

Batteries Quasi-solide à base de polymères biosourcés

19/06/2025

Our vision is shaped by the accelerating demand for high-performance materials



A SIGNATURE

FOR A VISION

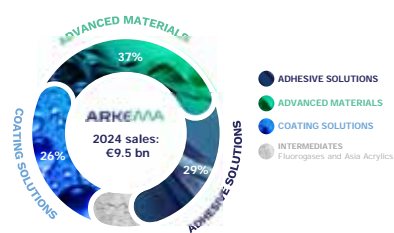
INNOVATIVE **MATERIALS** FOR A SUSTAINABLE WORLD

“Be the specialty materials leader, offering the most innovative and sustainable solutions to address our customers’ current and future challenges”

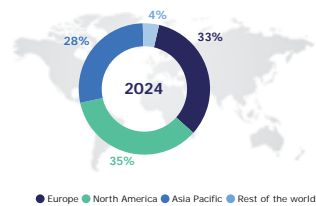
We have built over time an attractive and well-balanced portfolio of specialty materials



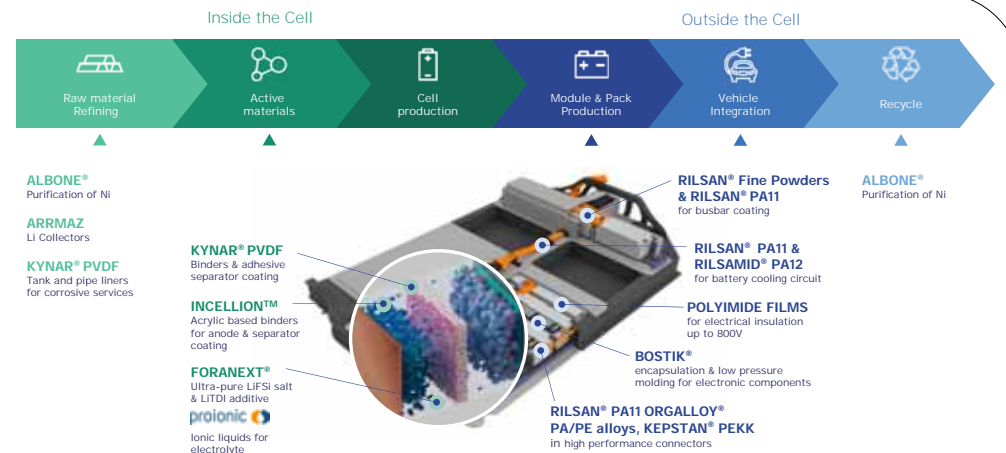
Towards 100% specialty materials



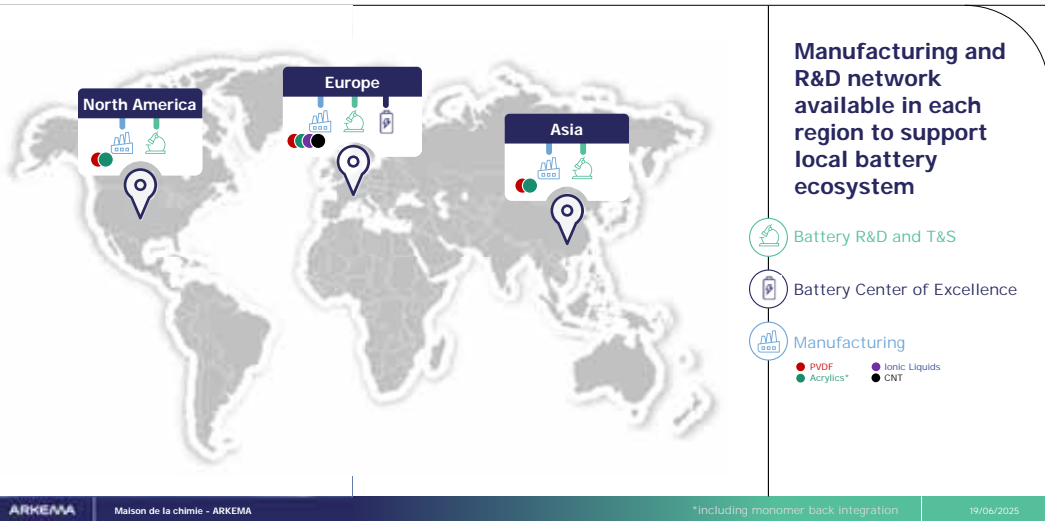
Balanced geographical footprint



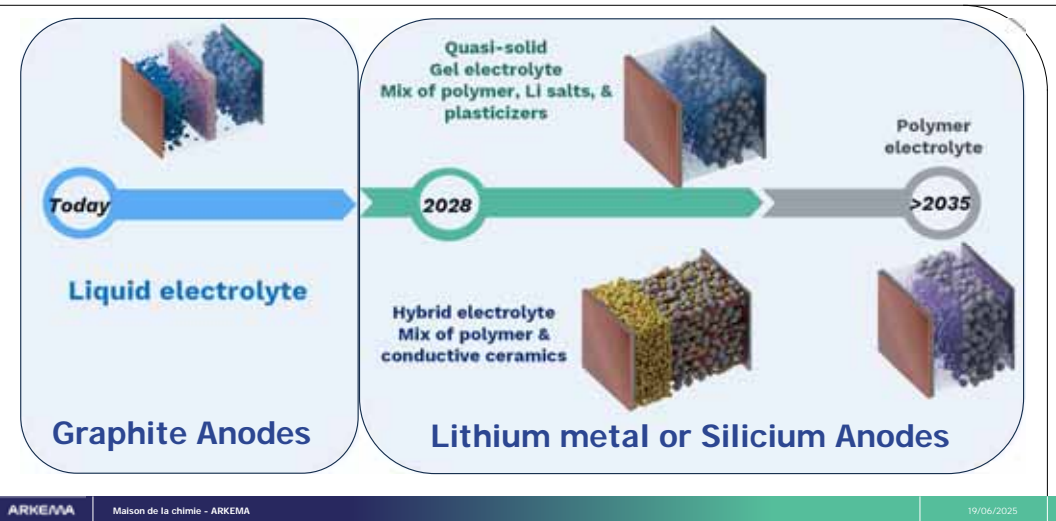
Arkema's solutions all along the battery value chain



Inside the cell: A global reach to support battery industry locally



Timeline of all technologies of electrolytes



Large range of Specialty Materials for all Gel Polymer Electrolyte (GPE) manufacturing process options

FORANEXT™
Ultra pure LiFSI salt and LITDI additive for electrolytes

proionic
Ionic Liquids for safer electrolyte formulation
Plasticizer / Electrolyte

KYNAR™
PVDF for Gel Polymer ex-situ membrane and catholyte formulation

INCELLION™ Pr
Waterborne acrylic for primer coating of current collector

GRAPHISTRENGTH™
MWCNT as a conductive additive for the catholyte

Ex-Situ Polymer Matrix

In-Situ Polymer Matrix

SARTOMER™
Broad range of Acrylic Monomers & Oligomers, Photoinitiators

LUPEROX™
Organic Peroxide Curing Agent

Coating of a free-standing film for the Impregnation Ex-Situ process

ARKEMA | Maison de la chimie - ARKEMA | 19/06/2025

In-Situ GPE Polymerization / A lesser steps process coming with its own challenges, but highly tunable to meet the target performances

IN-SITU POLYMERIZATION

ACRYLIC MONOMERS + PEROXIDE + SALT + IONIC LIQUID → POLYMERIZATION INITIATION

CHALLENGES

- Set-up of performances: electrochemistry and processability
- GPE formulation to meet the target performances
- Curing conditions

HIGHLY TUNABLE MATERIAL PORTFOLIO

OLIGOMER & MONOMER	CURING AGENT / INITIATOR	PLASTICIZER	LITHIUM SALT
<ul style="list-style-type: none"> Higher ionic conductivity Suitable electrochemical stability Mechanical properties <ul style="list-style-type: none"> Blends Processability <ul style="list-style-type: none"> Viscosity (wettability) 	<ul style="list-style-type: none"> Processability Curing conditions <ul style="list-style-type: none"> Kinetic Performances <ul style="list-style-type: none"> Monomer conversion Initiator residues 	<ul style="list-style-type: none"> Higher ionic conductivity Suitable electrochemical stability Improved safety 	<ul style="list-style-type: none"> Higher ionic conductivity Suitable electrochemical stability

ARKEMA | Maison de la chimie - ARKEMA | 19/06/2025

In-Situ polymerization principals

INITIAL STATE

LIQUID



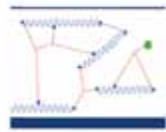
Liquid formulation

Temperature activation (°C)



FINAL STATE

SOLID



Final film

Oligomer
Monomer
Initiator
Substrate

Advantages →

Productivity
Shorter SEI formation step

Biobased products
Up to 80 % of Biobased content for the polymer matrix

Iso-process
Iso-process with liquid electrolyte battery production

Large portfolio of products
Calling for highly tunable GPE properties and processes optimization

A VERSATILE TOOLBOX OF MONOMERS AND OLIGOMERS FOR UNIQUE PROPERTIES

ALKANE



- Heat resistance
- Hydrophobicity
- Exterior durability
- Chemical resistance
- Adhesion promotion

ETHER



- Surface cure
- Hydrophilicity / hydrophobicity balance
- Chemical resistance
- Cutting power

ESTER



- Adhesion promotion
- Exterior durability
- Solvent resistance

AROMATIC RING



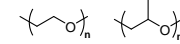
- Hardness
- Chemical resistance
- Adhesion promotion
- Poor exterior durability

ALIPHATIC RING



- Exterior durability
- Heat resistance
- Chemical resistance
- Adhesion promotion
- Hydrophobicity

ALKOXYLATION

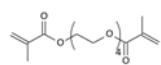


- Modifies:
- Surface cure speed
 - Tg
 - Viscosity
 - Pigment wetting
 - Solubility



An already available bio-based offer

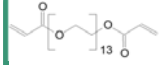
PEG200 Dimethacrylate



Bio segregated Content 45%

Segregated offer

PEG600 Diacrylate



Bio attributed Content 100%
PCF vs fossil -78%

Mass Balance offer

Complementary approaches to accelerate the transition

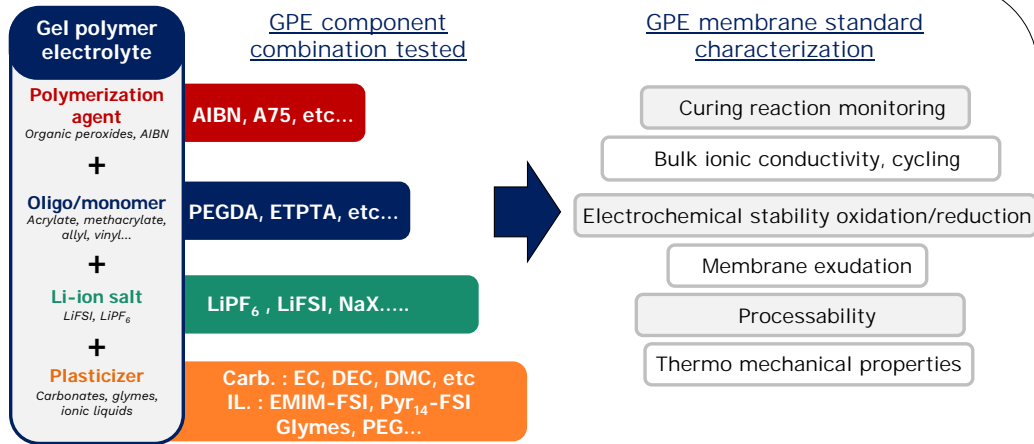
Properties of Ionic Liquids – a recyclable solvent with no VOC



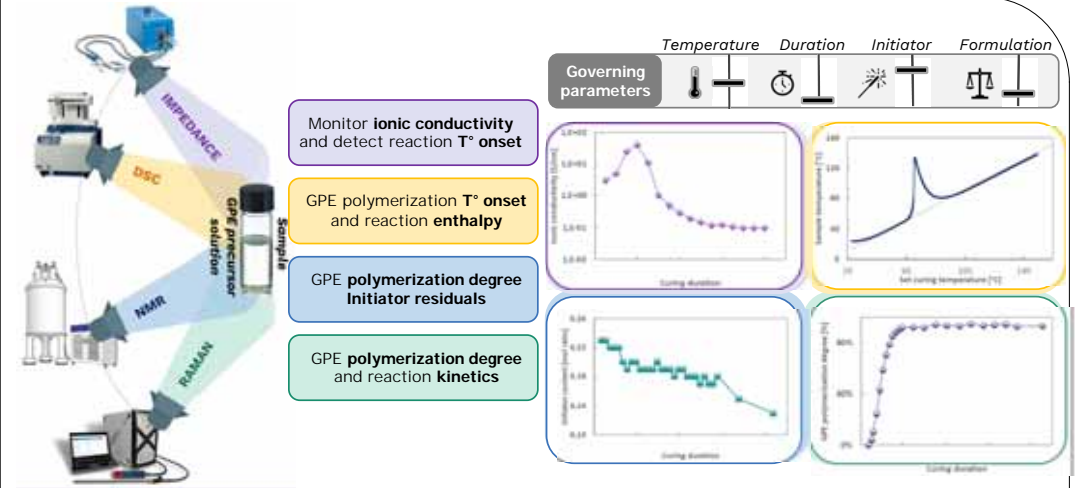
- no vapor pressure*, no boiling point
- Recyclable*
- non-flammable
- high thermal stability (up to 350 °C)
- applicable in a wide temperature range (down to -40°C)
- high electrochemical stability (0 - 5 V vs. W/WO₃)
- electrical conductivity 50 mS/cm to μS/cm @ 20 °C
- high tunability of properties (structure or formulations)
- unusual solvent properties
- high environmental & material compatibility
- very small friction coefficients

*<https://www.eea.europa.eu/en/european-zero-pollution-dashboards/indicators/waste-generation-in-the-chemical-industry>

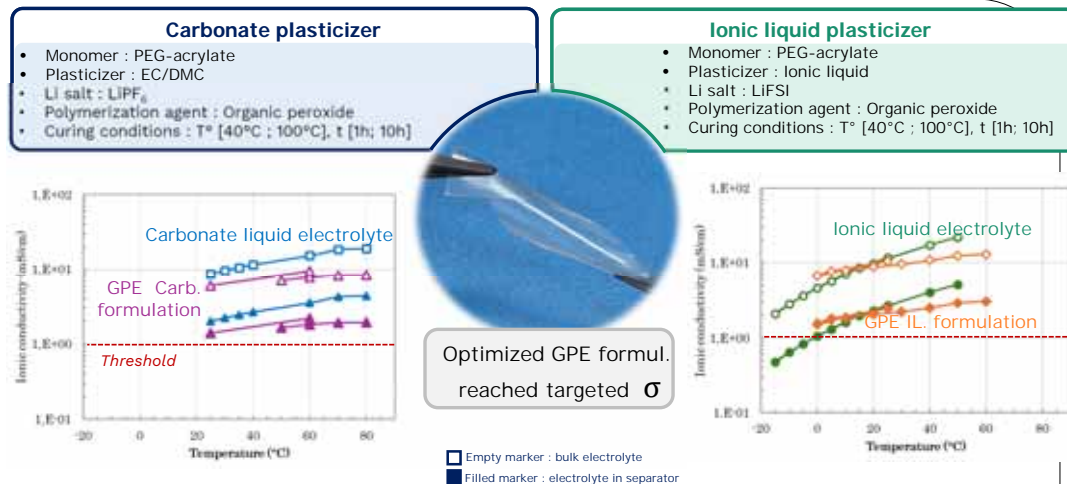
Acrylate-based Gel Polymer Electrolyte



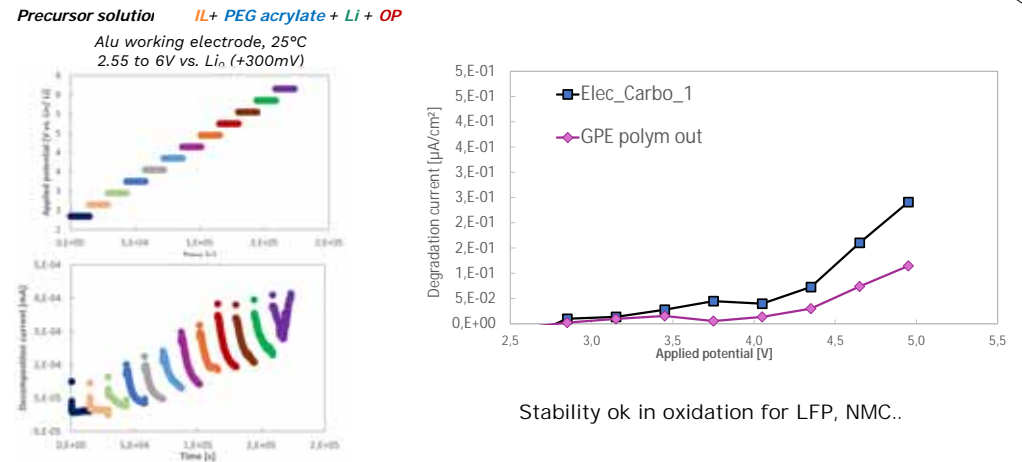
Gel polymer electrolyte –Curing step from monitoring towards control



Acrylate-based Gel Polymer Electrolyte



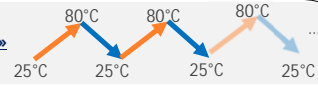
Is it stable? Liquid electrolyte carbonate vs in situ Semi solid ionic liquid based



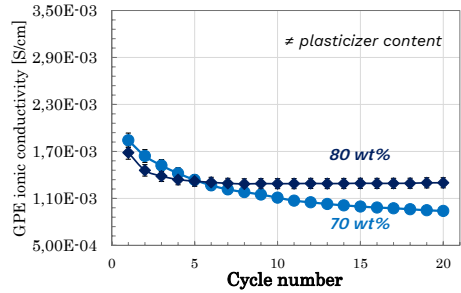
Is exudation an issue in semi-solid technology?

Fresh cell : 6 hours curing prior thermal cycles

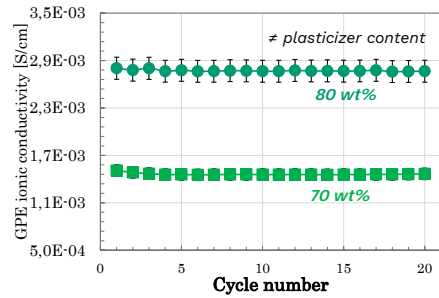
→ « Thermal cycles »



PEG Acrylate/ Li salt /Carbonate/Orga peroxide
Curing conditions : T* [40°C : 100°C], t [1h; 10h]

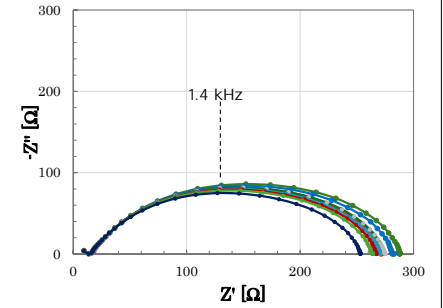
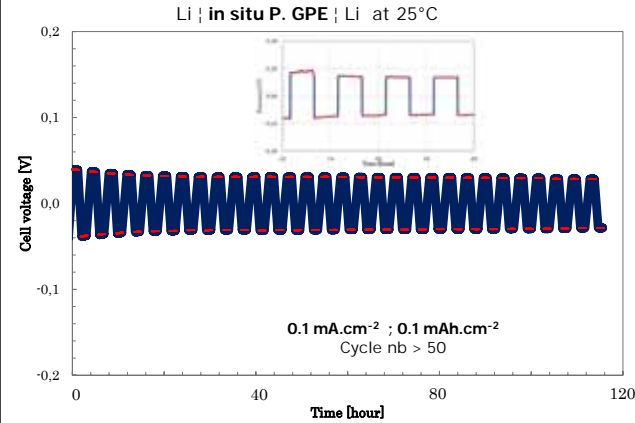


PEG Acrylate/ Li salt /Ionic liquid/Orga peroxide
Curing conditions : T* [40°C : 100°C], t [1h; 10h]



Li plating/stripping

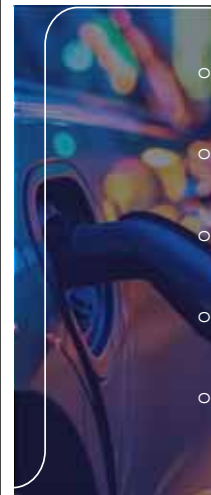
Polarization voltage curve of Li/Li symmetric cell at a current density of 0.1 mA.cm⁻² and a capacity of 0.1 mAh.cm⁻² at RT



First promising results in plating/stripping
But at low current density!

Cycling

Main takeaways



- In Situ semisolid technology could be a relevant short-term solution to allow Lithium metal or high silicon anode.
- Process is not significantly impacted but must be adapted (curing time, temperature, formulations..)
- Sustainable polymers, biobased or bio-attributed, can be used and designed for this technology.
- Ionic liquids are performance boosters for such technology while being fully recyclable and inducing no VOC generation
- Still some challenges to overcome but this technology could speed up the use of high energy cell in the market in a more sustainable way