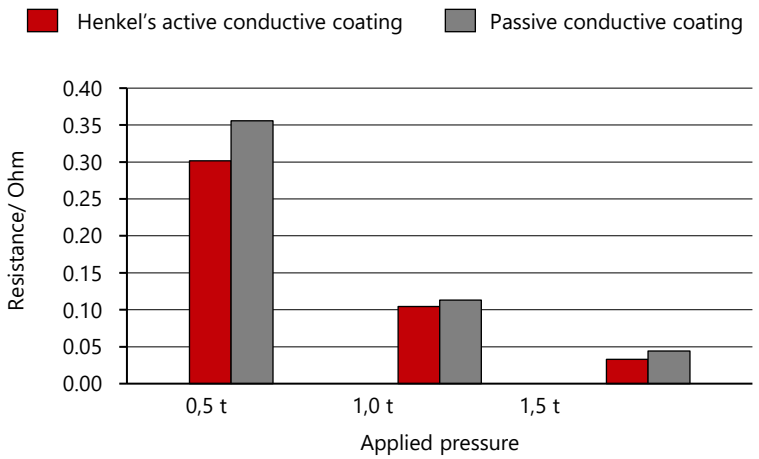
Lamination temperature variation



- Henkel active coating systems show cohesive failures for all temperature and pressure conditions
- Passive coating systems lead to adhesive defects at low temperatures
- **Positive effects: Milder processing conditions, reduced energy demand, improved cycle life & cell performance**

PERFORMANCE & SUMMARY
RESISTANCE & INTERFACE CHARACTERISTICS

Pressure dependent DC resistance



Key learnings

- Henkel conductive coatings enable reliable adhesion for wet and dry coated battery cells.
- Conductive coatings can reduce the cell resistance and increase battery performance and lifetime.
- Dry battery electrode manufacturing can reduce CAPEX and OPEX in cell manufacturing.
- The omission of NMP in dry battery production reduces toxic solvent and energy demand.

CORE HENKEL PRODUCT PORTFOLIO
ENERGY STORAGE MARKET

		DBE Processing BONDERITE B-CC 1020	**Wet Processing** BONDERITE B-CC 2200	**OTHER** BONDERITE S-FN EB-012
Formulation	Solvent	Water	Water	Water
	Electrode	Cathode & Anode	Cathode	Cathode & Anode
	Active materials	Any	LFP	Any
	Cell design	Any	Any	Any
Application	Application technology	(Micro-)Gravure	(Micro-)Gravure	(Micro-)Gravure & Spray
	Electrode application	Anode (Cu) / Cathode (Al)	Cathode (Al)	Anode (Cu) / Cathode (Al)
	Active materials	Any	LFP (some NMC)	Any
	Coating thickness (dry)	1 – 2 µm	1 µm	5 – 10 µm
	Adhesion (Al)	5B (100%)	5B (100%)	5B (100%)
Cell Performance	Contact resistance (Ω)	0.10 – 0.15	0.03 – 0.05	0.15 – 0.20
	Sheet resistance (Ω/sq/mil)	20 – 30 Ω/sq @1 mil	10 – 20 Ω/sq @1 mil	20 – 30 Ω/sq @1 mil
	Electrolyte resistance (double rubs)	> 20	> 100	> 30
	NMP resistance (double rubs)	n/a	>100	> 10
	Electrochemical stability (CV)	0 – 4.4 V vs. Li/Li^+	4.4 V vs. Li/Li^+	0 – 4.4 V vs. Li/Li^+

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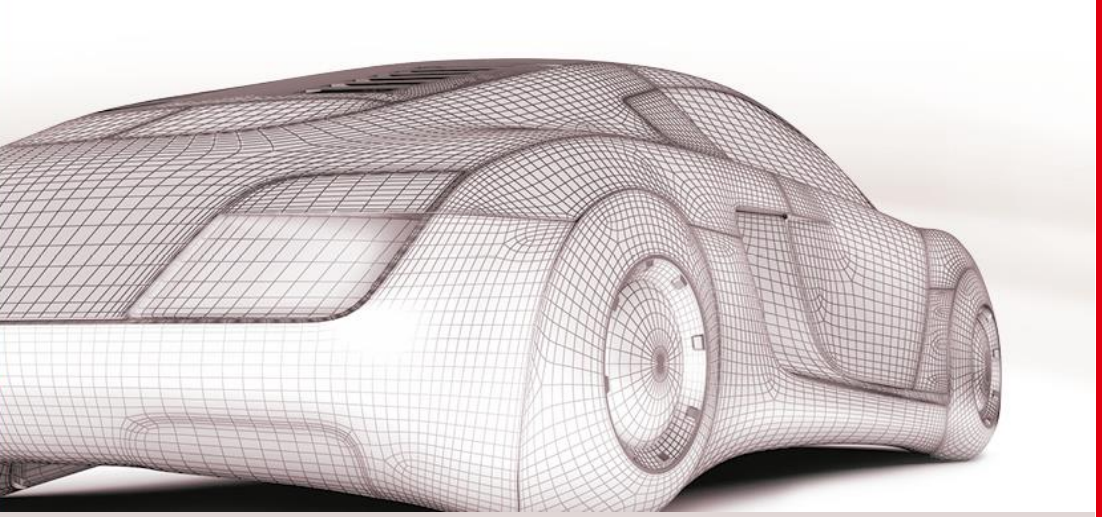

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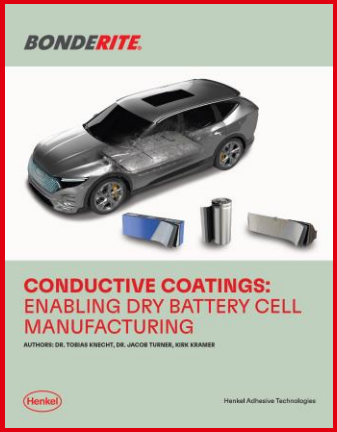
WE MAKE *FUTURE MOBILITY* HAPPEN

THANK YOU

Download the Whitepaper!



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