Application Leaflet

EXCELSPERSE™ FX 9000

Wetting & Dispersing Additive for Cathode Slurries

Unlock Stable, High-Solids Formulations
for Superior Battery Performance

ELEMENTIS

Unique chemistry, sustainable solutions

Key Benefits

- Higher slurry solids stability with improved shear thinning viscosity performance
- Reduced Direct Current Internal Resistance (DCIR) of the battery when current is applied. Lower DCIR means:
  - Less energy lost as heat
  - Higher power output
  - Better fast-charging capability
  - Improved overall charge rate efficiency
- Higher temperature performance and safety.

Chemical & Physical Properties

EXCELSPERSE™ FX 9000	
Composition	Copolymer with acidic groups
Appearance	Light yellow liquid
Non-Volatile Content	>95%
Acid value	ca. 135 mg KOH/g
Specific gravity	ca. 1.11
Electrochemical stability	0.1 V to 4.7 V (vs. Li/Li^+)
Solvent	Solvent-free (Low VOC- APEO-free)

Introduction

Rechargeable lithium-ion battery producers continue to face rising demands for consistency, efficiency, and performance as electric-vehicle OEMs push toward higher-capacity, longer-life cells. Achieving stable, high-solids cathode slurries with uniform dispersion and predictable rheology is critical to meeting these next-generation requirements.

EXCELSPERSE™ FX 9000 is a polymeric wetting and dispersing additive that is purpose-designed for cathode electrode slurry manufacturing. Engineered to optimize the dispersion of active materials and conductive additives in LFP (Lithium Iron Phosphate) formulations, EXCELSPERSE™ enables producers to achieve denser, more uniform electrode films with consistent conductivity and improved process reliability. By addressing several persistent performance gaps in slurry preparation, EXCELSPERSE™ helps manufacturers scale production while maintaining the quality demanded by today's advanced battery applications.

Features

- Low solvent formulation with >95% non-volatile content and APEO free
- Enables high solids loading (>60%) with stable dispersion and low viscosity
- Superior particle wetting and adhesion, reduces agglomerations and coating defects
- Proven temperature range (–20°C to 55°C) with storage stability at 55°C for more than one week.
- Tested and validated by leading rechargeable battery development labs

Target Application

EXCELSPERSE™ FX 9000 is suitable for high solids LFP slurry loading environments which are desirable for manufacturing electric vehicle (EV) rechargeable cathode battery cells.

Incorporation and Levels of Use

Practical Tips for Use

- **Dosage:** Use at 0.2 to 2 wt% relative to total slurry weight (as per tested formulation).
- **Mixing Order:** Add EXCELSPERSE™ FX 9000 after making (PVDF + NMP) binder concentrate and before introducing conductive carbon and LFP.
- **Quality Control:** Monitor viscosity, fineness, and sheet resistance to ensure optimal dispersion and performance.
- **Environmental Controls:** Maintain recommended temperature and humidity for best results.

Formulation Guidance on using EXCELSPERSE™ FX 9000

A. Typical Starting Point Formulation (for LFP Cathode Slurry)

Ingredient Type	Product Name	Supplier	Wt%
LFP	A8-4E	Hubei Wanrun New Energy	57.2
Conductive Carbon	SUPER P-Li	Imerys	1.2
PVDF	HSV 900	Arkema	1.8
Dispersant	EXCELSPERSE™ FX 9000	Elementis	0.2
Solvent	NMP	Taiwan Maxwave Co.	39.7

B. Slurry Preparation Process

- **Binder Making:** Mix PVDF binder and NMP for 180 minutes.
- **Dispersant Addition:** Add 0.2 to 2 Wt% EXCELSPERSE™ FX 9000 and mix for 10 minutes.
- **Conductive Carbon:** Add and mix for 60 minutes.
- **LFP + NMP:** Add and mix for 120 minutes.
- **Viscosity Adjustment:** Adjust with NMP for 30 minutes to reach coating viscosity (~7,000 cP at 20 RPM, 6# spindle).
- **Vacuum & Filter:** Final preparation before coating.

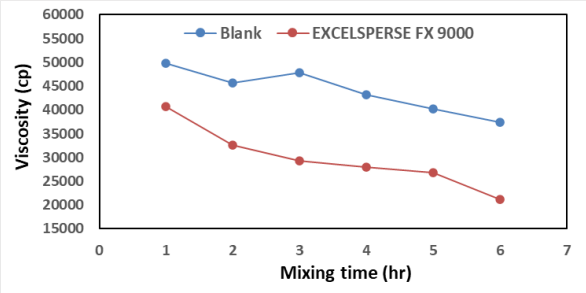
C. Equipment & Conditions

- Use a double planetary vacuum mixer.
- Maintain temperature at 25°C and dew point at -30°C.
- Target a 60% active slurry.

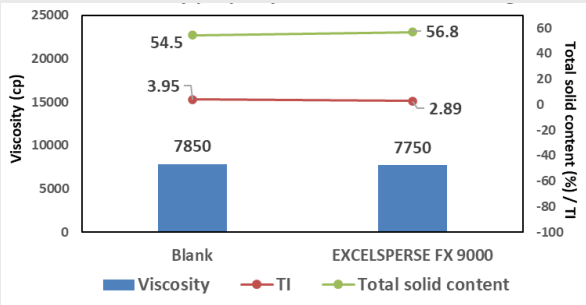
D. Performance Insights

- **Viscosity Reduction:** EXCELSPERSE™ FX 9000 reduces LFP slurry viscosity, shortens dispersion time, and allows for higher solid content.
- **Storage Stability:** Slurries with EXCELSPERSE™ FX 9000 show less (in process) viscosity increase over 48 hours compared to control.
- **Sheet Resistance:** Improved dispersion leads to lower sheet resistance (9.37 Ω/m² vs. 9.87 Ω/m² for blank).
- **Electrochemical Performance:** Lower direct current internal resistance (DCIR) and improved charge/discharge capacity at various temperatures.
- **Cycle Life:** No negative impact on cycle life after 1,000 cycles; capacity retention remains high (89%).
- **High-Temperature Stability:** Lower self-discharge rate and better retention after storage at 55°C for 7 days.

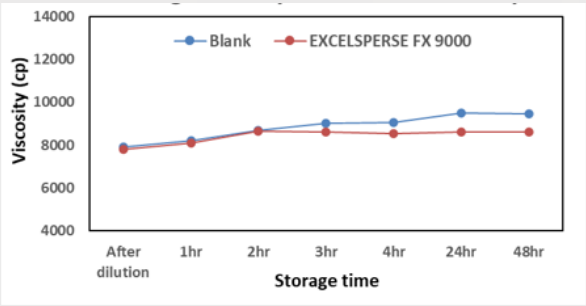
Graph 1: LFP slurry viscosity during dispersion (60% solid)



Graph 2: LFP slurry property after dilution for coating



Graph 3: Storage stability of LFP cathode slurry



Performance Data & Comparative Testing

Products Testing showing proof of performance:

Testing involved LFP cathode slurries prepared with EXCELSPERSE™ FX 9000 using a 5L double planetary mixer at 25°C with a controlled dew point. Slurries were adjusted to ~7,000 cP at 60% solids. Evaluations included viscosity stability of cathode electrode produced, particle dispersion quality, 4-Ah pouch cell electrochemical performance along with the safety and stability of pouch cells at 55°C for seven days.

Testing was carried out at the rechargeable battery product development laboratories of the Industrial Technology Research Institute (ITRI) Taiwan using standardized protocols.

Improved storage stability and better flow properties allow for more consistent control of key coating characteristics such as dried coating film homogeneity along with coat-weight density which are essential for maintaining high cathode performance over time.

Graph 1 and 2: EXCELSPERSE™ FX 9000 is extremely effective in reducing LFP slurry processing times and the need for solvents such as N-Methyl Pyrrolidone (NMP).

Graph 3: EXCELSPERSE™ FX 9000 enhances slurry storage stability by reducing 48 hour in-use viscosity spikes.

4-Ah Pouch Cell – Battery electrochemical performance attributes

Graph 4: Direct Current Internal Resistance (DCIR) comparison

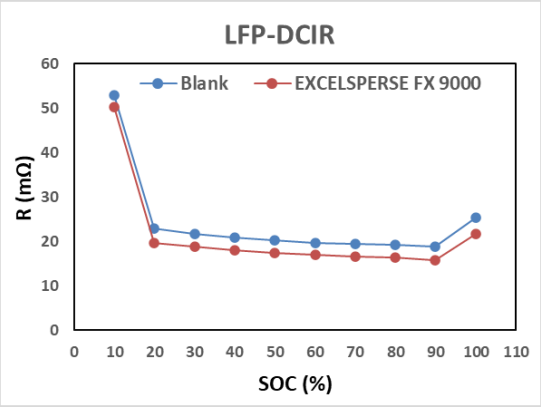
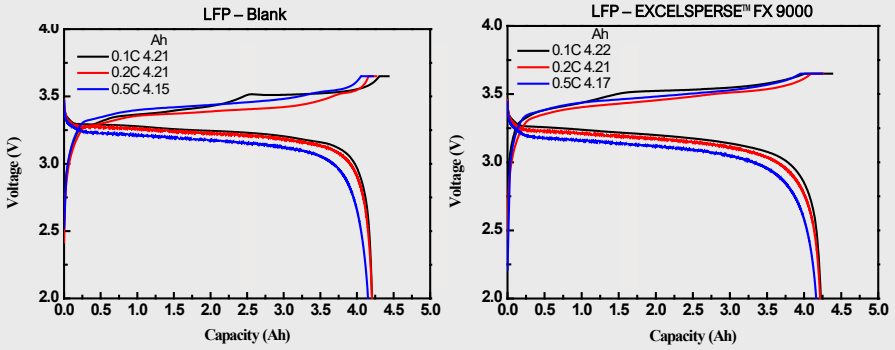


Chart 1

SOC	Blank	EXCELSPERSE™ FX 9000
%	R (mΩ)	R (mΩ)
10	52.96	50.29
50	20.21	17.42
100	25.41	21.59

Graph 5: LFP without and with EXCELSPERSE™ FX 9000



First efficiency: 94.69%

First efficiency: 94.56%

Test conditions: voltage range: 2.0V ~ 3.65V ; charge /discharge rate: 0.1C/0.1C

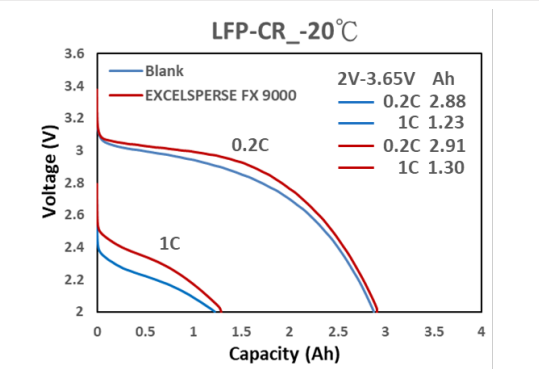
Direct Current Internal Resistance (DCIR)

Graph 4 and Chart 1: DCIR was used to compare cathode slurries with and without EXCELSPERSE™ FX 9000. Lower DCIR values - achieved when using EXCELSPERSE™ FX 9000 - indicate better particle dispersion, which enhances battery performance across different states of charge and temperatures.

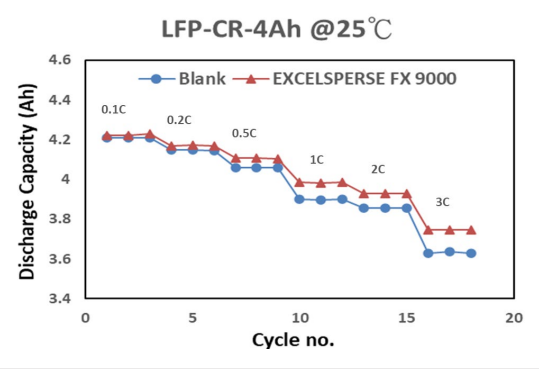
Note: DCIR measures a cell's internal resistance when current is applied. It reflects how much the battery resists current flow and is determined by applying a current step (charge or discharge) and measuring the resulting voltage change, calculated using Ohm's Law.

Graph 5: First cycle efficiency (First Efficiency %) quantifies the proportion of charge extracted during the first discharge relative to the charge supplied during the first charge. It reflects the irreversible loss of active lithium consumed in forming the solid electrolyte interphase or other side reactions during the initial cycle, making it a key metric for evaluating the irreversible capacity loss that occurs during a battery's first cycle. **Graph 5** demonstrates the effect of EXCELSPERSE™ FX 9000 on first cycle efficiency.

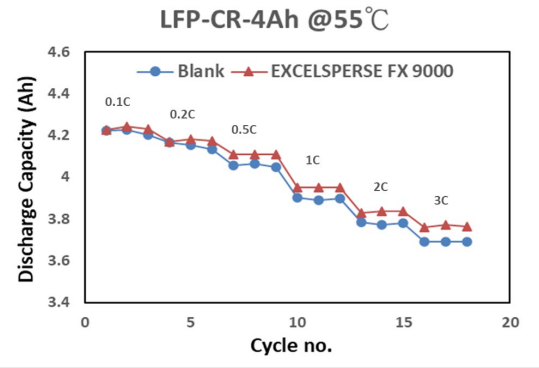
Graph 6A: C-Rate at -20ºC



Graph 6B: C-Rate at -25ºC



Graph 6C: C-Rate at -55ºC



Test conditions: voltage range: 2.0V ~ 3.65V ; cut-off: 0.05C; temperature: -20ºC, 25ºC, 55ºC

C-Rate (Charge-Rate) Performance at Different Temperatures

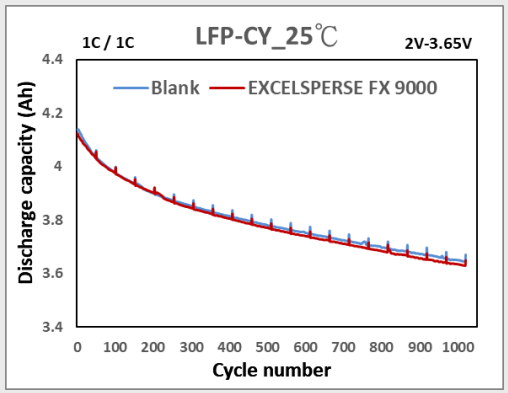
Graph 6A, 6B, 6C: C-Rate refers to how quickly a battery is charged (or discharged) relative to its total capacity. It is usually expressed as a C-rate: (e.g., 0.2C, 1C, 3C) standardized by the battery's capacity.

Under a test condition voltage range of from 2.0V ~ 3.65V at temperatures from -20°C, 25°C to 55 °C

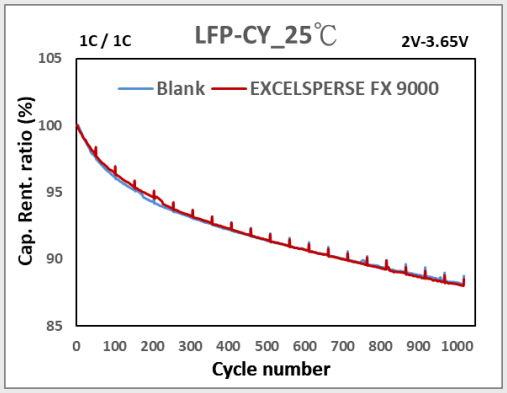
4-Ah pouch cells with EXCELSPERSE™ FX 9000 give higher discharge capacity than 4-Ah pouch cells without dispersant demonstrating that EXCELSPERSE™ FX 9000 does not negatively impact the C-rate performance of 4-Ah pouch cells at different temperatures.

Temperature	Capacity	0.2C	1C	3C
-20º C	Blank	69.20%	31.50%	
	EXCELSPERSE™ FX 9000	70.00%	**32.70%**	
25º C	Blank	98.46%	92.58%	86.24%
	EXCELSPERSE™ FX 9000	98.84%	**94.43%**	**88.82%**
55º C	Blank	98.33%	92.30%	87.44%
	EXCELSPERSE™ FX 9000	98.74%	**93.39%**	**89.04%**

Graph 7A： Discharge Capacity (Ah)



Graph 7B： Capacity Retention Ratio (%)



Test conditions: voltage range: 2.0V ~ 3.65V ; charge /discharge rate: 1C/1C;

CV cut-off: 0.05C; rest time: 10min

What is Cycle Life?

Cycle life refers to the number of complete charge and discharge cycles a battery can undergo before its capacity drops to a specified level, typically 80% of its original capacity. One cycle means charging the battery fully and then discharging it to a defined lower limit. Consumer-grade lithium-ion battery cells have a typical range of 300–1,500 cycles.

Why is Cycle Life Important?

Longevity: Higher cycle life means the battery lasts longer before replacement.

Cost Efficiency: Extends the useful life of expensive battery packs (critical for EVs and energy storage).

Performance: Maintains reliable energy output over time.

Sustainability: Reduces waste and demand for raw materials.
Factors that affect Cycle Life include temperature extremes, fast charge/discharge rates, material quality and electrode design.

Graph 7A & 7B: After 100 cycles, the cycle life of 4-Ah pouch cells with EXCELSPERSE™ FX 9000 were comparable to 4-Ah pouch cells without a dispersant. Therefore, it is believed that EXCELSPERSE™ FX 9000 does not negatively affect the cycle life of 4-Ah pouch cells.

55°C, 7-day Safety and Stability Testing

Storing pouch-type lithium-ion cells at 55 °C for seven days is a critical test for confirming safety, stability, and long-term reliability. Elevated temperature accelerates internal chemical reactions, revealing issues—such as swelling, gas generation, leakage, or deformation—that might otherwise take months to appear and that commonly occur in real-world hot environments. Because pouch cells rely on soft packaging rather than a rigid metal case, the test also verifies that the pouch material and seals remain intact under thermal stress. Global standards such as UN, IEC, and UL require this high-temperature storage test before batteries can be shipped or certified. After seven days, engineers verify that the cell retains normal shape, performance, and capacity without safety concerns. Overall, the 55°C/7-day test ensures the battery can withstand harsh conditions, remain safe for consumers, and meet international compliance requirements.

4-Ah pouch cell @55°C/7days	Self discharge rate	Retention	Recovery
Blank	6.1%	93.9%	99.6%
EXCELSPERSE ™ FX 9000	4.3%	95.7%	99.7%

Test conditions: (1) 1C charge to 100% SOC, voltage: 3.65V

(2) cut-off: 0.05C

(3) Storage at 55°C for 7 days

(4) 1C discharge to 0% SOC, voltage: 2V

Conclusion: 4-Ah pouch cells with EXCELSPERSE™ FX 9000 have a lower self-discharge rate and better retention than 4-Ah pouch cells without dispersant after high temperature storage. Seven days storage results at 55°C suggest that the addition of EXCELSPERSE™ FX 9000 does not negatively affect the heat stability of 4-Ah pouch cells after being subjected to periods of elevated temperature.

Conclusion

EXCELSPERSE™ FX 9000 delivers a step-change improvement in LFP slurry stability and overall cell performance. By reducing viscosity by up to 30% at solids loadings above 65%, it enables smoother processing, more uniform particle distribution and measurably lower sheet resistance.

In 4-Ah pouch cells, EXCELSPERSE™ FX 9000 consistently improves electrochemical performance reducing DCIR across all SOC levels, maintaining high first-cycle efficiency (~94.6%) and increasing discharge capacity from –20 °C through 55 °C.

LFP slurries formulated with EXCELSPERSE™ FX 9000 also demonstrate robust long-term stability, supporting extended cycle life and excellent high-temperature storage behavior with reduced self-discharge.

Together, these advantages establish EXCELSPERSE™ FX 9000 as a powerful additive solution for maximizing LFP battery performance and manufacturing efficiency.

NOTE:

The information herein is currently believed to be accurate. We do not guarantee its accuracy. Purchasers shall not rely on statements herein when purchasing any products. Purchasers should make their own investigations to determine if such products are suitable for a particular use. The products discussed are sold without warranty, express or implied, including a warranty of merchantability and fitness for use. Purchasers will be subject to a separate agreement which will not incorporate this document.

February 2026

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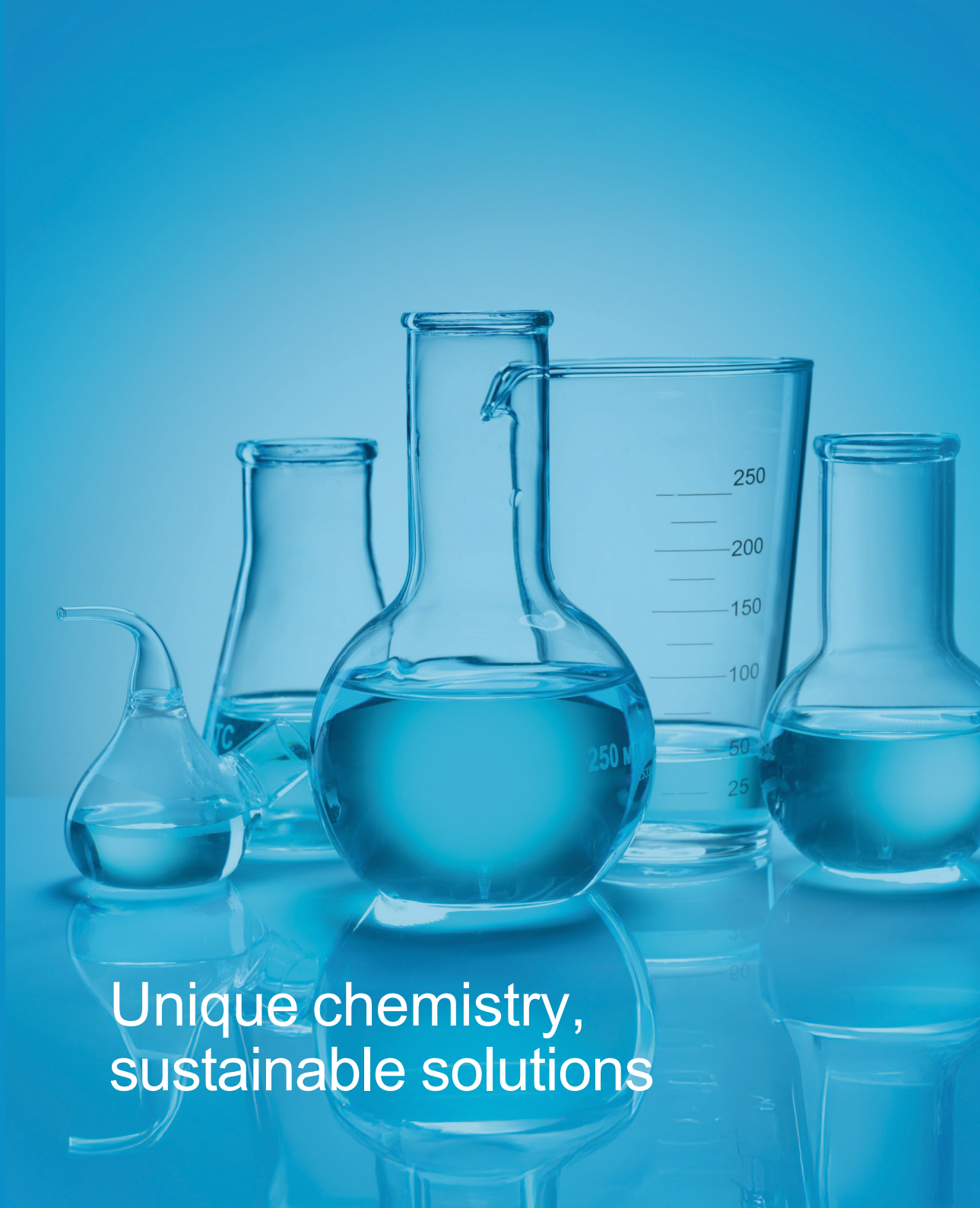

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