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AMI | Events
Plastics in Electric Vehicles
6-7 June 2023 | Munich, Germany

Safety of Electric Vehicles:

How the Right Choice of Polymers and Flame Retardants Can Help?

Cefic sector group

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Dr. Sebastian Hörold studied chemistry at university Braunschweig and Oldenburg and finished his PhD thesis in 1994 in technical chemistry.

He joined Hoechst AG Knapsack site in 1994 and worked in research and development for phosphorus based flame retardants. Later he was also responsible for technical service for thermoset polymer applications. In 1997 the former division of Hoechst was transferred to Clariant AG.

Since 2002 he is head of development of flame retardants for thermoplastic polymers in Gersthofen, D. From 2011 to 2015 he was head of application technology plastics of the business unit Additives. Since 2015 he is responsible for market development and technical service for plastics globally.

Cefic sector group

Notes and references

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How phosphorus flame retardants can enhance the fire safety of electric vehicles

Dr. Sebastian Hoerold,

Head of Technical Business Development Flame Retardants

Clariant

Cefic sector group

Clariant at a glance – a globally leading company in specialty chemicals

4372

Sales 2021[1] (CHF m)

708

EBITDA 2021[1] (CHF m)

3

Core Business Units

11 537

Total staff 2021[1] (FTEs)

292

Net result 2021[1] (CHF m)

16.2%

EBITDA margin 2021[1]

67

Production sites 2021[1]

[1] Continuing operations

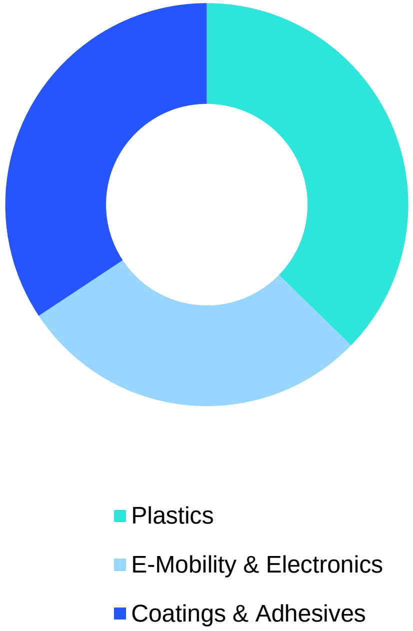
Our Additives business – a global, diversified solution provider

Plastics
Our additives solutions prevent oxidation, dissipate electric charge accumulation, improve heat, light and weather resistance, and enhance the processing and the molding properties of plastics.

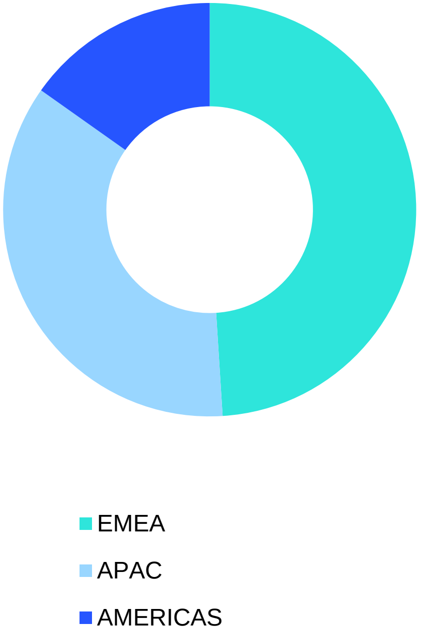
E-Mobility & Electronics
Our halogen-free flame retardants provide environmentally compatible fire protection for a wide range of thick to thin-walled applications in e-mobility as well as electrical and electronic equipment.

Coatings & Adhesives
We create value for our customers by offering high performance functionality with safe and sustainable chemical solutions through a broad range of surface modifying, stabilizing and flame retarding additive solutions.

Sales 2021 by business segment



Sales 2021 by region



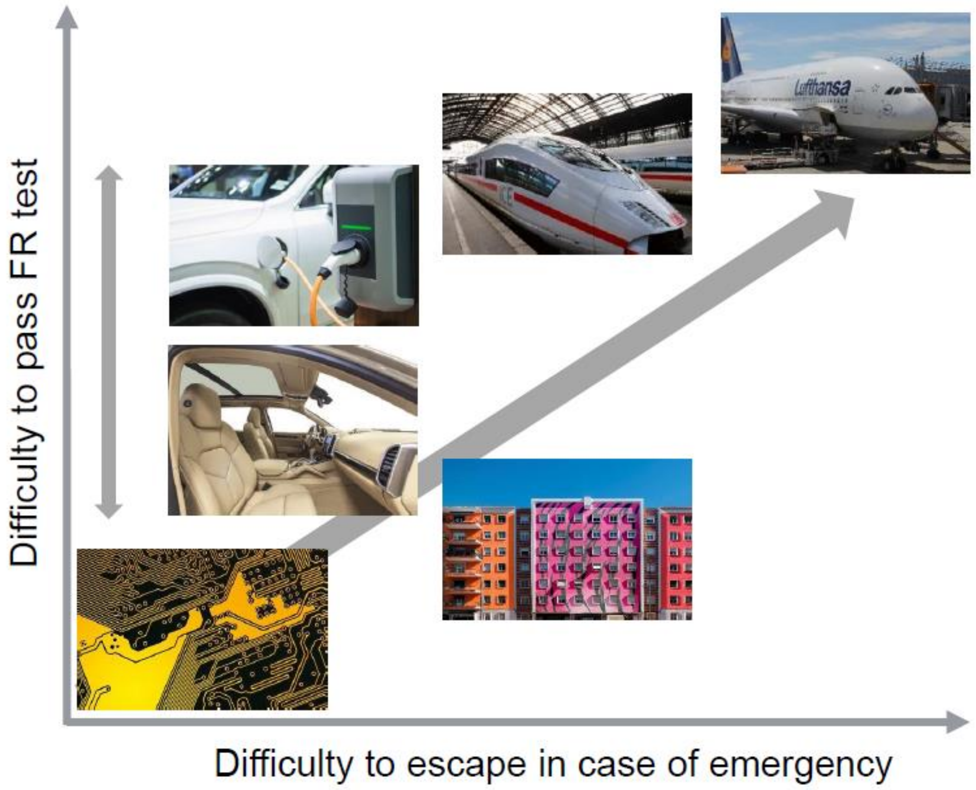
~ 920
Employees

8
Production Sites

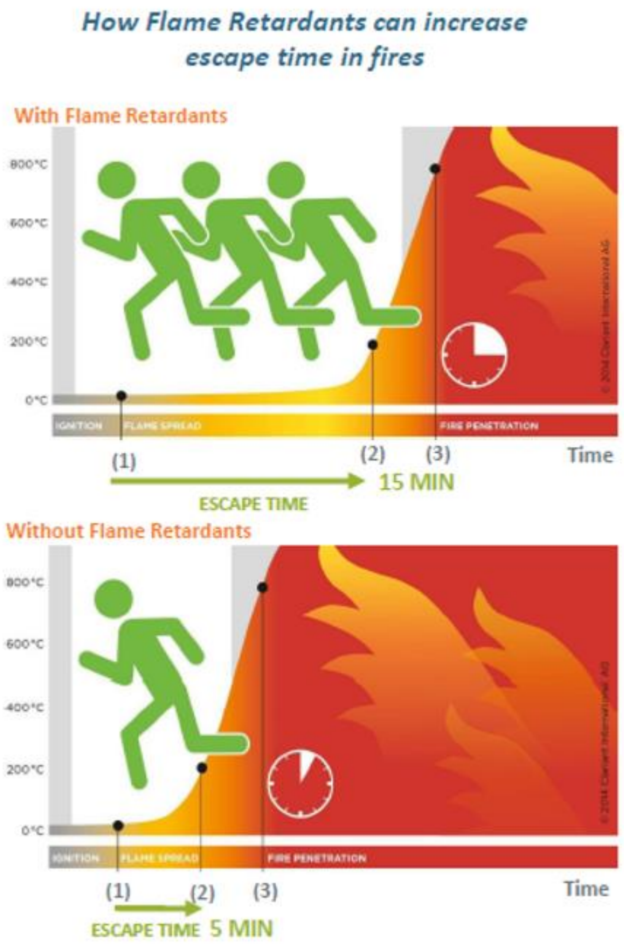
4
Technology Centers

3
Innovation Centers

Flame Retardants protect property and save lives



- Flame Retardants reduce the risk of ignition and fire spread of plastics
- Flame Retardants protect property and save lives
- Flame retardants help control smoke and smoke toxicity



Fire Tests and Flame Retardants

- Standards are defined by regulation or by industry voluntary agreement
- Standards specify that in certain applications, materials must respect certain requirements, which can include fire performance
- Standards will usually specify which fire test must be used, and under what conditions, to verify conformity to the required fire performance

- **The objective is to ensure protection of people and property against risks of fire and smoke**

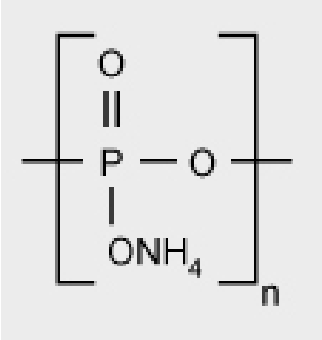
- Flame retardants are generally used as required to ensure that a material passes Fire Test(s) specified in a Standard or by a customer. Thus, the loading of flame retardant used is defined to ensure to reliably pass the fire test

UL 94 vertical fire test.
Simulates resistance against ignition by a small flame.
Photos © Clariant R. Baumgarten

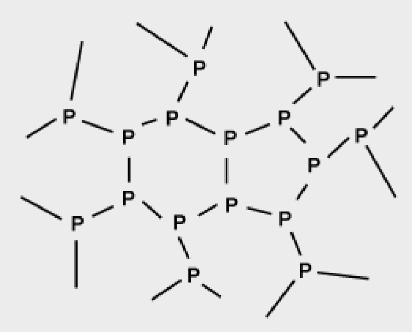
Glow wire fire test. Used widely for electrical and electronic equipment.
Simulates resistance to ignition or fire spread from a localised,
high temperature heat source, comparable to electrical faults

Phosphorus Flame Retardants – Products

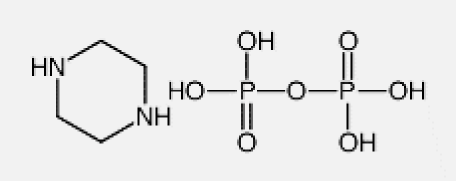
Inorganic & Organic



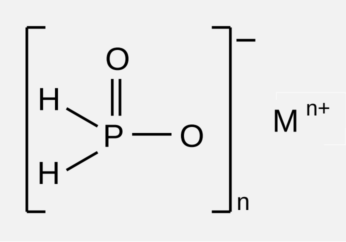
Ammoniumpolyphosphate (APP) plus Synergisten
Polyolefine, Elastomere



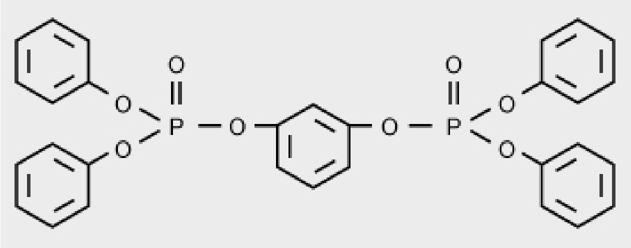
Red Phosphorus
PA 66-GF



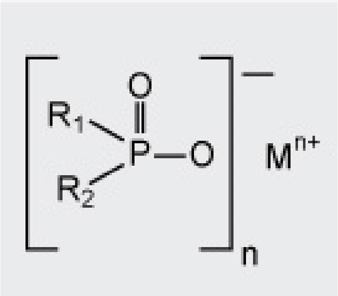
Pyrophosphates (Melamine- or Piperazine-)
Polyolefine, Elastomere



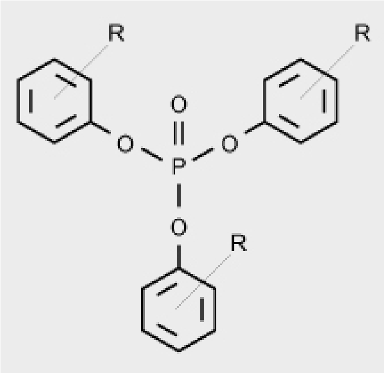
Inorganic Metallphosphinates (Hypophosphites)
PP, PBT, Elastomeres



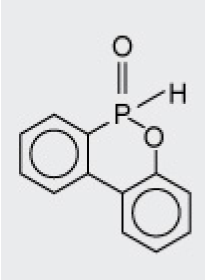
Resorcindiphosphor-säuretetraphenylester (RDP)
PC/ABS, PPO/PS



Organic Metallphosphinates
PA-GF, PBT, PET, Elastomere



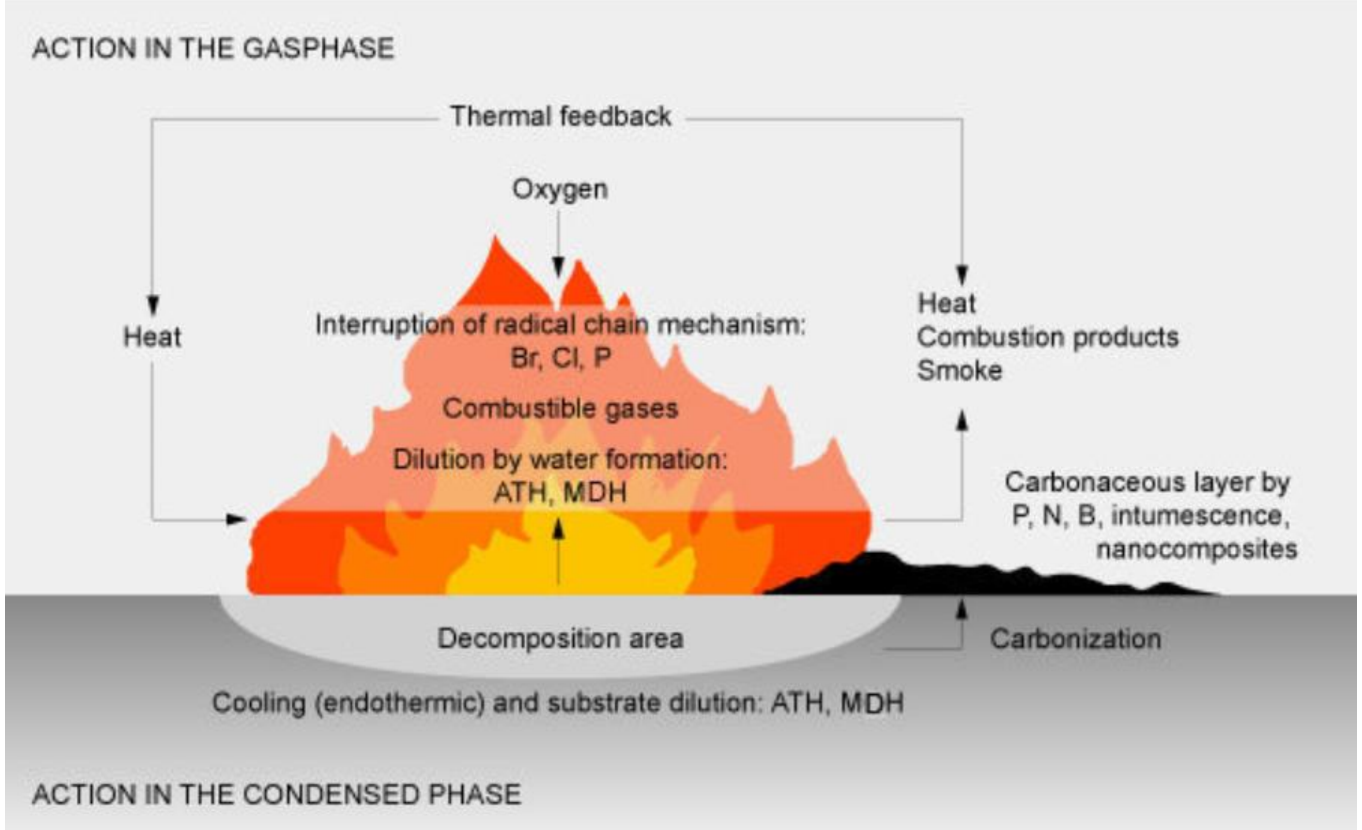
Triarylphosphate (z.B. TPP)
PVC, HIPS



9,10-Dihydro-9-oxa-10-phosphaphen-anthren-10-oxide (DOPO-Derivatives
PET, PCBs

Flame Retardants – Schematic Modes of Action
Example Polyamides

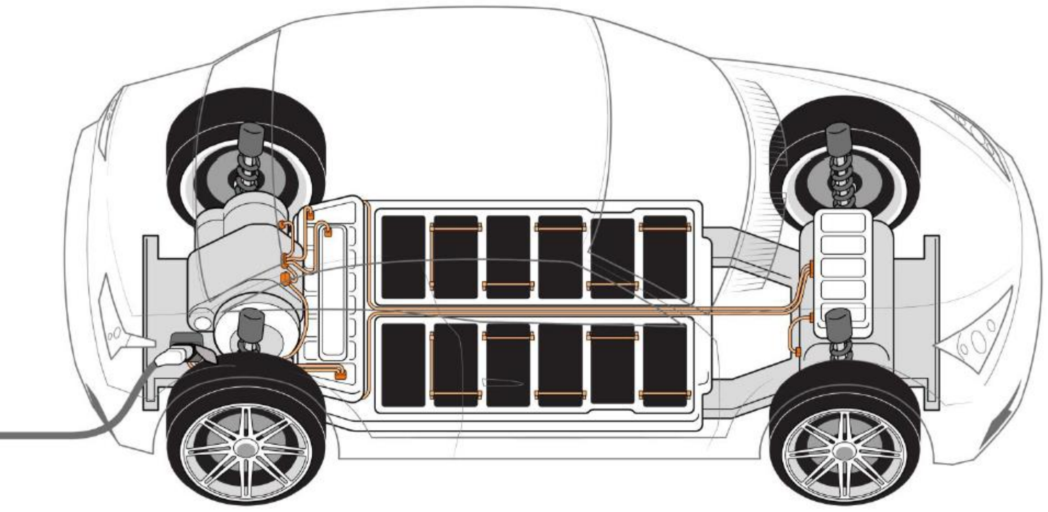
– In polyamides, all types of flame retardants are commercially used (Br/Ato, P, N, hydroxides)



Flame Retardants for Polyamides

	Halogen + Antimony trioxide	Melamine salts (N)	Phosphinates (P + N)	Red Phosphorus
Gas phase	+		+	+
Char formation		+	+	+
Cooling/ Dripping		+		
Inert gas		+	+	

Sustainable fire protection for electric vehicles



- Electric Vehicles have different fire risks compared to combustion engines because of high voltages and currents during charging and the battery with a large amount of electro-chemical energy
- If lithium-ion batteries short-circuit, cells can enter a state known as "thermal runaway," in which they continue heating up to a point where they can eventually ignite
- Batteries can catch fire long after the initial damage has occurred

Electro-mobility Poses New Challenges for Fire Safe Polymers

- Long-term reliability
  - Component and orange colour stability at elevated temperatures
- Increased safety
  - Stable dielectric strength over temperature and UL94-V0 flame-retardance standard
- Miniaturization
  - Enabled by maximum tracking index (CTI 600 V)
- Complex shapes
  - High-flow capability allowing thinner walls & design flexibility
- Design flexibility
  - High elongation at break and good balance of mechanical properties
- Increased productivity
  - Robust processing window
- Easy part traceability
  - UV laser marking Halogen-free: Avoids electrical contact (galvanic) corrosion

Photo © Sutterstock

Fire test procedures for E-Mobility

Compared to fire test from traditional combustion engine cars, fire test procedures for electrical vehicles are stronger and require higher FR-loadings

FMVSS 302
(automotive test for interior PUR foam applications)

UL 94
Globally used test for E&E and automotive applications,

FR for batteries and battery enclosures
for EV applications (different tests)

Intensity of test

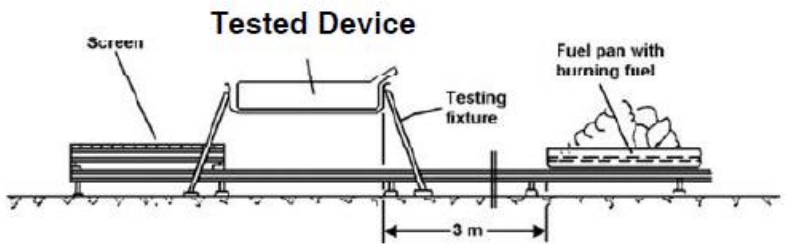
The required tests for battery enclosures are expensive and require in most cases a test at the final battery housing

Some tests focus on external fire scenario. Other tests also include thermal runaway scenario.

Different battery enclosures tests by region:

International	US	Europe	Korea	China
ISO12405 SAEJ24644 SAEJ2929	UL2580	ECE R 100	KMVSS18	GB38031

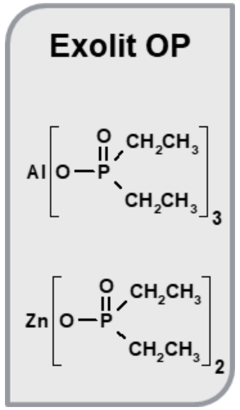
Example ECE R 100



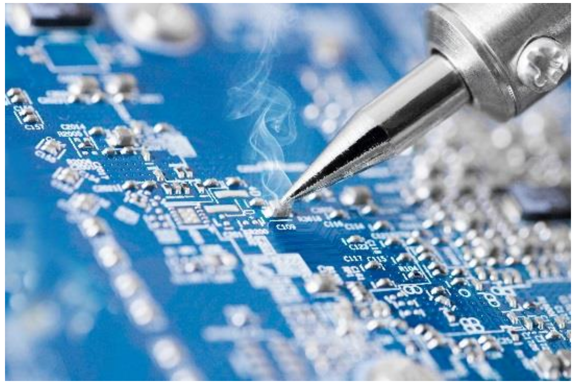
UL 2596 Test method for Thermal and mechanical Performance of Battery Enclosure in Thermal Runaway

Exolit® OP phosphinate based flame retardants – application areas

Non-melting filler like flame retardants,
available as single substance or
in combination with synergists

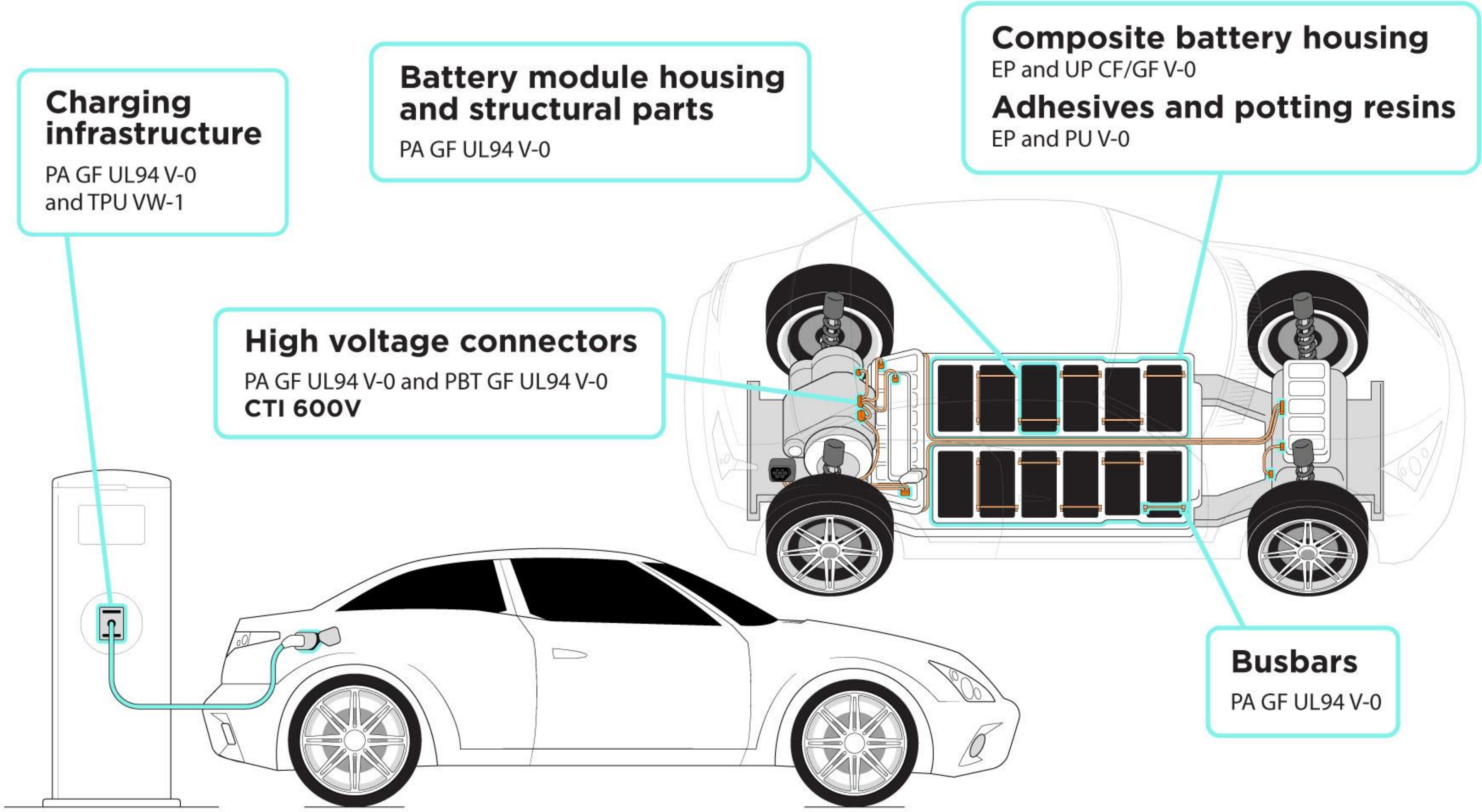


Polyamides
Polyesters
Thermoplastic Elastomers
Epoxies
Acrylates
Polyurethanes



New Capacity for Exolit OP will be on-stream in Q3/2023

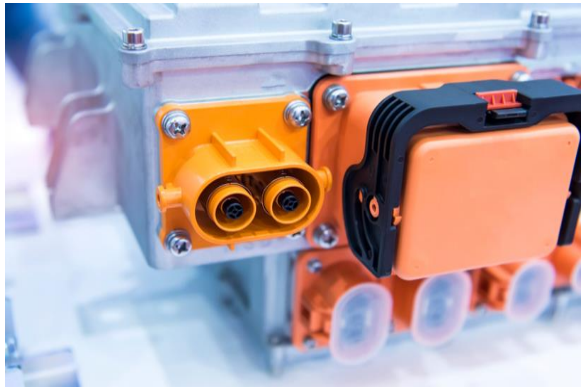
Exolit® OP brings safety, sustainability and performance to e-Mobility



E-Mobility Applications for Exolit® OP phosphinates

High voltage connectors

- **PA GF and PBT GF**
- **UL-94** V-0 down to 0.4 mm
- **CTI** of 600 V allows closer packing
- **Glass fiber** contents up to 45%
- **Orange color** stability
- **Laser Marking**



Charging accessories

- **PA 6&6 GF**
- **Halogen-free** flame retardancy
- **GWIT ≥ 775 °C**
  UL 746C f1 rating
- **Black color**

Structural Parts for Battery

- **PA6&66 GF or PA/PP LFT**
- **UL 94 V-0 or 5VA, GB/T 31467**
- **High stiffness**
- **Recyclability**

Applications for FR Thermosets in e-Mobility

Composite battery housing

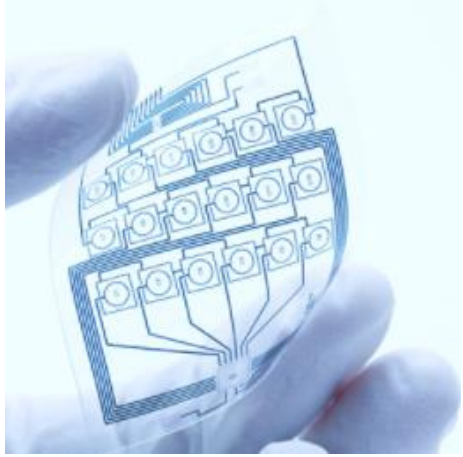
- FR composite full-size battery housing based on thermoset resins compete with metal housings
- Main application for covers so far

Adhesives, potting, foams

- Various applications in battery housing to fix parts or to used as potting resin for cylindrical cells
- FR foam between pouch cells

FCCL and PCB

- FCCL used in sensors and electronic equipment

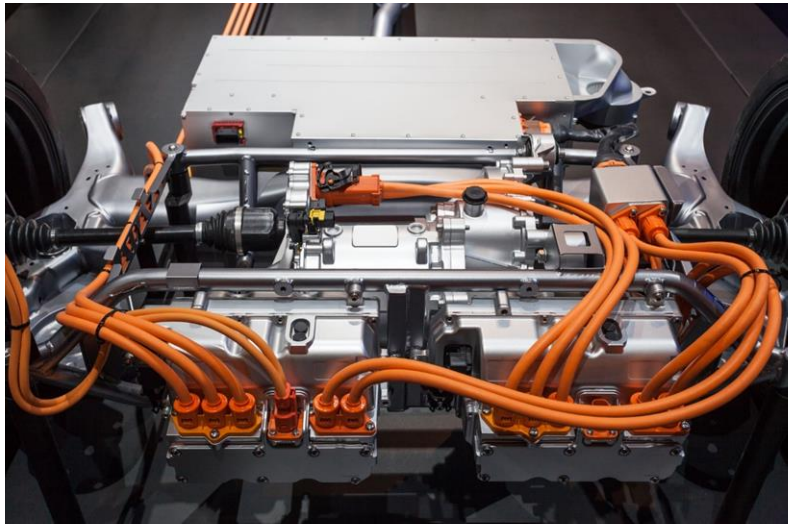


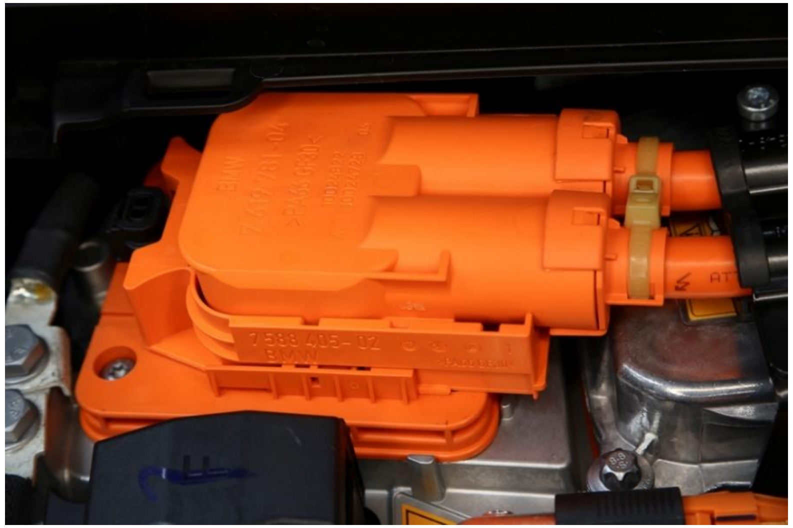
Source: Materials Today, General Motors, Cytec

Technical challenges related to e-Mobility for Polyamides & Polyesters

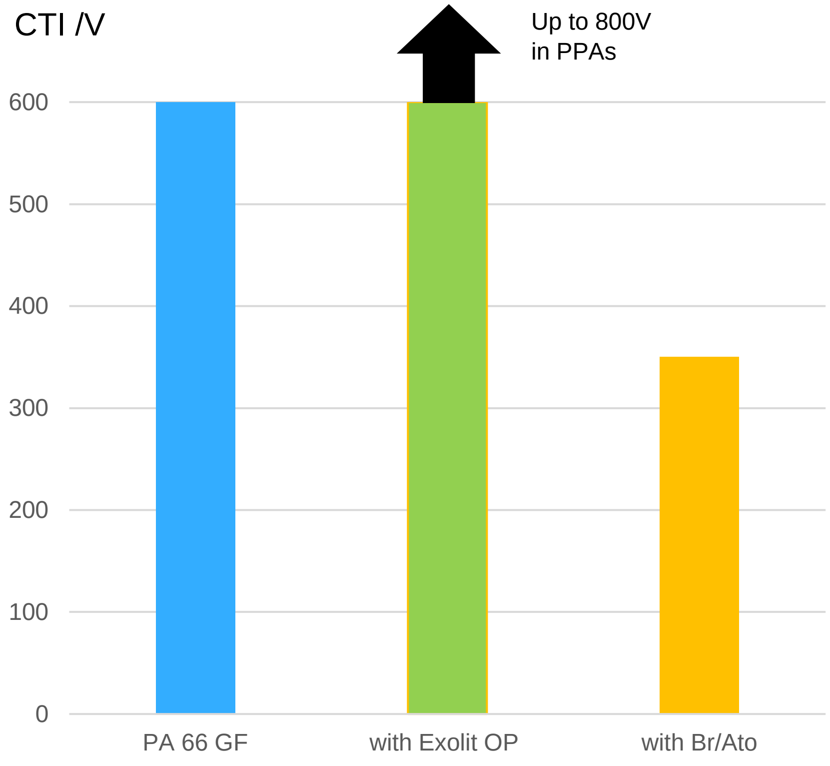
- Flame retarded polyamides and polyesters are available and widely used in E&E industry
- Exolit OP is the preferred solution for e-mobility application

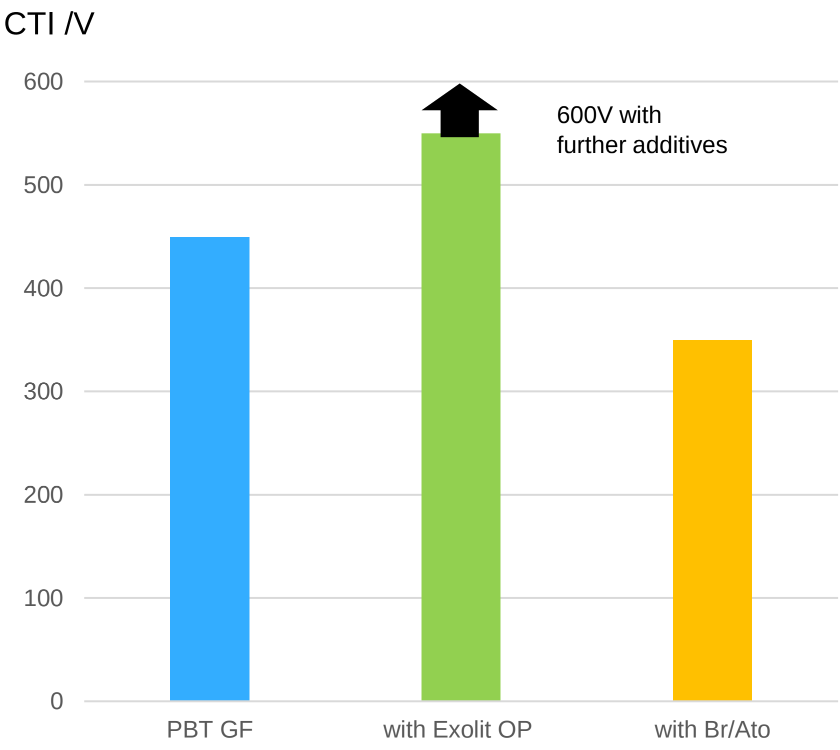
- New challenges for its use in automotive are
  - Resistivity against water and other fluids
  - Flame retardancy & electric properties after aging
  - CTI of 600 V and above
  - Low density – reduce weight



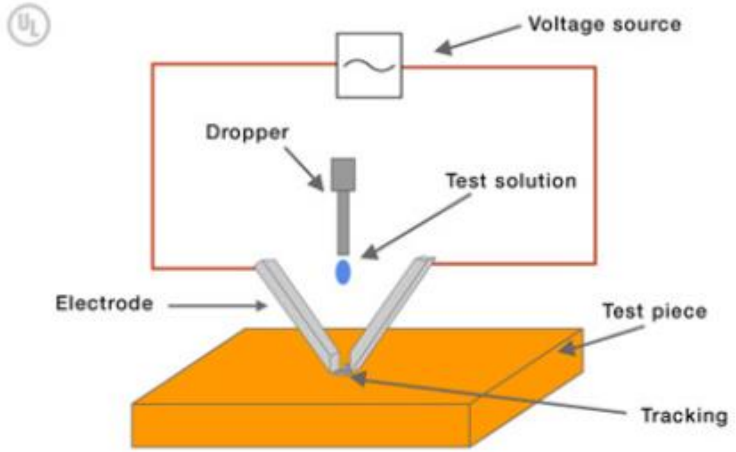


Compounds containing Exolit® OP achieve CTI of 600 V and above, allowing miniaturization and complex designs





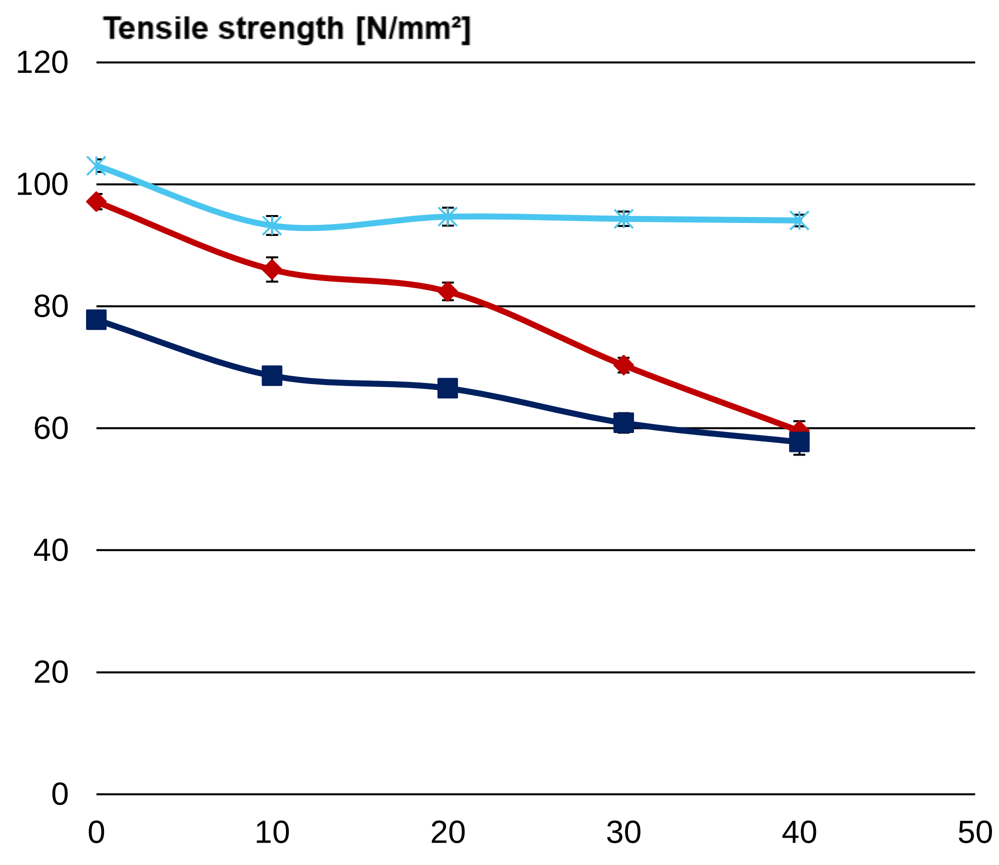
Comparative Tracking Index (CTI) IEC 60112

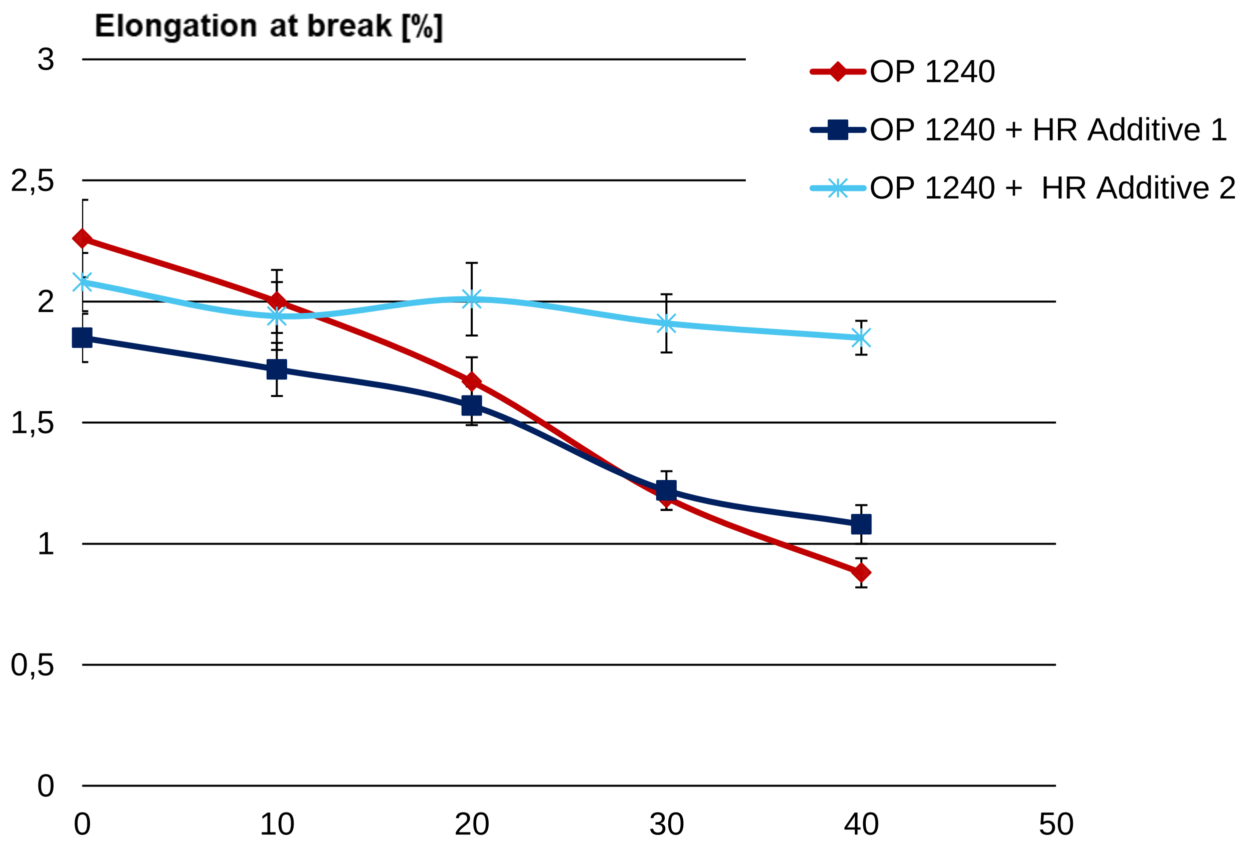


Comparative Tracking Index or CTI is used to measure the electrical breakdown (tracking) properties of an insulating material.

Hydrolysis Resistance (HR) of PBT GF V-0

Tensile Test, PBT w/o HR additives, 40 days at 85°C/85% rh





What is a Sustainable Flame Retardant?

Hazards

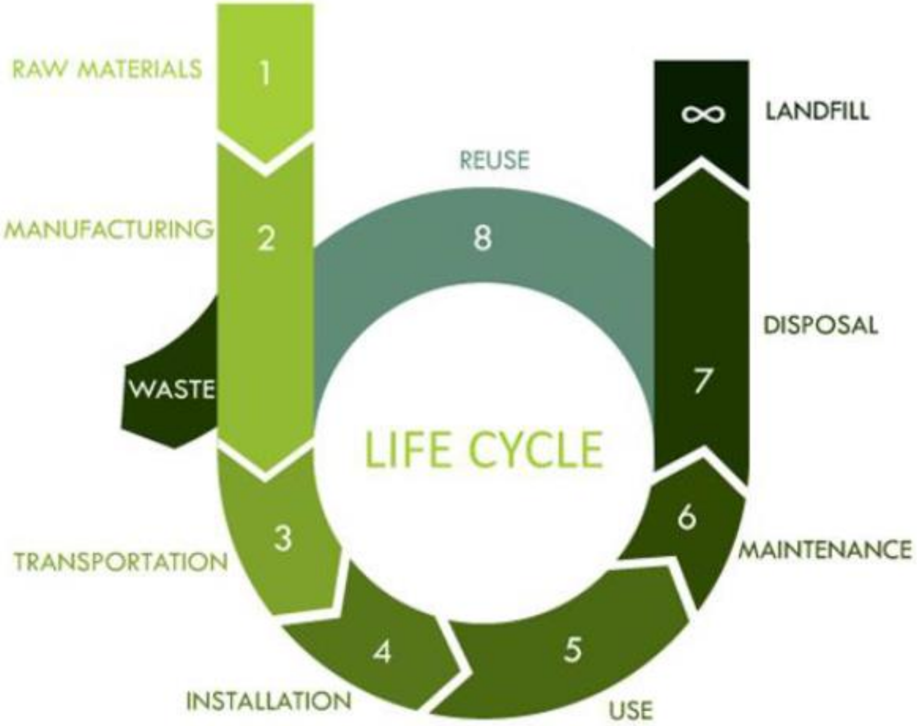
- PBT: Persistence, Bioaccumulation, Toxicity
- CMR: Carcinogenicity, Mutagenicity, Reproductive Toxicity
- Endocrine effects, Mobility (new)

Life Cycle

- Carbon footprint (global warming potential) and other Product Environmental Footprint criteria
- Production (value chain): impact on workers
- Use Phase: impact on consumers
- End-of-life → Recycling properties

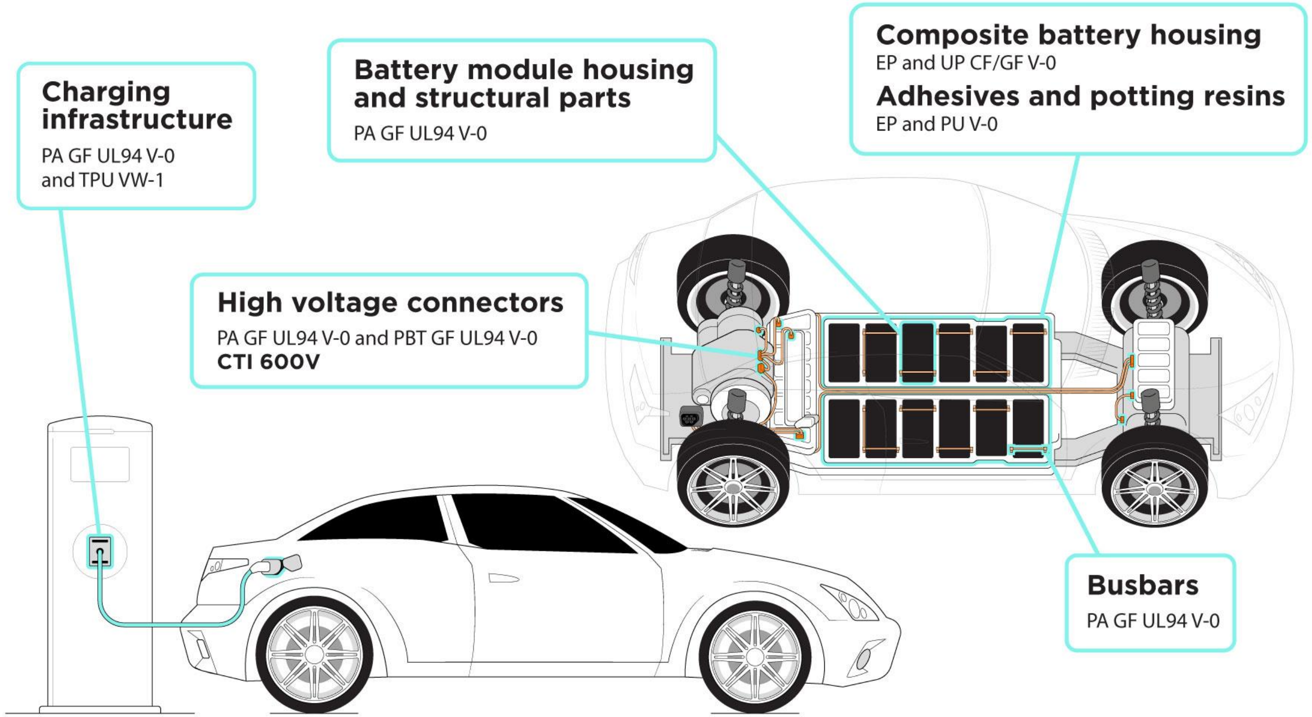
Other

- Critical raw materials
- Fires: Smoke formation / toxicity
- Social impact



Summary

- Exolit® HFFR offers protection against fire risks in E-mobility applications
- Efficient flame retardancy for engineering plastics with good balance of mechanical and electrical properties
- Efficient flame retardancy for various adhesives and thermoset resin
- Exolit® offers also low smoke density and toxicity



ECOTAIN®

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Thank you.

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About Cefic

Cefic, the European Chemical Industry Council, founded in 1972, is the voice of large, medium and small chemical companies across Europe, which provide 1.2 million jobs and account for 15% of world chemicals production. Cefic members form one of the most active networks of the business community, complemented by partnerships with industry associations representing various sectors in the value chain. A full list of our members is available on the Cefic website.
Cefic is an active member of the International Council of Chemical Associations (ICCA), which represents
chemical manufacturers and producers all over the world and seeks to strengthen existing cooperation with global organisations such as UNEP and the OECD to improve chemicals management worldwide

Cefic sector group