TNCE 2023 Conference
Pattaya

Enabling Sustainable and Low Carbon Mobility through Next Generation Materials

Logan Ravisanker
Technology & Business Development Director

DOW®

Seek Together™

This is Dow

Seek Together™

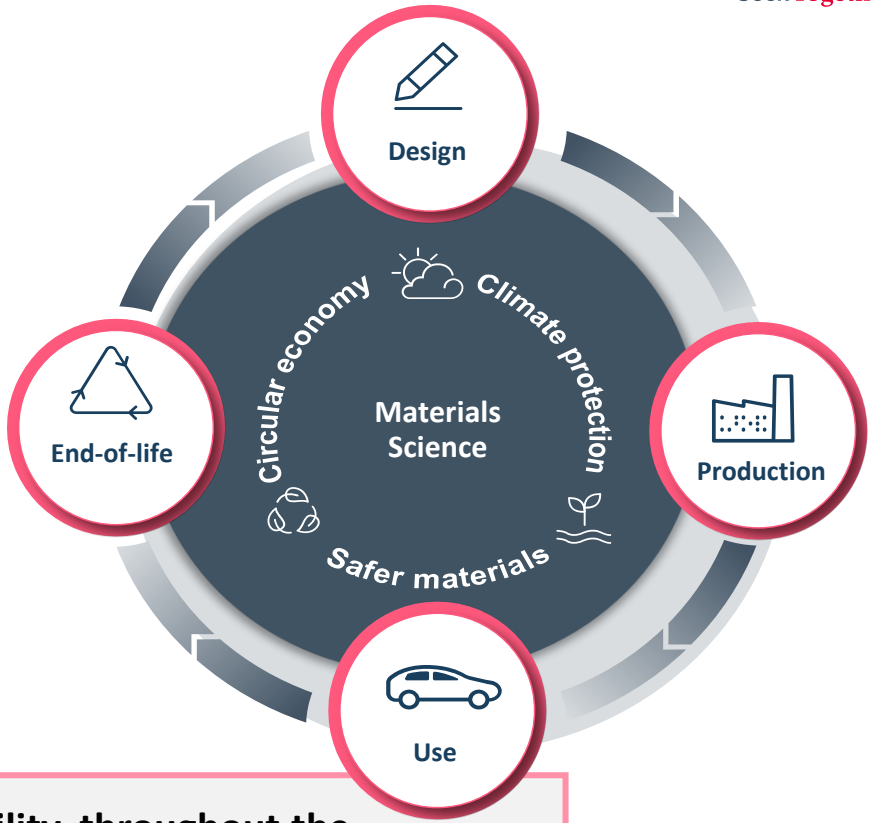
104 manufacturing sites in **31** countries
12 Innovation Centers in **10** countries on **4** continents

Local Reach and Collaborative Innovation

DOW®
Seek Together™

Mobility and Material Science Technology Trends

- E-mobility
- Autonomous
- Connectivity
- Acoustics
- Lightweighting
- Safety
- Comfort



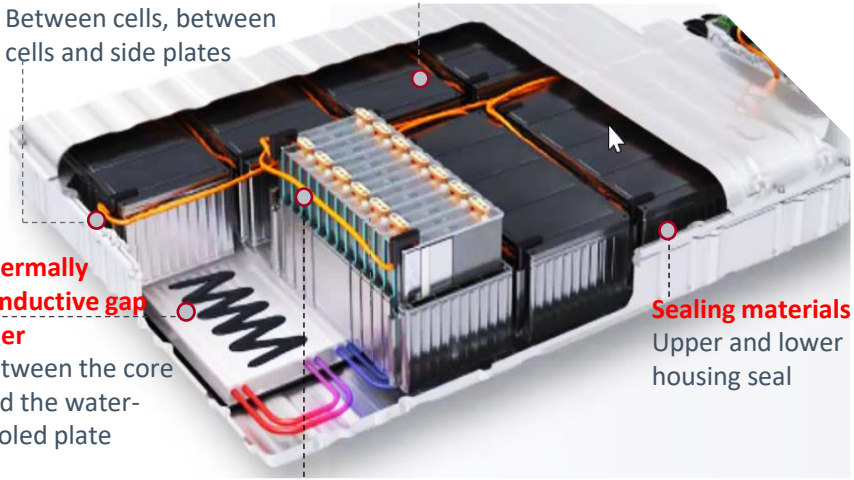
All under pinned by Sustainability, throughout the vehicle life cycle

MobilityScience™

Battery Assembly Types and Trends

Seek Together™

CTM (Cell to Module to Pack)



Electrical insulating coating
Inside the lower shell and the outer surface of the battery cell

Structural Adhesive
Between cells, between cells and side plates

Thermally conductive gap filler
Between the core and the water-cooled plate

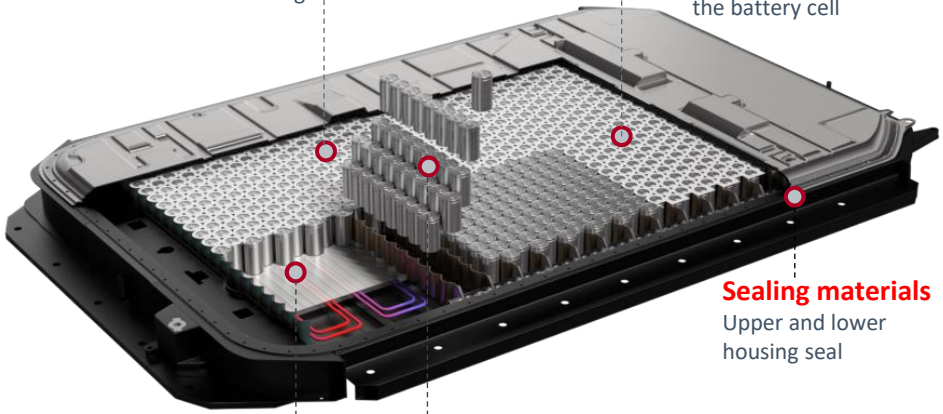
Sealing materials
Upper and lower housing seal

Anti-thermal runaway material
On the inner diaphragm of the battery cell

CTP (Cell to Pack)

Foaming and potting adhesives
Column cell filling

Electrical insulating coating
Inside the lower shell and the outer surface of the battery cell



Sealing materials
Upper and lower housing seal

Structural adhesive
Between the core and the base plate

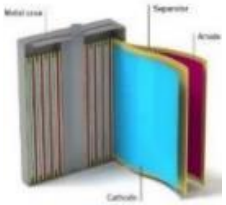
Anti-thermal runaway material
On the inner diaphragm of the battery cell

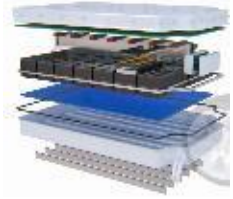
Enabling new generation battery assembly for improved efficiency and performance requires material science innovation to address unique challenges

Battery Safety – Addressing Thermal Runaway

The root causes

Puncture (60-70%) | **Overcharge (20-30%)** | **System failure (10-20%)**

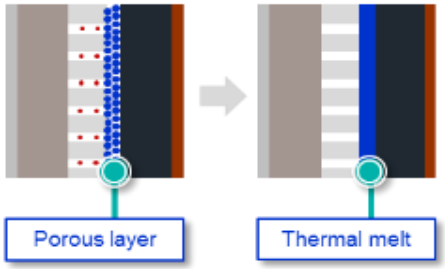


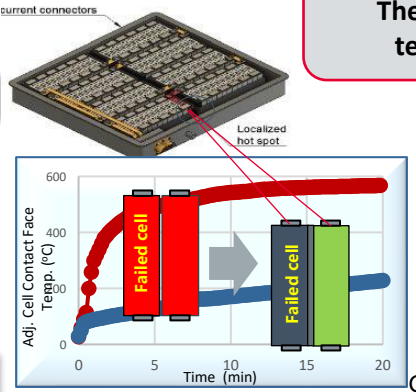


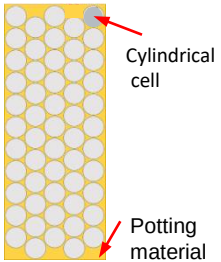
Raw materials → **Electric core** → **Module** → **Battery Pack** → **Whole car**

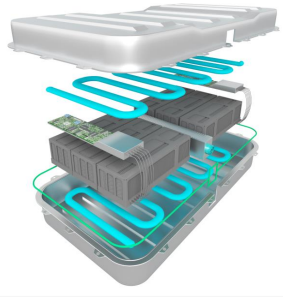
- **Thermal Response Technology**
- **Thermal Insulation & Thermal barrier technologies**
- **Thermal Conductive & Structural Enhancement Technologies**
- **Structural Reinforced Filled Foam**

Innovation: Separator shut-down

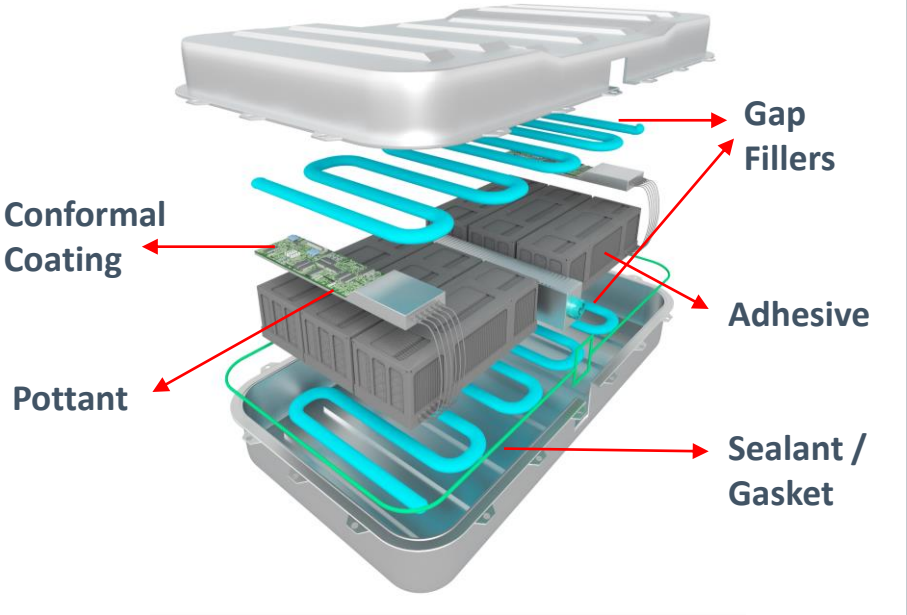








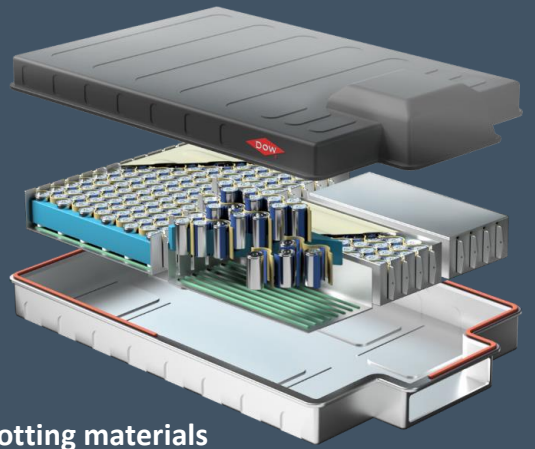
Battery Assembly – Developments in Protection Technologies

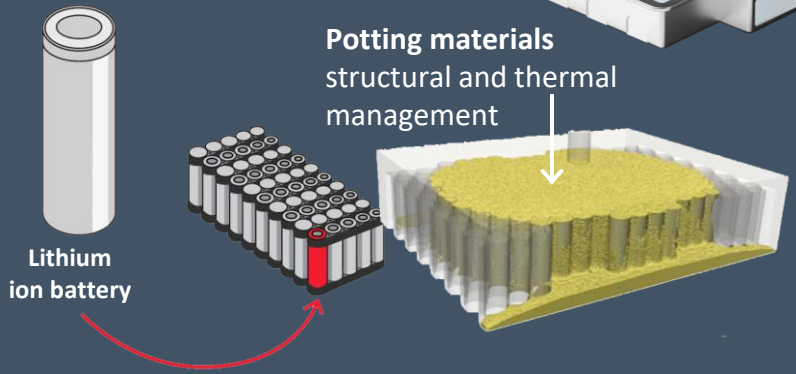


Enabling effective heat management across battery pack, battery management and other control systems

Advanced Potting Resins

- Lower viscosity
- Balancing rheo-mechanical properties
- Different polymers for desired properties

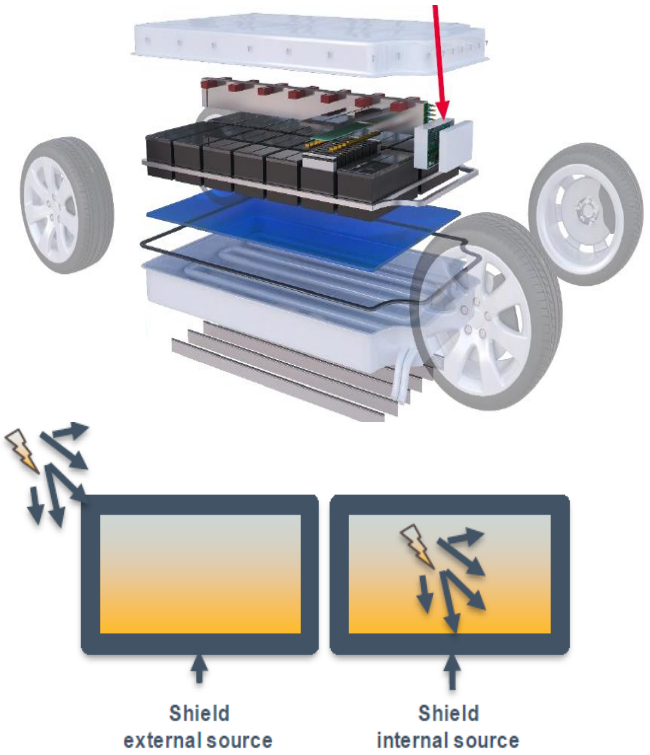




Connectivity – Managing EMI In EV, Autonomous Vehicles

Seek Together™

Electrically Conductive Material for Grounding and Shielding



High Performance Silicones for EMI Protection

- ✓ **Stable performance** under harsh environments
  - UV, high temperature, solvent, water, humidity
- ✓ **EMI shielding** over wide range of frequencies
- ✓ **Stress Relief:** Vibration damping

Lightweighting – How can we achieve more with less?

Challenge: Delivering CO_2 Emission Targets by lightweighting for ICE& HEV*

95 g/km by 2021

59 g/km by 2030

Lightweighting

- Plastics & Composite Materials to replace Metal
- Bitumen pad replacement
- Downgauging engine compartments
- Lower Density Materials
- Aluminum / Magnesium to replace Steel

*CO_2 emission standards for passenger cars in EU; www.theICCT.org

Long history of TPO in Automotive Interior/Exterior Applications

Seek Together™

1970s

Plastic Bumper

- Lightweighting- Fuel efficiency
- Safety
- Multi design-low cost

1980s

Limited Application of TPO

- Balance of stiffness-toughness
- Flowability
- Paintability

1990s

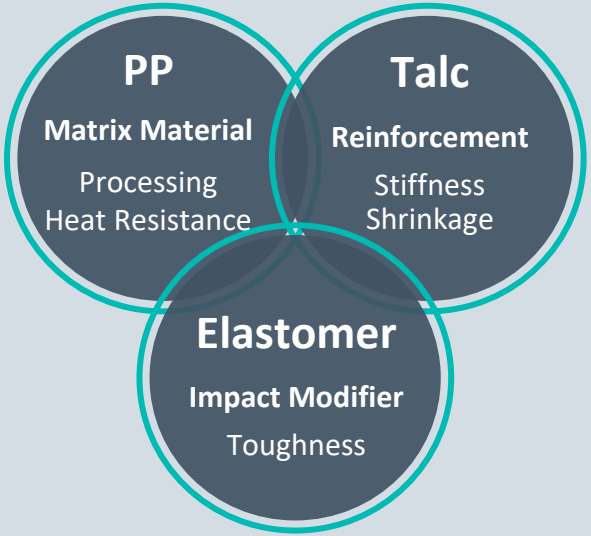
TPO for Exterior Application

- Replacement of EPDM by POE
- Better overall materials properties and processability

2000s

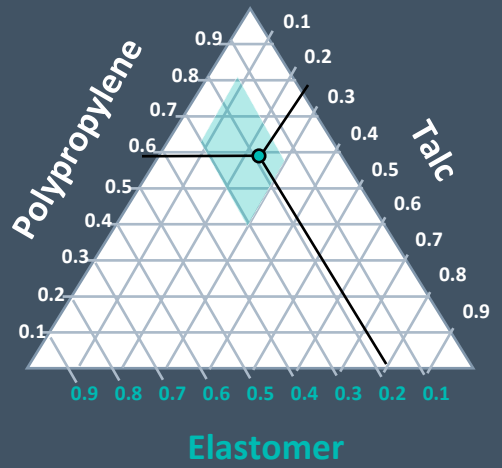
TPO for Interior Application

- Better properties
- More safe and comfortable



Wide range of Thermoplastic Polyolefin (TPO) compound design options

Balancing melt flow, modulus, toughness and thermal expansion characteristics



Weight Reduction Enabled by New Generation Polyolefin Elastomers

Seek Together™

Thermoplastic Polyolefin (TPO) Compounds in Automotive

Interior applications
Instrument & door panels, pillars, air-bag covers

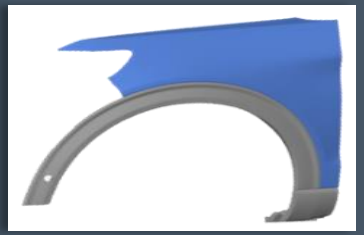
Exterior applications
Bumper fascia, trim, rocker panels, tail gate

Enables Lightweighting Strategies in Automotive Plastic Parts

Lower Density	Metal Replacement
Thin Walling	Foaming

> 25% Weight Reduction by Replacing Metal with TPO
SUV Front Fender Example

4.4kg Steel Fender Design
- 4 Pieces of Stamped Steel
- 33 Fasteners



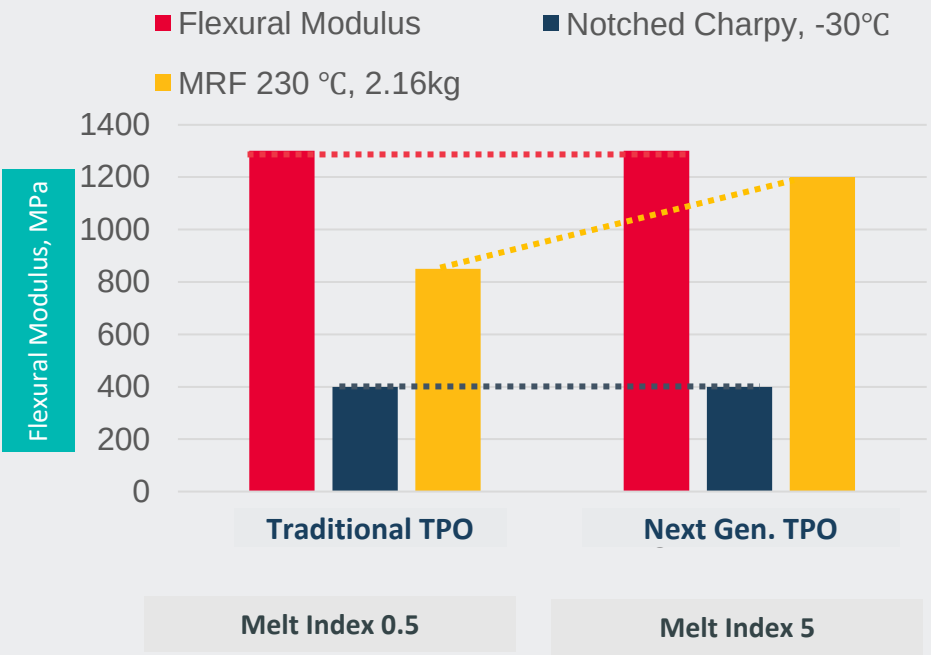
3.2kg TPO Fender Design
- 3.0mm Class A Surface TPO outer
- 9 Fasteners

Other Benefits

Cost Reduction > 8%
Part/Assembly reduction

Design Freedom
Remove all metal forming constraints

Balance between higher toughness and fluidity contributes to lightweight interiors and exteriors



Low-density → Toughening efficiency ↑; Filler content ↓

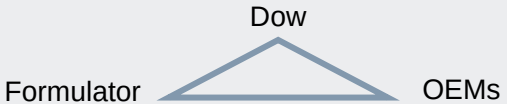
Thin-walled → Maintain high toughness →; Improve fluidity ↑

Component	wt%
25 MFR ICP	65
Elastomer	15
Talc	20

Lightweighting
LASD (Liquid Applied Sound Dampener)

Solution introduction based on value proposition

- Weight reduction
- Excellent sound damping performance
- Faster model redesign and line flexibility



Industry or environment impact with Quantified benefits

- **35% lighter weight***
- **1.2 million MT CO_2 emission saved****

**Vs bitumen pad*

*** with an addressable market for LASD of 38 million vehicles, assuming a 12-year lifetime, an annual average of 12,000-mile travel distance*

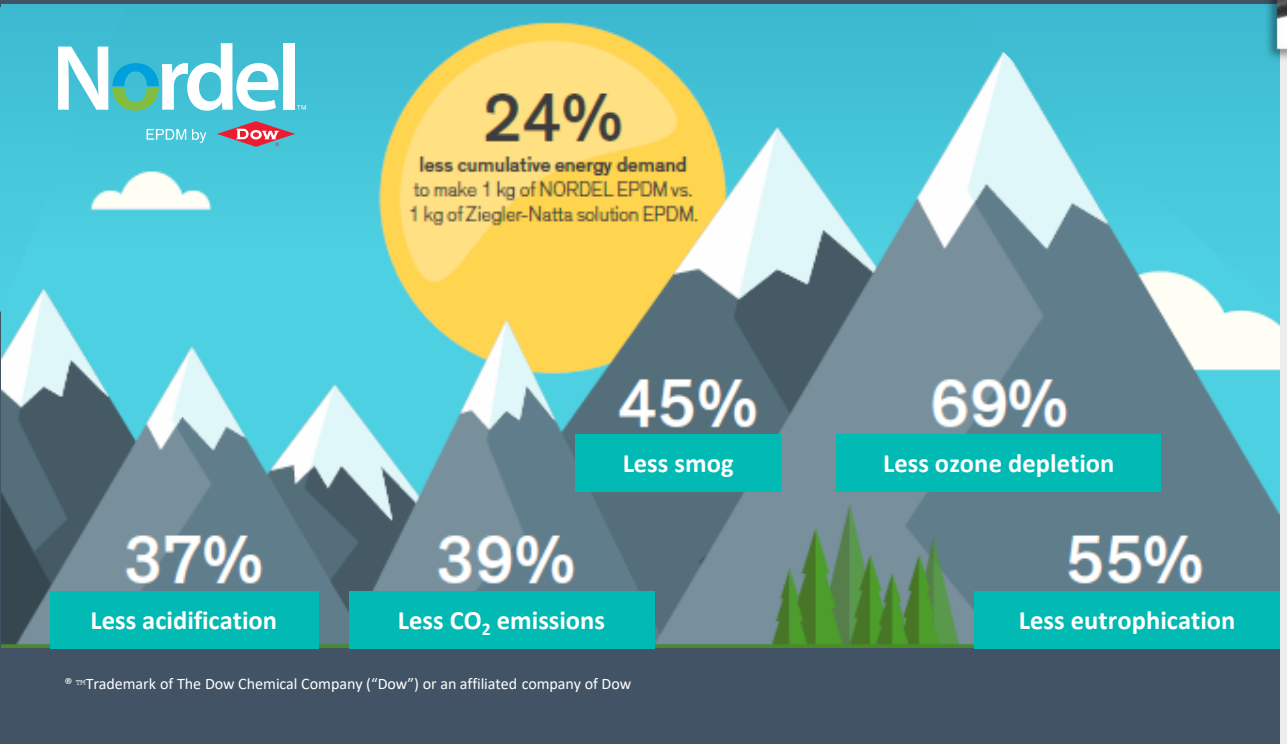
Lightweighting

Materials produced with lower environmental impact

Seek Together™

Comparative Life Cycle Assessment (LCA) from cradle to gate

EPDM material for weatherseals, hoses and belts



NORDEL™ EPDM production by Advanced Molecular Catalyst technology has a significantly lower environmental impact than Ziegler-Natta solution EPDM

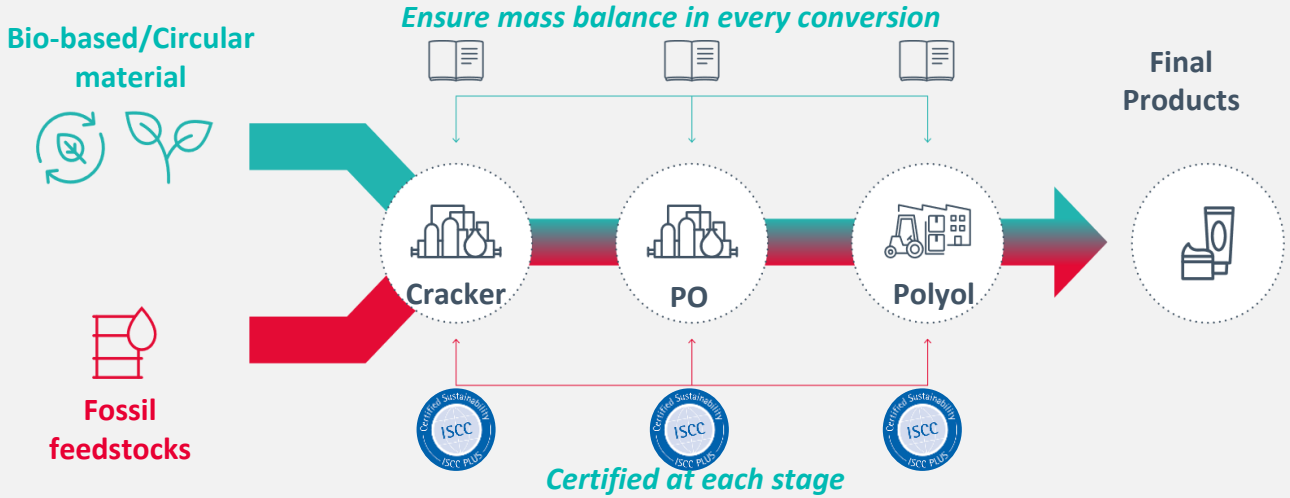
Source: Dow LCA calculations framed by ISO standards 14040 and 14044 and validated by third party Quantis

ISCC*+ Mass Balance Approach: Sustainable Polyurethane Foams

ISCC+ certification :

- The first worldwide accepted sustainability certification program for bio-based and circular (recycled) raw materials
- Provides a solid proof of traceability towards a sustainable source across the whole supply chain with rigorous mass balance approach

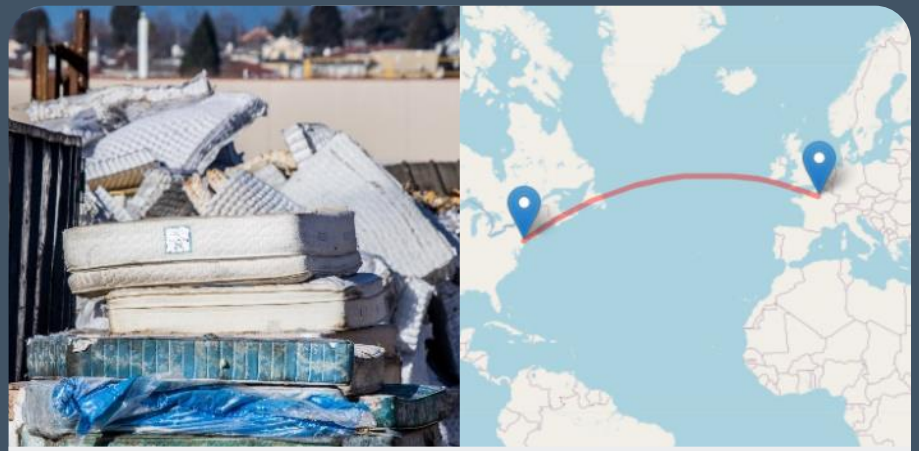
Advanced technologies for circular and bio-based materials



Chemical Recycling – Renuva™, realizing circularity of PU foams

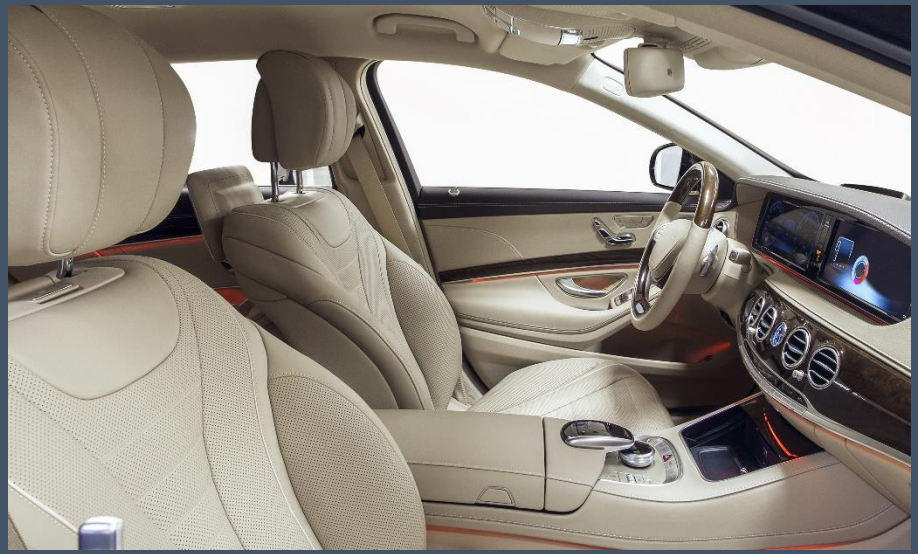
Seek Together™

Imagine stacking all mattresses discarded in Europe in 2017…

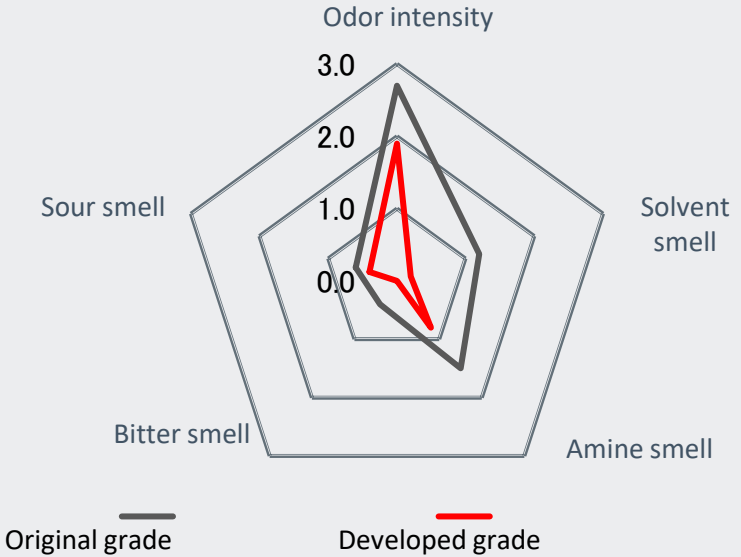


… covers the distance from Paris to New York

Low Odor Seat – New Gen PU systems, for interior design quality



Odor Improvement of Developed Seating Foam



3D Loop – Recycling Solution for Mobility Seating & Mattress

Seek Together™

POE FOR 3D LOOP

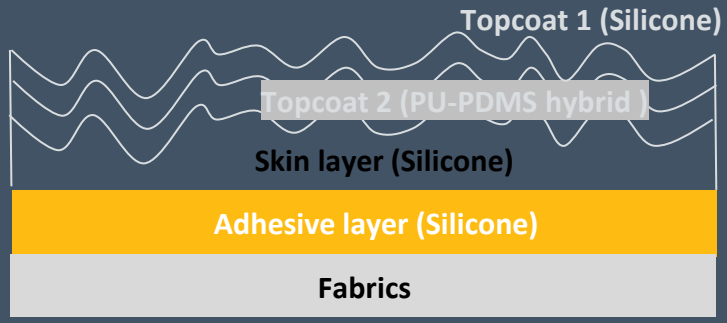
3D Loop Benefits

- Easy clean (Covid-19 concern)
- Highly breathable
- Heat management
- Low VOC/odor
- Recyclable

Key Applications

Novel Material Science Solution for Comfort and Safe Interior

Synthetic Leather for Interiors



Multi-layer laminate structure

World's First Si-leather for Automotive

Partnership With an OEM

Interior: Seat, door panels, armrest….

The 4S of LUXSENSE™

- Sense of **SUSTAINABILITY** (no plasticizer, harmful solvents and contributes to animal welfare,…)
- Sense of **SIGHT** (easy to clean, bright colors,..)
- Sense of **SMELL** (odor free, low VOC)
- Sense of **TOUCH** (skin-feel soft touch, skin friendly,..)

Q&A