CHEMISTRY THAT MATTERS™

# FLAMMSCHUTZ UND NACHHALTIGKEIT

## EV APPLICATIONS & NEW DEVELOPMENTS

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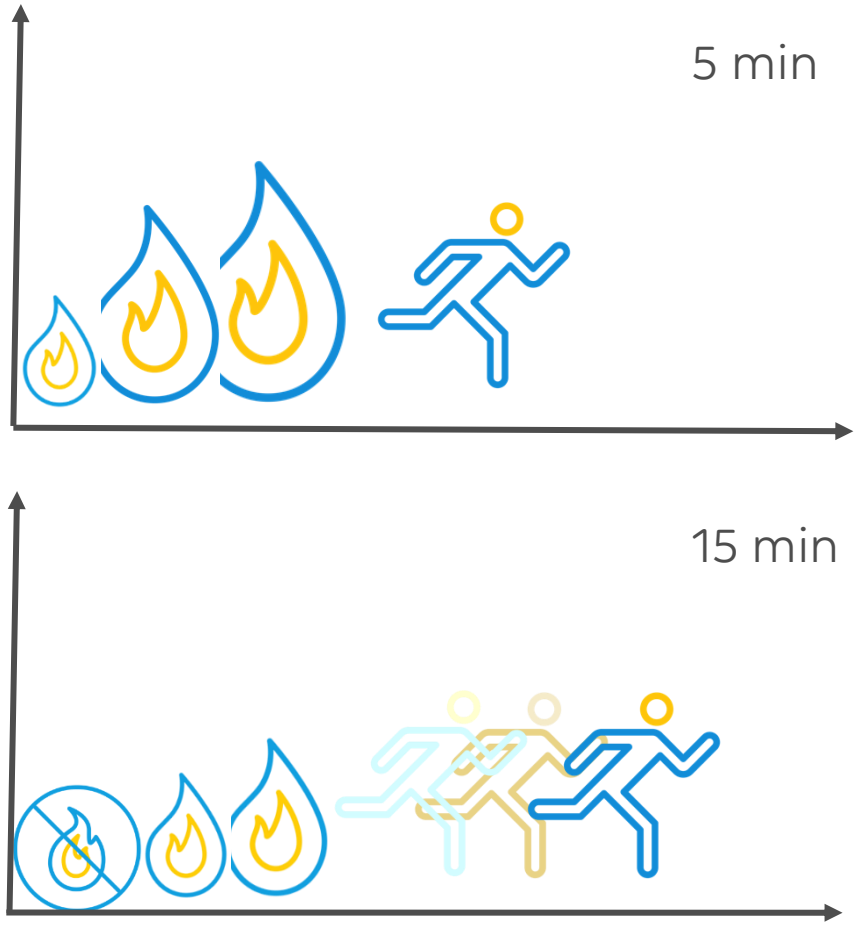
# BACKGROUND ON FLAM RETARDANT

# WHAT IS THE ROLE OF A FLAME RETARDANT?

Flame retardant increase the escape time



# 5 KEY-EFFECTS DURING A FIRE EVENT

**Test standards:** UL94, EN 45545-2, FAR 25.853,...

Self-ignition

Droplets

Heat Release , Flame spread

Smoke release

Gas & Smoke toxicity

# FLAM RETARDANT & SUSTAINABILITY

## Widely used FR types

### Halogenated Hydrocarbons

**(Chlorine, Bromine and Fluorine** containing Compounds and reactive flame retardants)

### Inorganic flame retardants

(Boron Compounds, **Antimony oxides**, Aluminium Hydroxide, molybdenum Compounds, zinc and magnesium oxides)

### Phosphorus containing Compounds

(Organic Phosphate Esters, Phosphates, **halogenated phosphorus** Compounds and inorganic phosphorus containing salts)

## Environmental concerns:

- **Chlorine, Bromine** containing Compounds are no longer used for new product development at SABIC Specialties Europe.
- FR system containing **PFAS** could be restricted in the near future

# EV-BATTERY COMPONENTS & FR MATERIALS

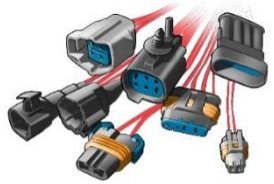
# SABIC SPECIALTIES SOLUTIONS FOR ELECTRIFICATION IN AUTOMOTIVE

## High-voltage connectors

VALOX™ ENH (PBT) & new Noryl PBT/PPE EXNL with CTI0, V0 @<1mm, Br-/Cl-free and RTI of 140°C

## COAX connectors

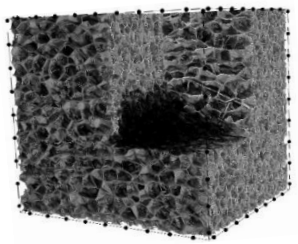
NORYL™ (PPE/PS) due to excellent low dk / df properties



## Battery Applications

NORYL™ GF (PPE/PS) & Cycoloy (PC-CoPo-Blend), V0@1,5mm (development: 0,8mm), dimensional stability, chem. resistance vs electrolytes.

FOAMS: extruded and particle foams (lightweight, FR & energy absorbing)



FILM/SHEET: capacitor film, CTI0+V0 (0,3mm)-sheet for “electrical”-protection

## Power Electronics: Inverter / Converter

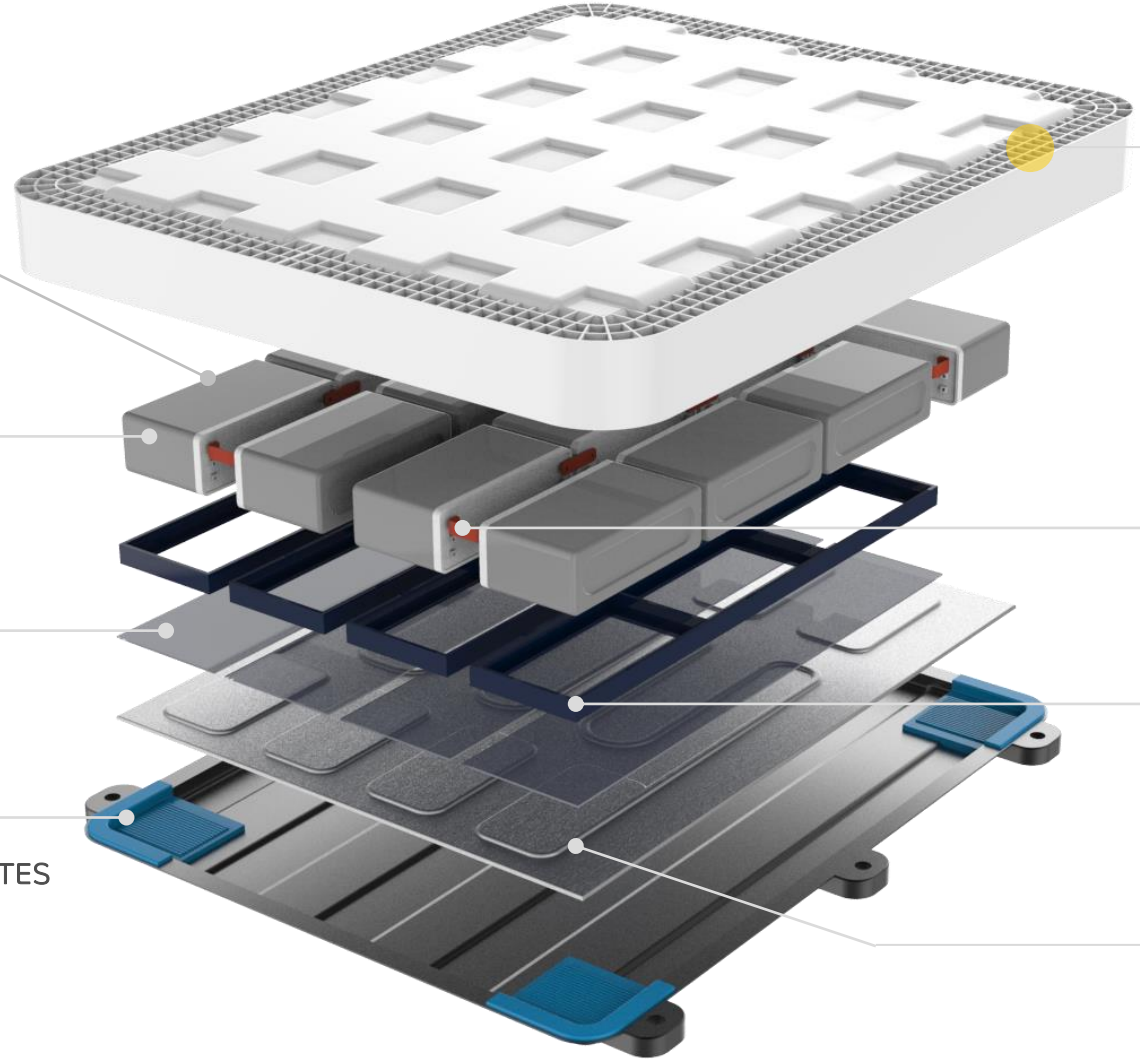
NORYL™ PPX (PPE/PP) due to improved dimensional stability and less moisture absorption vs PA66

## E-engine: Bus Bar/Ring Applications*

NORYL™ (PPE/PS) with CTI0, orange, V0@0,75mm, RTI 100°C
NORYL™ GTX (PPE/PA) & Ultem (PEI) for higher temp. requirements

Pictures: A2mac1, SABIC internal, *broad application focus, including high voltage and higher short-term heat

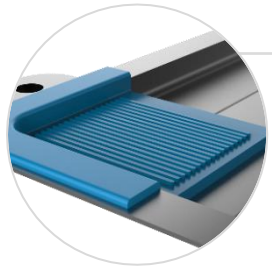
# BATTERY PACK WITH 4 SIDES ENERGY ABSORBER



MODULE ENCLOSURES
NORYL™ - PPE/PS
LNP ELCRES™ - PC/ABS

MODULE APPLICATIONS
NORYL™ (PPE/PS)
LNP™ (PC-Copolymer/ABS)

Isolation layer
NORYL™



CORNER PLATES
NORYL GTX

INTEGRATED ENERY ABSORBERS:
NORYL™ GTX (PPE/PA)

LAMINATED BUS BARS
ULTEM™ (PEI)
NORYL™ (PPE/PS)
NORYL™EXNL (PPE/PBT)

CELL FRAMES & CELL DIVIDERS
NORYL™ (PPE/PS)
NORYL™ GTX (PPE/PA)

COOLING PLATE
NORYL™ (PPE/PS)

# APPLICATION REQUIREMENTS FOR BATTERY MODULE ENCLOSURES & BRACKETS

| | |
|---|---|
| **FR** | • Non- Cl, Br FR V0 ≥ 0.8 mm preferred |
| **MECHANICAL** | • High stiffness and impact strength<br>• Low temperature impact resistance<br>• Weld-line strength |
| **PHYSICAL** | • Dimensional stability (low warpage)<br>• Chemical resistance, e.g., electrolyte, coolants<br>• Compatible with secondary ops. e.g.,<br>• Good processability → High flowability<br>• Lightweight (low density) |
| **ELECTRICAL** | • Electrically insulating<br>• Thermal resistance (RTI w/ impact >100 °C) |

**MODULE ENCLOSURES / MILD HYBRID BATTERY HOUSINGS**
Impact strength and stiffness

**MODULE COVERS**
High processing - flowability

**MODULE BRACKETS**
Stiffness and impact strength

# SPECIALTIES MATERIAL´S PROPERTIES FOR BATTERY MODULE ENCLOSURES & BRACKETS

| | |  NORYL™ NHP5054 resin |  NORYL™ NHP6011 resin **NEW** |  NORYL™ GTX4610 resin |  CYCOLOY™ CX7240 resin & CX7410 resin |
|---|---|---|---|---|---|
| **RUNNING APPLICATIONS** | | Mild hybrid battery housing | End plates | Module bracket | Module top covers |
| **PROPERTIES** | | High Stiffness | Robust FR | Impact & FR | High flow |
| **POLYMER CHARACTERISTICS** | CHEMISTRY | PPE / HIPS-GF20 | PPE blend-GF8 | PPE/Nylon blend-GF10 | PC EXL/ ABS blend |
| | STRUCTURE | Amorphous | Amorphous | Amorphous \| Semi-crystalline | Amorphous |
| | DENSITY | 1,30 g/cm³ | 1,16 g/cm³ | 1,21 g/cm³ | 1,2 g/cm³ |
| **SAFETY** | FLAME PERFORMANCE (UL94) | V0 ≥ 0.75 mm | V0 ≥ 1.5 mm | V0 ≥ 1.5 mm | V0 ≥ 0.75 mm |
| | ELECTRICAL PERFORMANCE TRACKING RESISTANCE (UL 746) | CTI PLC 3 | CTI PLC 2 | CTI PLC 1 | CTI PLC 3 |

# APPLICATION REQUIREMENTS FOR EV BATTERY MODULE PARTS

**FR**
- Non- Cl, Br FR V0 ≥ 0.8 mm preferred
- V0 ≥ 1.5 mm must

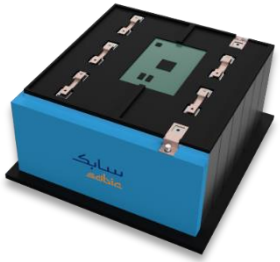
**MECHANICAL**
- High stiffness and impact strength
- Crash resistance

**PHYSICAL**
- Dimensional stability (low warpage)
- Chemical resistance, e.g., electrolyte, coolants
- Good processability → High flowability

**ELECTRICAL**
- Tracking resistance: min. CTI PLC 2
- Thermal resistance (RTI w/ impact >100 °C)
- Electrical insulation

CELL FRAME

BUSBAR-HOLDER



CYLINDRICAL CELL RETAINER

**TREND: Increasingly strict UL94 FR requirements***

* Source trend: SABIC internal studies - CTQ standards from battery producers

# EV BATTERY MODULE APPLICATIONS

THERMOCOMP™
9F005P compound

NORYL™ | CYCOLOY™
N1050 resin | CX7211 resin

NORYL™
NHP6012resin

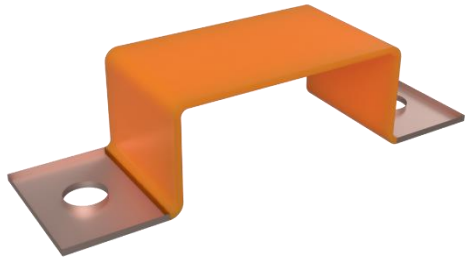
NEW

| | | | | | |
|---|---|---|---|---|---|
| RUNNING APPLICATIONS | | Cell retainer | Spacers / Frames | | Busbar frame |
| PROPERTIES | | Dimensional stability | Chemical resistance | | FR downgauging |
| POLYMER CHARACTERISTICS | CHEMISTRY | PC-Blend GF | PPE / HIPS | PC/ABS | PPE Blend GF10 |
| | STRUCTURE | Amorphous | Amorphous | | Amorphous |
| | DENSITY | 1,30 g/cm³ | 1,11 g/cm³ | | 1,19 g/cm³ |
| SAFETY | FLAME PERFORMANCE (UL94) | HB ≥ 0.75 mm | V0 ≥ 1.5 mm | | V0 ≥ 1.5 mm |
| | ELECTRICAL PERFORMANCE TRACKING RESISTANCE (UL 746) | CTI PLC 3 | CTI PLC 2 | CTI PLC3 | CTI PLC 2 |
| PROCESSING | FLOWABILITY MFI | 56 g/10min | 25 g/10min | 14 g/10min | 25 g/10min |

# SPECIALTIES MATERIAL´S PROPERTIES FOR CELL RETAINER

| | | LEXAN™ ML6411 resin | NORYL™ NH4050 resin | NORYL™ N1250 resin | THERMOCOMP™ 9F005P compound |
|---|---|---|---|---|---|
| **PROPERTIES** | CHEMISTRY | PC-Copolymer | PPE / PS | PPE / HiPS | PC-Blend GF |
| **POLYMER CHARACTERISTICS** | Moisture (23°C – 50% r.LF / 23°C - sat.) | 0.1% / 0.3% | 0.06% / 0.1% | 0.05% / 0.25% | 0,01% / - |
| | CTE (DIN ISO 11359-2) | 7.0 / 7.0 | 8.0 / 8.2 | 6.1 / 6.8 | 2.68 / 5.69 |
| | Tensile Strain (brk) | 100% | 19% | 15% | 2% |
| | Charpy 23°C (notched) | ~50-60 kJ/m² | 16 kJ/m² | 7 kJ/m² | 9 kJ/m² |
| | FLOW | 18 cm³ / 10min (260°C / 5kg) | 32 cm³ / 10min (280°C / 5kg) | 12 g/cm³ (280°C / 5kg) | 47 g/10min (260°C / 5kg) |
| **SAFETY** | FLAME PERFORMANCE (UL94) | V0 ≥ 1.5 mm | V0 ≥ 1.5 mm | V0 ≥ 0.75 mm | HB ≥ 0.75 mm |
| | ELECTRICAL PERFORMANCE TRACKING RESISTANCE (UL 746) | CTI PLC 2 | CTI PLC 2 | CTI PLC 2 | CTI PLC 3 (200V) |

# SPECIALTIES MATERIAL´S PROPERTIES FOR BUSBARS OVERMOLDING



| | | NORYL™ NHP5054 resin | NORYL™ NHP8000VT3 resin **NEW** | NORYL™ NH6020 | NORYL™ EXNL5130 **Development** |
|---|---|---|---|---|---|
| **PROPERTIES** | | High Stiffness | high FR-Performance | CTI & FR | CTI & FR |
| **POLYMER CHARACTERISTICS** | CHEMISTRY | PPE / HIPS-GF20 | PPE / PS | PPE / PS | PPE / PBT blend-GF |
| | STRUCTURE | Amorphous | Amorphous | Amorphous | Amorphous \| Semi-crystalline |
| | DENSITY | 1,30 g/cm³ | 1,10 g/cm³ | 1,14 g/cm³ | 1,38 g/cm³ |
| **SAFETY** | FLAME PERFORMANCE (UL94) | V0 ≥ 0.75 mm | V0 ≥ 0.3 mm | V0 ≥ 0.75 mm | V0 ≥ 0.4 mm |
| | ELECTRICAL PERFORMANCE TRACKING RESISTANCE (UL 746) | CTI PLC 3 | CTI PLC 0 | CTI PLC 0 | CTI PLC 0 |

# THE NORYL™ RESIN DIFFERENTIATION: BENCHMARKING*

| | FEATURE | VALUE | NORYL RESIN | PC<br>PC/ABS | PA | PBT | FR-PP |
|---|---|---|---|---|---|---|---|
| 1 | Low Specific Gravity | Weight out<br>Better energy efficiency | ● | ● | ● | ● | ● |
| 2 | Chemical Resistance to Li-ion Electrolytes | Enhances battery safety | ● | ● | ● | ● | ● |
| 3 | Non-halogenated Robust Flame Retardant | Enhance battery safety | ● | ● | ● | ● | ● |
| 4 | Dimensional Stability | Structural integrity for large and complex designs | ● | ● | ● | ● | ● |
| 5 | Impact Strength | Enhance battery safety | ● | ● | ● | ● | ● |

● EXCELLENT ● GOOD ● POOR

*Source: SABIC Technology – internal comparison study

# KONDUIT

# WIRELESS CONNECTIVITY WITH LNP™ COMPOUNDS

## WIRELESS COMMUNICATION

LNP™ KONDUIT™ compound

- Radio frequency (RF)-transparency
- Thermal conductive
- Electrical insulating
- Flam retardant

# EV-CHARGER COMPONENTS & ELECTRIFICATION

# EV CHARGER INFRASTRUCTURE

## Domestic

Home Charger / Wall mounted

Power cable, connector, charger handle

## Public

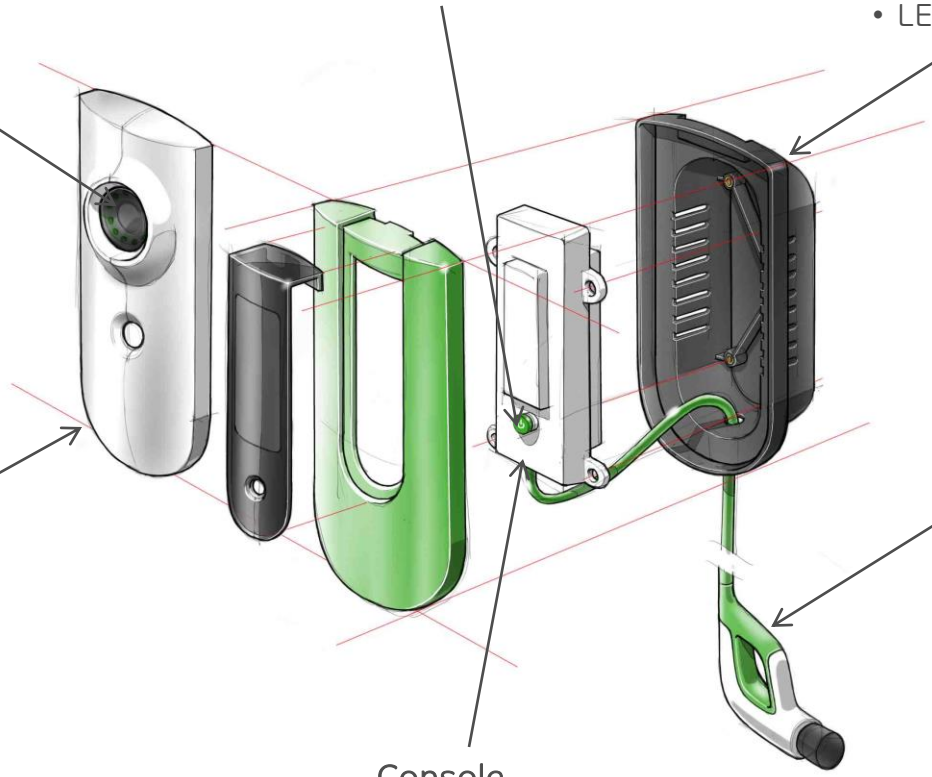
Charging pole

# DESIGN CONCEPT FOR DOMESTIC

**Display**
- LEXAN LUX
- LEXAN SLX

**Connector & Socket**
- VALOX ENH3500
- LEXAN ML6411

**Frame**
- LEXAN Structural foam
- LEXAN EXL9330
- LEXAN EXL9134
- LEXAN EXL9112



**Frame**
- LEXAN EXL9330

**Fascia**
- LEXAN EXL9330
- LEXAN EXL9134
- LEXAN EXL9112

**Console**
- LEXAN 9330
- LEXAN ML6411

# EV CHARGER SABIC SOLUTIONS

| | | EXL9330<br>EXL9134<br>EXL9112 | EXL5689 | SLX2271T | LEXAN™<br>LUX7436C |
|---|---|---|---|---|---|
| | | Housing/ Socket | Housing | Display | Display |
| PART PERFORMANCE | Vandalism proof, ductility | Ductile < -30°C | Good balance impact/stiffness | | |
| SAFETY, RELIABILITY | Flame performance | V0 at 1.5 mm<br>5VA at 3 mm<br>GWFI 960°C at 1 mm<br>Non-Br, non-Cl | V0 at 1.5 mm<br>5VA at 3 mm<br>GWFI 960°C at 1 mm<br>Non-Br, non-Cl | V2 at 1.5 mm<br>-<br>GWFI 960°C at 1.5mm<br>Non-Br, non-Cl | V0 at 1.2 mm<br>5VA at 3 mm<br>GWFI 960°C at 1.0 mm<br>Non-Br, non-Cl |
| | Electrical performance | RTI 125°C<br>CTI PLC 3 | RTI 130°C<br>CTI PLC 3 | RTI 110°C | RTI 125°C<br>CTI PLC 3 |
| | Heat resistance | Ball pressure test 125°C | Ball pressure test 125°C | Ball pressure test 125°C | Ball pressure test 125°C |
| | Environmental | f1 | f1 | f2 | f1 |
| AESTETICS | | Transparent and Opaque | Opaque | Transparent Opaque | Transparent Diffusive |

# EV SOCKETS REQUIREMENTS – SABIC SOLUTIONS

| | | VALOX™ ENH 3500 | VALOX™ ENH 4560 / (4565) | LEXAN™ EXL9330 |
|---|---|---|---|---|
| PART PERFORMANCE | Ductility<br>Stiffness | Good balance impact/stiffness | High stiffness | Ductile < -30°C |
| SAFETY, RELIABILITY | Flame performance | V0 at 0.8 mm<br>5VA at 3 mm (BK)<br>GWFI 960°C at 0.8 mm<br>Non-Br, non-Cl | V0 at 0.8 mm<br>GWFI 960°C at 0.8 mm<br>Non-Br, non-Cl | V0 at 1.5 mm<br>5VA at 3 mm<br>GWFI 960°C at 1 mm<br>Non-Br, non-Cl |
| | Electrical performance | RTI 150°C<br>CTI PLC 0 | RTI 140°C<br>CTI PLC 0 | RTI 125°C<br>CTI PLC 3 |
| | Thermal performance | Ball pressure test 125°C | Ball pressure test 125°C | Ball pressure test 125°C |
| | Environmental | - | - | f1 |
| AESTHETICS | UV resistance<br>Color-ability | ✓<br>Good | ✓<br>Good | ✓<br>Good |
| RESISTANCE TO CHEMICALS | | Excellent | Excellent | Good |

# INNOVATIONS

DESIGN FREEDOM (thin wall)
SUSTAINABILITY
CHEMICAL RESISTANCE

# CHEMICAL RESISTANCE, HIGH IMPACT & FLAME-RETARDANT SOLUTIONS ELCRES™ CRX RESINS

# INTRODUCING LNP™ ELCRES™ CRX RESIN: A NON-Br/Cl FR PRODUCT FOR DURABILITY AGAINST HARSH ENVIRONEMENTS

A high-performance amorphous material to meet customer demands for world-class chemical resistance against a broad range harsh disinfectants, industrial and consumer chemicals.

## Properties Vs Alternative Resins

| Feature | FR PC / PBT | FR PC / ABS | CRX7412U |
|---|---|---|---|
| ESCR* | ● | ■ | ● |
| INI, 23°C > 600J/m | ■ | ■ | ● |
| Low shrinkage | ■ | ● | ● |
| V0 ≤ 1.5 | 0.8mm | 0.8mm | 1.2mm |
| Non Br/Cl | ■ | ● | ● |
| Custom colors | ▲ | ● | ● |

## COMPLIANCE WITH REGULATIONS*

Possibility to provide flame retardant CRX solutions based on non-Br/Cl flame retardant to meet

- Product durability
- While addressing the presence of hazardous chemicals in products

* https://ec.europa.eu/commission/presscorner/detail/en/QANDA_20_419

# POTENTIAL APPLICATIONS FOR CHEMICAL RESISTANT AMORPHOUS MATERIALS

| | Healthcare | Electrical & Electronics | Mobility & MT |
|---|---|---|---|
| Applications |  |  |   |
| Chemicals | **Disinfectant,** Ethanol | **Sunscreen, Deet,** Paint, Coating | **Brake fluid,** Diesel additive; **Disinfectant,** cleaning agents |
| | CRX7412U | CRX7416U | |

Benchmarking

| Competition | Potential differentiating features of CRX |
|---|---|
| Non-Br/Cl FR PC ABS | Low temp Impact, Heat / Hydro, Chemical Resistance |
| Halogenated FR VALOX | Impact, Dimension stability, Processability, Heat / Hydro |

LNP™ CRX resins have strong feature combination & differentiation that can bring value to different segments

# SUSTAINABILITY OPTIONS

# INTEGRATE CIRCULAR SOLUTIONS IN OUR VALUE CHAIN

LNP™ circular ambition is driven by the growing industry desire for sustainable solutions and fueled by our vision to compound the answer.

## RENEWABLE COMPOUNDS

Bio-based resins and second generation sources of cracker feedstock:

- ✓ Potential drop in
- ✓ Virgin equivalent properties
- ✓ Opportunity to source intermediates

## CHEMICAL RECYCLING

Chemically recycled resin:

- ✓ De-polymerization
- ✓ Pyrolysis using post-consumer mixed-plastic waste
- ✓ Virgin equivalent property

## MECHANICAL RECYCLING

Mechanically recycled resins and/or fillers:

- ✓ Potential closed loop opportunities
- ✓ Hybrid solution; mix with virgin material
- ✓ Opportunities for PCR and PIR materials

## SUSTAINABLE DESIGN

Design to improve recyclability, durability & reuse:

- ✓ Mono-material, part simplification
- ✓ Reduce weight & material use
- ✓ Non-halogenated FR
- ✓ Processing efficiency

# OVERVIEW LNP™ SUSTAINABLE SOLUTIONS[1,2]

## MECHANICAL RECYCLING

20-80%
Sustainable Content

Up to:
46%
$CO_2$ reduction

## CHEMICAL RECYCLING

20-60%
Sustainable Content

Up to:
41%
$CO_2$ reduction

## RENEWABLE COMPOUNDS

30-60%
Sustainable Content

Up to:
63%
$CO_2$ reduction

1. Lower carbon footprint in comparison to same materials containing 100% crude oil feedstock.
2. Based on preliminary data from ELCRIN iQ PBT 3rd generation development


THANK YOU

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