HIGH PERFORMANCE POLYMERS

Advanced solutions for e-mobility

E-mobility

RADICI GROUP

Engineering polymers driving the future of e-mobility

In a rapidly evolving **electric mobility** landscape, RadiciGroup High Performance Polymers stands out as a strategic partner for the development of **safe**, **durable and high-performing solutions**. Our **high-performance engineering polymers** are designed to **meet the most demanding technical and regulatory requirements**. Flame retardancy, electrical insulation, dimensional stability, mechanical strength and hydrolysis resistance are just some of the essential properties our materials deliver in e-mobility applications.

Our material portfolio includes Radilon®, Radiflam®, Radistrong®, Raditer® and Raditeck® compounds based on polyamides, PBT and PPS. Alongside our conventional solutions, we provide sustainability-oriented materials – Renycle® (PA6 and PA66 from mechanical recycling) and Bionside® (bio-based polyamides such as Radilon® D PA610) – enabling a lower environmental impact without compromising performance.
Our focus on sustainability goes hand in hand with our contribution to **vehicle lightweighting** – a key driver in e-mobility.
By **replacing metal with high-performance polymers**, we help reduce vehicle weight and, as a result, energy consumption.
Thanks to our **global R&D network** and **customer-centric technical service teams**, we take a solution-provider approach to **support innovation and tailor formulations** to specific needs – helping our customers meet the challenges of e-mobility.

RadiciGroup High Performance Polymers plant in Villa d'Ogna, Bergamo, Italy.

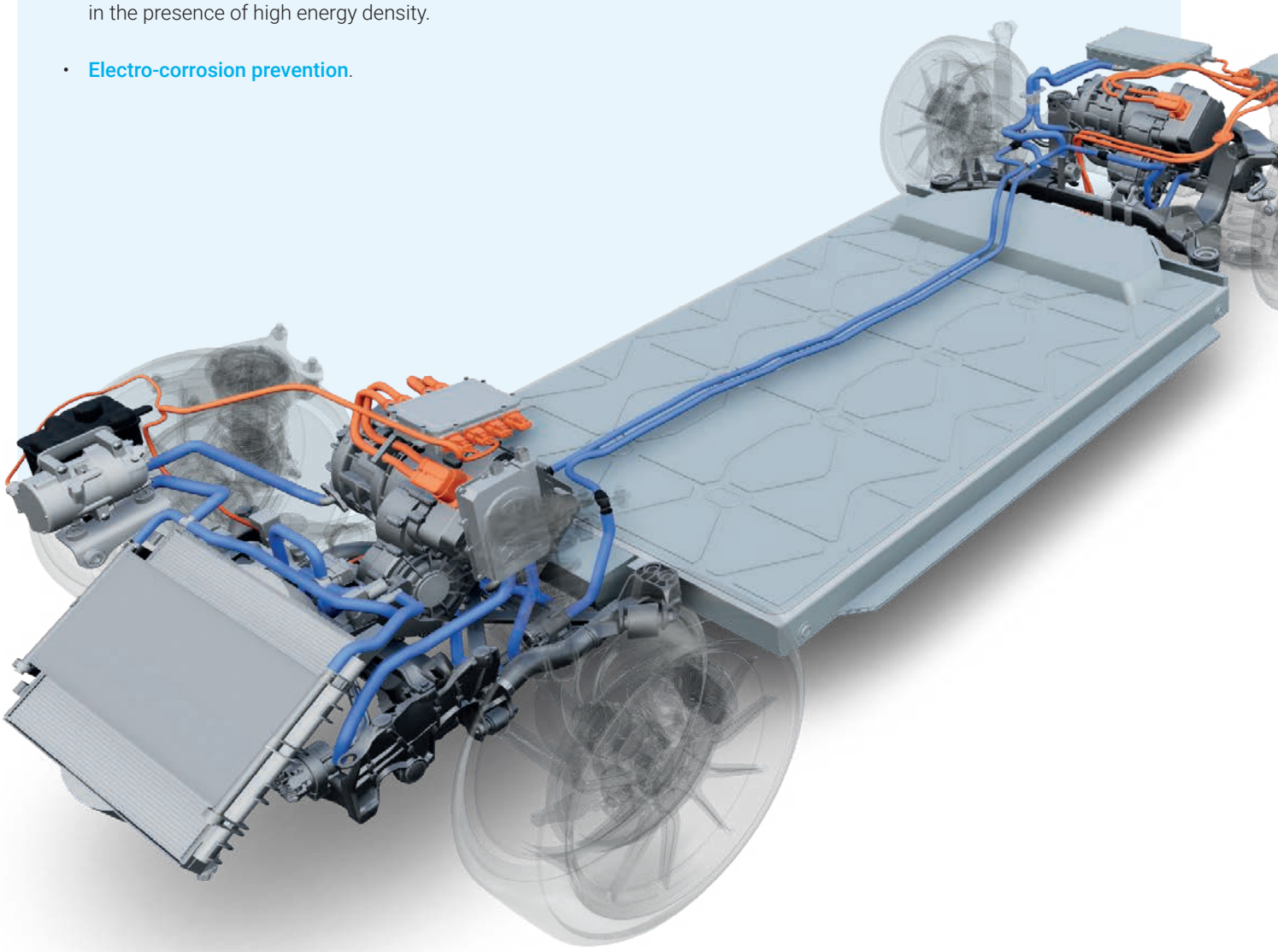
Key technical challenges in e-mobility

The **transition from internal combustion engine (ICE) vehicles to hybrid electric and full electric vehicles** (HEVs, PHEVs and EVs) has brought new opportunities and technological challenges.

The new systems found in electric vehicles — such as power generation and distribution, electric motor and transmission — often require **innovative materials** compared to systems used up to now in internal combustion engine vehicles. **Thermal management**, which involves the battery and power electronics systems and the vehicle interior, has become **more complex**, with a significant increase in the number of components.

Today’s e-mobility components require materials with specific features:

- **Flame retardancy** UL V-0 from 0.4 mm thickness.
- **Properties retention** in hostile environments for prolonged periods of time.
- **Electrical insulation** in the presence of high voltage and high temperature (CTI > 600 V and, in the future, up to 1000 V).
- Need to guarantee **electromagnetic interference (EMI) shielding** for power electronic components.
- **Battery protection** in the event of a collision.
- **Thermal resistance** of power electronic components in the presence of high energy density.
- **Electro-corrosion prevention**.
- **Thermal management system efficiency** to guarantee battery, e-engine, power electronic and other component performance.
- Materials suitable for **welding and laser marking**.
- **Low environmental impact** thanks to halogen-and-red-phosphorous-free formulations and recycled or bio-based solutions.



Our product range powering e-mobility

The **Radiflam®** product range comprises a wide selection of semi-crystalline compounds taking advantage of a variety of flame-retardant technologies. Radiflam® is the brand name for PA6, PA66, specialty PAs and PBT thermoplastic compounds featuring excellent flame-retardant properties, in addition to the highest UL ratings (V-0 and 5VA). Radiflam® polyamides are formulated using various FR additives and include a wide range of halogen-and-red-phosphorus-free products. As of today, Radiflam® B (PBT) and Radiflam® Aestus (PPA) are also available in halogen-free versions.

The **Radilon®** product range comprises Radilon® S (PA6), Radilon® A (PA66), Radilon® D (PA610), Radilon® DT (PA612), Radilon® Aestus (PPA) and other Radilon® polyamides for high-temperature applications, as well as special grades that are used in numerous e mobility applications due to their excellent mechanical, chemical and thermal resistance and ease of processing.

The **Radistrong®** range includes special PA66 engineering polymers that can be reinforced with high glass-fibre content, ensuring excellent structural performance. Radistrong® has a high fluidity level, producing an impeccable surface appearance even for grades with high filler content.

The **Raditeck®** range offers high performance PPS compounds featuring inherently flame-retardant properties, electrical insulation even at high temperatures, excellent retention of mechanical properties when exposed to high temperatures for prolonged periods of time, high dimensional stability thanks to very low water absorption and superior chemical resistance.

The **Raditer®** range comprises PBT polyester engineering polymers featuring high stiffness and mechanical resistance, excellent hydrolysis resistance for certain grades, excellent electrical insulation properties and very low moisture absorption.

The **Renycle®** brand includes PA6 and PA66 compounds that contain post-industrial and post-consumer raw material from selected sources.

The **Bionside®** brand includes totally or partially bio-based PA610 (Radilon® D family) and other special experimental grades based on PA510 (Radilon® PX), PA1012 (Radilon® TT) and PA56 (Radilon® P).

Our product naming at a glance

Radiflam®	A	RV250	HF	333BK
Brand	**Polymer type** A = PA66 S = PA6 B = PBT AT1, AT2 = PPA	**Grade peculiarities** e.g. reinforcement, stabilization, etc.	**Flame-retardant technology** HF, FR = halogen-and-red-phosphorus-free AF = Red phosphorous AE = Halogenated	**Colour code**

Find the ideal product for your needs and download the technical data sheet.

Typical application segments

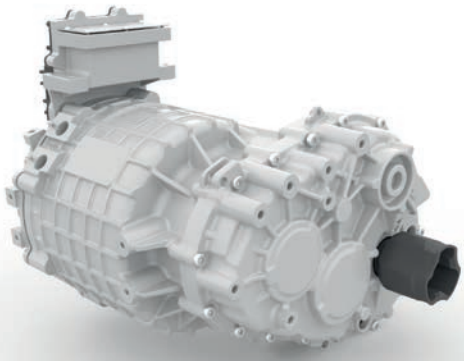
E-motors

RadiciGroup High Performance Polymers' contribution to this segment is the supply of specialty polyamides with **high mechanical, temperature and fluid resistance properties**, which are valid alternatives in **metal replacement and electrical insulation applications**.

Radiflam® Aestus T2 RV300 HF, flame retardant PPA grade, has been selected by famous e-powertrain makers for making busbar or wiring terminal insulation in e drive systems. Its high temperature resistance (UL 746B RTI rating at 150°C) and excellent electrical properties (CTI > 600 V) have been evaluated for related applications.

Radilon® PA66 and PA6 electrical neutral product series with special heat stabilizers for ATF oil resistance are the ideal choices for e-motor applications like resolvers, oil shower rings and oil drainage. Another example is the replacement of thermoset materials in stator holders.

As a further demonstration of continuous innovation, Raditeck® PPS new special compounds are being validated at e-powertrain makers for high thermal shock resistance in insulation parts.

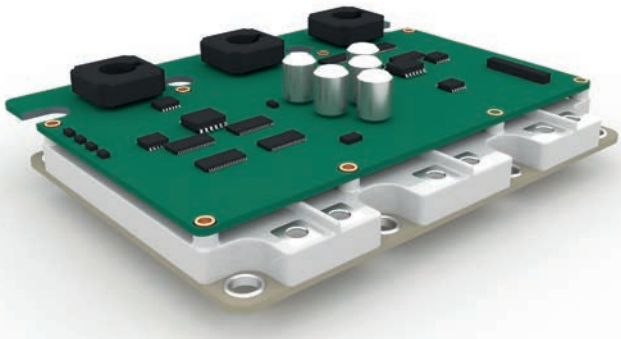


E-motor

Power electronics

Engineering polymers used in power electronic systems must meet **specific requirements**, including:

- **Flame resistance** with a UL V-0 flame rating at 0.4 mm.
- **Excellent electrical insulation** (CTI 600 V).
- **High dielectric strength** at high temperature (for certain applications >10 kV at 150°C).
- **Adequate thermal conductivity** to ensure the integrity of electrical and electronic components at high temperatures.
- **EMI shielding properties**.
- **Good mechanical resistance**, dimensional stability and planarity.



IGBT baseplates made of Radiflam® A RV300 HF

There is also a **growing demand for halogen-and-red-phosphorus-free materials**, in keeping with **environmental sustainability** principles. RadiciGroup High Performance Polymers provides experimental polyamide grades, such as Radiflam® S RV100 FR with a measured thermal conductivity of 1 (W/m°K, in plane and through plane, according to ASTM E1461 at 23°C).
The Group is also working on **new EMI shielding solutions** through the development of innovative compounds and is also proposing **hybrid solutions with the use of metal inserts** for casings and lids.

The picture above shows an IGBT baseplate made of halogen-and-red-phosphorus-free 30% glass-filled PA66.

Battery packs

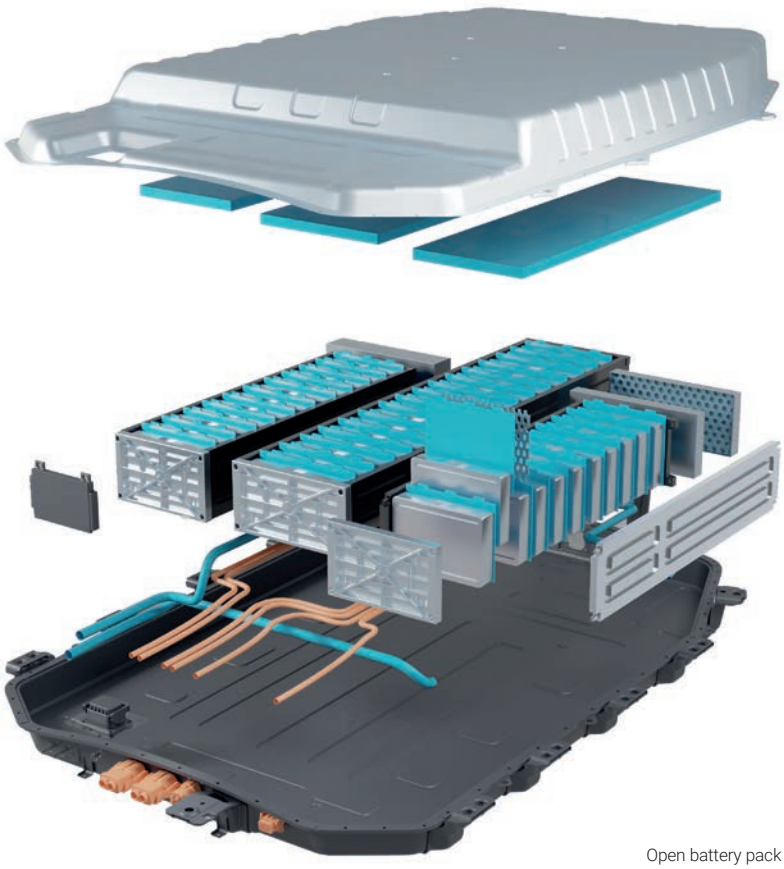
The greatest challenge of electric vehicles is **boosting the energy density** of the battery cells and **lightweighting the whole system** in order to increase **vehicle efficiency**.

A battery pack is a **complex system** consisting of **various components**, such as interconnected battery modules configured to perform their energy storage function. Included are cells and modules, power electronics, power supply circuitry and overcurrent shut-off systems.

Here are the **main requirements for the battery system**:

- **Flame resistance**, for which reason there is a growing demand for halogen-and-red-phosphorus-free materials.
- **Electrical insulation** (CTI up to 600 V and beyond, in the future).
- **Superior mechanical characteristics**, including creep and fatigue resistance.
- **EMI shielding** properties for some components.
- **Electrically friendly materials**.
- **Excellent chemical resistance**, also in case of accidental contact with battery electrolyte.
- **Resistance** to prolonged contact with cooling fluids, oils or other fluids.

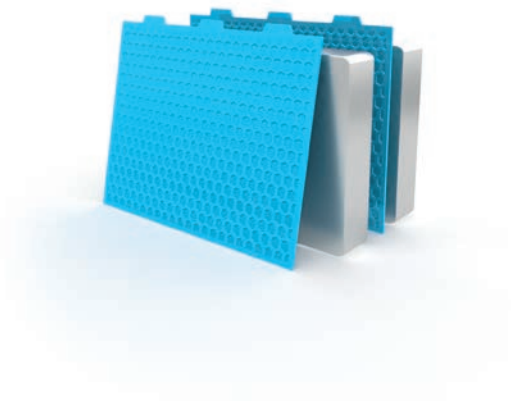
Moreover, ease of processing, dimensional stability and reduced warpage are fundamental requirements for other parts, such as battery covers, battery module covers, battery cell frames and battery spacers.



Open battery pack

Cell spacers

Materials: Radiflam® A RVXXXHF, Radiflam® A FR or Radiflam® S FR (halogen-and-red-phosphorus-free PA66 and PA6 grades, respectively)

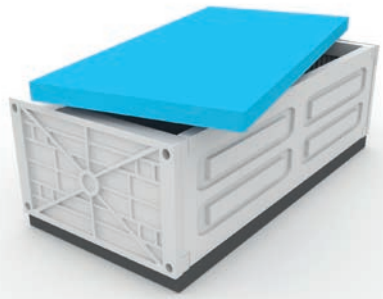


Main requirements

- Flame retardancy
- Easy moulding
- Chemical resistance
- Creep resistance

Battery module covers

Material: Radiflam® A RV250 HF (halogen-and-red-phosphorus-free PA66-GF25)

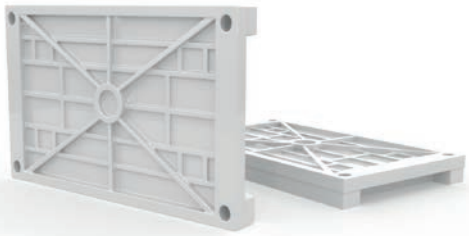


Main requirements

- Flame retardancy
- Planarity
- Easy moulding
- Good stiffness and mechanical strength

End plates

Materials: Radiflam® A RV250 HF (halogen-and-red-phosphorus-free PA66-GF25). For more demanding applications, RadiciGroup High Performance Polymers offers Radiflam® Aestus RV300 HF, a partially aromatic polyamide (halogen-and-red-phosphorus-free PPA)



Main requirements

- Flame retardancy
- Planarity
- Easy moulding
- Good stiffness and creep resistance

Pouch cell frames

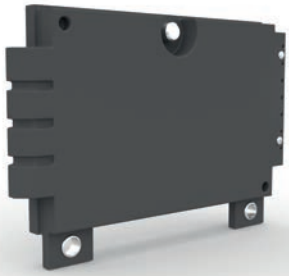
Material: Radiflam® A RV350 HF (halogen-and-red-phosphorus-free PA66-GF35)

Main requirements

- Flame retardancy
- Dimensional stability
- Easy moulding
- Good stiffness, creep and mechanical strength

Cell management controller housing

Material: Radiflam® A RV250 AF grades (red-phosphorous-based PA66-GF25)



Main requirements

- Flame retardancy
- Good dimensional stability
- Low warpage
- High stiffness and mechanical resistance

Electrical connectors

Connectors must be **reliable, stable and resistant**. Moreover, to ensure the proper functioning of these parts, the materials used to manufacture connector housings must meet specific requirements, for example:

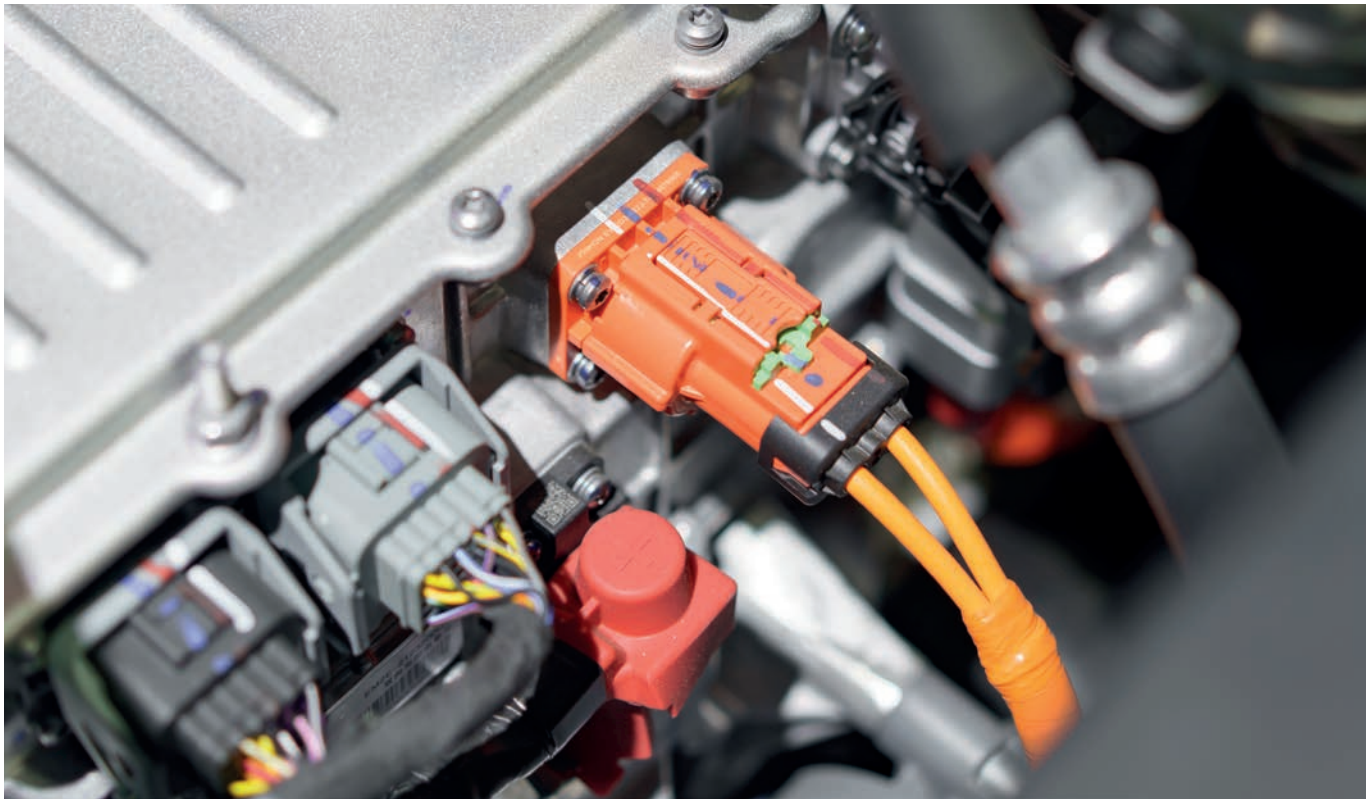
- **Flame resistance** with a UL V-0 rating at thicknesses of 0.4 mm.
- **Excellent insulation properties** (CTI up to 600 V).
- **Orange colour stability** after prolonged exposure to heat.
- **Dielectric strength** > 10 kV at 150°C (sometimes required).
- **Excellent fluidity** for optimal filling of thin-walled parts during injection moulding.
- Suitability for **laser marking**.

Connectors made of Radiflam® A RV250 HF

For this application, RadiciGroup High Performance Polymers offers the **Radiflam® A HF** and **Radiflam® S HF** product lines, with halogen-and-red-phosphorus-free PA66 grades and PA6 grades, respectively.
If self-extinguishing properties with the highest rating are not required, the electrically neutral glass-fibre-filled PA66 and PA6 **Radilon® A or Radilon® S** grades are adequate to cover the requirements for connector components.

For this kind of application, the PBT compounds of the **Raditer®** family can also be successfully used, in particular, the specially formulated Raditer® B ERV300TKB grade with enhanced hydrolysis resistance.

For more severe requirements, the ideal choice is **Radiflam® Aestus** T2 RV300 HF, a 30% glass-fibre-reinforced PPA with a UL V-0 flame-retardant rating. This product combines excellent property retention even after **high-temperature heat ageing**, with enhanced chemical resistance and low water absorption.



Orange colour range for HV connectors, busbars and other components

RAL 2003 orange colour is used on electric vehicles as a **safety warning** to alert individuals to the presence of **high voltage components**.

RadiciGroup High Performance Polymers has developed many compounds that demonstrate excellent colour stability following exposure in hot air for up to 1000 hours at a temperature of 130°C.
The product range encompasses **Raditer®** (PBT), including a hydrolysis-resistant version; **Radilon®** (PA), based on PA6 and PA66; and **Radiflam®**, based on PBT, PA, and PPA.

In the table below, the excellent colour stability of three innovative products can be observed after thermal ageing in air at 130°C:

- **Radilon® D 40K**: PA610 for extrusion, partially bio-based, UL V-2 at 0.8 mm, CTI 600 V
- **Radiflam® B RV300 HF**: PBT-GF30, halogen-free, UL 94 V-0 at 0.4 mm, CTI 600 V
- **Radiflam® Aestus T2 RV300 HF**: PPA-GF30, halogen-free, UL 94 V-0 at 0.4 mm, CTI 600 V.

Orange colour variation (ageing temperature 130°C)

Grade	0 h	after **500 h**	after **1000 h**	**ΔE** (after 1000 h)
radilon® D 40K				5.5
radiflam® B RV300 HF				4.7
radiflam® Aestus T2 RV300 HF				3.5

Thermal management

To assist customers in selecting the most suitable materials for use in **cooling systems**, RadiciGroup High Performance Polymers has developed diverse formulations that exactly meet the technical requirements for this kind of application.

For thermal management system applications that require **excellent hydrolysis resistance**, **superior chemical resistance** and **resistance to road salts**, the Group has developed specialty grades in the Radilon® D, Radilon® DT, Radilon® Aestus and Raditeck® P ranges.

The **Radilon® D** range (Bionside®) comprises **PA610** grades for injection moulding and extrusion. PA610 polymer is made from **64% renewable source materials** and features special characteristics such as **excellent chemical resistance** (better than PA6 and PA66), **temperature resistance** higher than PA12, excellent **hydrolysis resistance**, **low water absorption** and **good dimensional stability**.

The **Radilon® DT** portfolio consists of **PA612** grades, among which the experimental grades Radilon® DT 40EP50RG and Radilon® DT 40E50USR are particularly recommended for extrusion applications. PA612 has the advantage of **excellent chemical resistance**, even in contact with calcium chloride and zinc chloride solutions. Radilon® DT has passed all the tests required by the normative standards for the various types of lines, even in contact areas between pipes and fittings where the **material is under permanent stress and strongly affected by stress cracking**.

Battery cooling module corrugated tube made of Radilon® DT 40E50USR

The **PPA grades** in the **Radilon® Aestus range** (specifically Radilon® Aestus T1 RV330RG) and the **PPS grades in the Raditeck® P** range have proven to be suitable materials for use in thermal management applications, by virtue of their superior dimensional stability, **mechanical and heat resistance**, and **property retention** over time.

Supporting and connecting parts

An electric vehicle has many supporting and connecting parts, such as **cable brackets** and **cable channels**. The choice of materials best suited for these components may vary according to where they are positioned and the specific function they perform.

Radiflam® S RV300 HF, a halogen-and-red-phosphorus-free 30% glass-fibre-reinforced PA6 grade, is used for **cable channels**, thanks to its **high flame resistance** (UL V-0) and **high mechanical resistance**. In the case of applications not requiring high flame resistance, for which materials with a UL V-2 or UL HB rating may be adequate, **Radilon® A products**, particularly the impact-modified grade Radilon® A USX016W, can be valid alternatives.

Cable channel made of Renycle® S GF1501K 3030 BK

Renycle® range products, obtained from post-industrial and post-consumer raw materials, are perfectly adequate **for supporting parts**. Renycle® A and Renycle® S are used for the production of cable channels in different formulations.

Charging systems

In order to guarantee **efficient power conversion**, **parts reliability** and the **full functionality** of all parts, materials for charging systems must be selected very carefully, depending on the requirements of the particular charging system, including the expected recharge speed.

There is an increasing demand for **materials resistant to flame and cooling fluids** (for high-power fast charging). The **colour must remain stable** in case of outdoor exposure, and **excellent electrical insulation** properties are required with high CTI (over 600 V in fast charging systems).

Sustainable recycled grades are also available to reduce environmental impact.

EV charger plugs

Material: Radilon® S ERV70T (PA6, impact modified, glass-filled, enhanced impact resistance)

Main requirements

- Enhanced impact resistance
- Good dimensional stability
- Different colours
- Suitable for outdoor exposure

Recharge sockets

Materials: Radiflam® A RV250 HF and other Radiflam® A HF grades (halogen-and-red-phosphorus-free PA66)

Main requirements

- Good dimensional stability
- Excellent flame-resistant properties (UL V-0 rating and insulation properties (CTI 600 V)
- High mechanical resistance
- Suitable for outdoor exposure according to UL 746C (f1)

EV charging plug handles

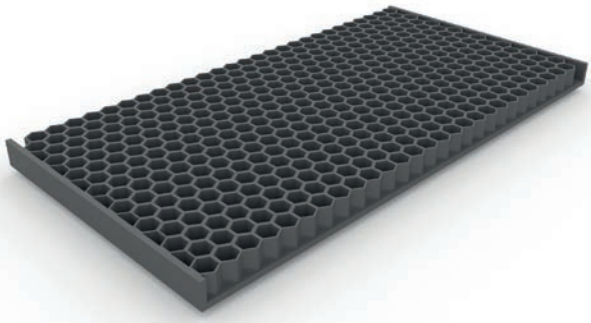
Material: Renycle® S N101 3030BK

Main requirements

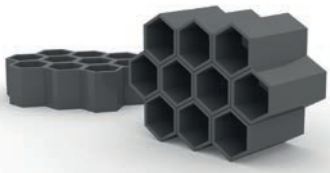
- UV resistance
- GWT 650°C
- Impact resistance
- Abrasion resistance

Other applications

RadiciGroup High Performance Polymers products are also used in **e-mobility applications other than automobile parts**. Some examples include battery pack supports for **e-bikes** and e **motorbikes** and industrial uses. Radiflam® A FR and Radiflam® A RV250 HF are the products of choice for these components.



Battery pack supports for motorbikes and industrial applications made of Radiflam® A RV 250 HF



Battery pack supports for e-bikes and e-motorbikes made of Radiflam®

Want to know more? Explore RadiciGroup AutoInsight

AutoInsight, the Group's tool for **navigating a car in 3D mode**, is dedicated to all the players in the automotive industry supply chain. Dive deeper into advanced materials for electric vehicles, ICE powertrains, chassis, E&E lighting and both interior and exterior applications.

RadiciGroup AutoInsight
Navigating Materials, Driving Innovation

Empowering innovation through advanced technical support

RadiciGroup High Performance Polymers delivers end-to-end **technical support** that blends proven materials expertise with cutting-edge **Engineering Service**.

Our **Global Technical Service Team** partners with you to pinpoint the ideal polymer for each application, whether you are designing next-generation e-mobility components, replacing metal parts or tackling other demanding projects. Our **Engineering Service Team** uses advanced material modelling and integrated simulation to accurately predict the behaviour of our engineering polymers, as well as their process-induced properties.

This data-driven approach lets you **optimize performance**, **cut weight**, and hit ambitious **sustainability targets**, while accelerating time to market. By combining comprehensive technical know-how with virtual prototyping, we help lower development costs and reduce risk —so you can bring innovative products to life faster and with greater confidence.

engineering service

Product name	Product description	Electrical and fire behaviour				
		UL 94	GWIT IEC 60695-2-1/3	GWFI IEC 60695-2-1/2	CTI IEC 6011	RTI (E) UL 746
radiflam® AT2 RV300 HF	PPA GF30 HF FR	V-0 (0.4 mm) 5VA (1.5 mm)	825 (3 mm)	960	600	150
radiflam® A RV250 HF	PA66 GF25 HF FR	V-0 (0.75 mm) 5VA (1.5 mm)	875 (3 mm)	960	600	140
radiflam® A RV350 HF	PA66 GF35 HF FR	V-0 (0.75 mm)	875 (3 mm)	960	600	140
radiflam® A FR	PA66 unfilled FR	V-0 (0.4 mm)	960 (0.4 mm)	960	600	130
radiflam® A FR X	PA66 unfilled FR	V-0 (0.25 mm)	960 (0.4 mm)	960	600	130
radiflam® S RV300 HF	PA6 GF30 HF FR	V-0 (0.8 mm)	775 (2 mm)	960	550	-
radiflam® S FR	PA6 unfilled FR	V-0 (0.4 mm)	960 (1 mm)	960	600	-
radilon® AT1 RV330RG	PPA GF33 HR	HB	-	-	-	-
radilon® A USX016W	PA66 unfilled	HB	-	650	-	-
radilon® A RV500RW	PA66 GF50	HB	725	700	-	-
radilon® S ERV70T	PA6 GF7	HB	-	650	450	-
radilon® DT 40E50USR	PA612 unfilled	HB	-	-	-	-
radistrong® A RV500W	PA66 GF50	HB	-	-	-	-
raditeck® P RV400K	PPS GF40	V-0 (0.4 mm) 5VA (1.5 mm)	960 (0.75 mm)	960	-	-
raditer® B ERV300TKB	PBT GF30	HB	-	700	450	-
RENYCLE® S GF1501K 3030 BK	PA6 GF15 partially recycled	HB	-	-	-	-
BIONSIDE® Radilon® D RV300RG	PA610 GF30 HR	HB	-	-	-	-

Mechanical properties				Applications						
*Charpy notched Impact strenght ISO 179/1EA	**Stress at break [MPA] ISO 527-2/1A	*Strain at break ISO 527-2/1A	*Tensile modulus [MPA] ISO 527-2/1A	Charging system	Battery system	Cable brackets/ channels	Power electronics	E-motors	Connectors	Cooling pipes & connectors
10/11	160/135	2.4/2.2	11100/11000	•	•		•	•	•	
12/18	140/110	2.9/3.5	9000/7500	•	•		•	•	•	
10/14	145/110	2.3/2.5	11800/10100	•	•		•	•	•	
4.5/6.5	77/50	12/>50	3450/2600		•				•	
4.5/-	71/-	3/-	3700/-		•				•	
7/15	150/95	3/4.5	11200/7200			•			•	
5/-	75/-	12/-	3500/-		•					
13/12	215/195	2.6/2.5	11900/11800							•
55/65	50/35	20/30	1900/900			•				
18/25	245/190	3/3.1	17000/14250					•		
18/-	70/-	8.2/-	3200/-	•						
75/-	31/-	-	950/-							•
15/17	250/190	2.3/3	17600/14500		•					
8	190	1.6	14500					•		•
75	115	3.5	9500						•	
5.5/11	125/70	3/12	5900/3500			•				
15/17	150/120	5/6	8500/6800							•

* The first value refers to dam (dry-as-moulded) state; the second, to conditioned state. ** For unfilled grades, is stress at yield.

RadiciGroup.
Inside your world.

RadiciGroup is among the world leaders in the manufacture of chemical intermediates, polyamide polymers and high-performance engineering polymers, including recycled and bio-based solutions. RadiciGroup products are the result of our outstanding chemical expertise and vertically integrated polyamide production chain and have been developed for use in a variety of industries, such as automotive, electrical and electronics, consumer and industrial goods, water management, transportation, household appliances and sport. At the core of the Group's strategy is our strong focus on innovation, quality and customer satisfaction – always in alignment with our ESG principles.

Sustainability

Every day at RadiciGroup, we work to make circularity our business model. We optimize the use of materials while fine-tuning our processes, designing out waste and promoting recyclability from the earliest product design phases. We are always looking for low-impact solutions in terms of natural resources and energy. We rely on certified management systems for Quality, Health and Safety, Environment and Energy to keep our companies in line with the highest sustainability standards. Since 2004, the Group has released its Sustainability Report every year.

RADICI NOVACIPS SpA (Headquarters)
Via Bedeschi, 20 - IT - 24040 Chignolo d'Isola (BG)
Tel. +39 035 4991311 - Fax +39 035 4994386
www.radicigroup.com
info.plastics@radicigroup.com