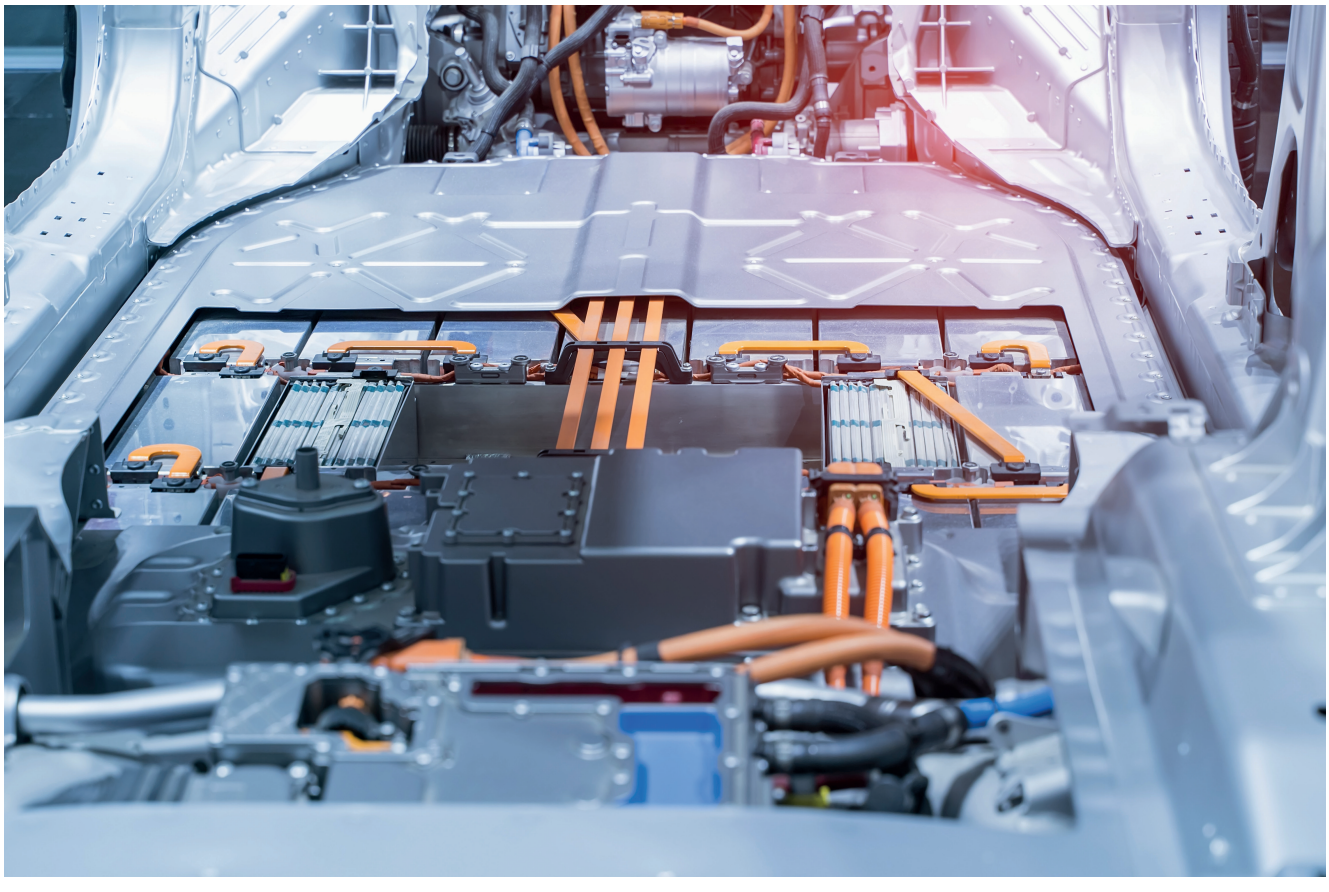
High Voltage in Cars

Polyamide Specialties for Electromobility

Electrical architecture in an E-car is significantly more challenging than for conventionally powered vehicles. Particularly for insulation of high-voltage (HV) components, the demands on the materials used are increasing. With specially-tailored materials for electric vehicles, challenges in automotive high-voltage technology can be overcome.



Insulation of high-voltage components in electric vehicles makes high demands on the materials used © xiaoliangge; Adobestock

Electrification of automotive power trains requires an electricity supply that is capable of carrying higher voltages than those used in vehicles with combustion engines. A clever design of performance electronics in hybrid and electric vehicles is therefore key to cost reduction and a success factor for automotive manufacturers. During development of vehicle concepts, this is reflected in an even more powerful, low-weight and compact design of the electrical architecture. As electromobility evolves, the demands on materials used for the manufacture of individual components are steadily increasing.

All automotive components connected on the various different voltage levels must be constructed for safe operation. Depending on the application, approval requirements for single components are stricter for the high-voltage than for the traditional 12V/24V and 48V classes. Excellent behavior of the materials used under extreme conditions is a prerequisite for a compact vehicle design using thin-walled components.

With Grilamid TR XE 10991, Swiss manufacturer of high-performance polymers EMS-Grivory has developed a new polyamide (PA) which exhibits superior behavior as an insulating material. The PA is designed primarily for use in extrusion processes to produce thin-layer sheathing for

metal electric conductors, but is also suitable for injection-molding processes. To date, PA12 has been used as an easily processable and resistant high-performance material, although for applications with less demanding requirements. The PA12 specialty grades Grilamid L XE 3817, Grilamid L XE 4165 and the adhesion-modified variant Grilamid L XE 10951, have proved successful as extrusion materials. Due to its outstanding electrical properties at low thicknesses, Grilamid TR XE 10991 shows superior performance, compared to otherwise excellent PA12 materials, for applications at high-voltage levels.

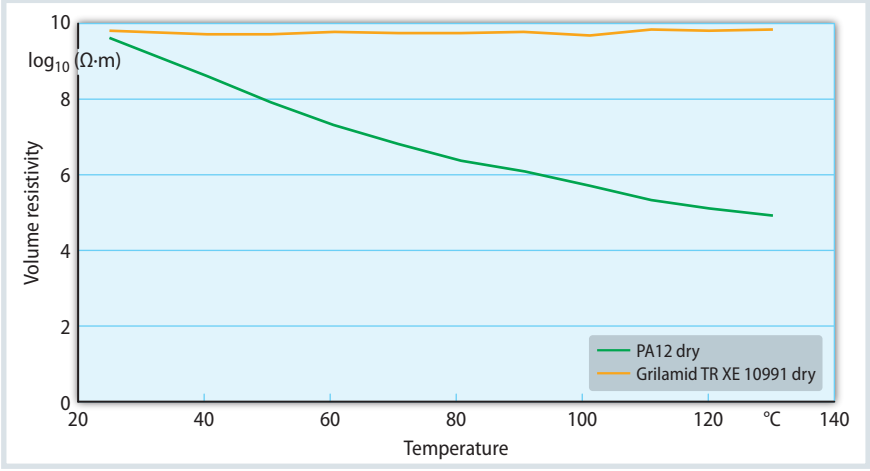


Fig. 1. Volume resistivity of Grilamid TR XE 10991 shows a more stable performance at high temperatures compared to PA12 Source: EMS-Grivory; graphic: © Hanser

Improved Volume Resistivity in Comparison to PA12

The volume resistivity of the sheathing materials is determined between 23 °C and 130 °C as a characteristic parameter for the electrical insulation capacity. While the volume resistivity of PA12 drops with increasing temperature, TR XE 10991 maintains a constant level over the whole temperature range (**Fig. 1**). Grilamid TR XE 10991 also exhibits superior dielectric strength compared to PA12 materials in both a conditioned and dry state (**Fig. 2**). The suitability of this specialty grade for applications involving high voltages is rounded off with a measured comparative tracking index (CTI) of 825 V. For the end application as conductor sheathing, Grilamid TR XE 10991 provides electric insulation over a wide temperature range and an increased dielectric strength under moist conditions.

In standard tests of sheathed conductors for high-voltage levels, the electric properties are tested in a dry state and stored in an aqueous solution. The combination of constant volume resistivity at higher temperatures and superior dielectric strength in a conditioned state proves to be a crucial factor for success. In order to prevent unintentional contact with high voltages, automotive insulation jackets should not crack or break, even under extreme conditions. Decisive for this is not only optimal behavior under mechanical loading, but also good processability and compatibility with the conductors to be sheathed.

Less Stress Cracking due to Good Thermal Expansion Behavior

No stress cracking of the cable sheathing should occur, especially under thermal loading. The coefficient of thermal expansion (CTE) of Grilamid TR XE 10991 remains linear between 0 and 100 °C. As a result, the PA shows similar deformation behavior under changing temperatures as the metals used for high-voltage lines. Formation of stress cracking between »

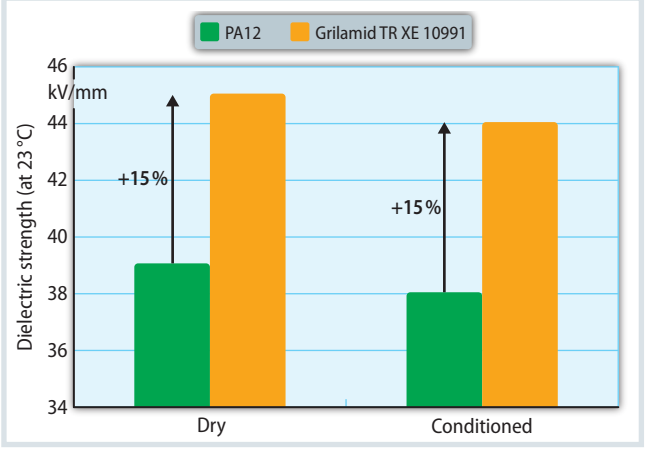


Fig. 2. Grilamid TR XE 10991 exhibits clearly higher dielectric strength in both a dry and conditioned state than PA12 Source: EMS-Grivory; graphic: © Hanser

The Author

Dr. Doris Abt is Project Manager in Research & Development of EMS-Grivory.
Contact: welcome@emsgrivory.com

Service

Digital Version

↘ A PDF file of the article can be found at *www.kunststoffe-international.com/archive*

German Version

↘ Read the German version of the article in our magazine *Kunststoffe* or at *www.kunststoffe.de*

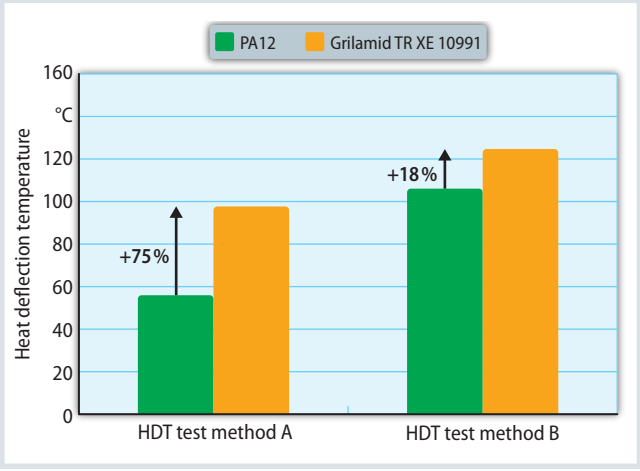


Fig 3. Grilamid TR XE 10991 exhibits a higher heat deflection temperature (HDT) under load than PA12 Source: EMS-Grivory; graphic: © Hanser

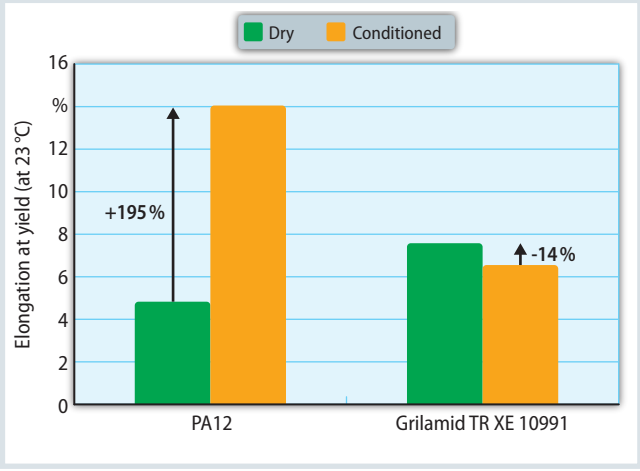


Fig. 4. While the elongation at yield of PA12 differs in a dry and conditioned state by 195 %, the behavior of Grilamid TR XE 10991 remains virtually unchanged Source: EMS-Grivory; graphic: © Hanser

cable sheathing and metal conductor is minimized by the similar behavior of the CTE for both materials. This exceptional thermal behavior can also be seen from the heat deflection temperature (HDT, **Fig. 3**). Compared to PA12, Grilamid TR XE 10991 has a better HDT value under load. This means that Grilamid TR XE 10991 can be used at higher temperatures without suffering loss of function due to deformation.

Low Influence of Moisture

Moisture-dependent characteristics, typical for PA materials, have been reduced in the new specialty polymer so that it behaves in a nearly identical way to non-hygroscopic materials (such as PE). While the elastic limit of PA12 almost doubles upon conditioning, the specialty polymer outperforms with a difference of only 14 % (**Fig. 4**). Flawless mechanical characteristics of the PA under the influence of temperature and moisture also contribute to a higher loading capacity of the product during use as a sheathing material.

The rapid advances made in E-mobility with increasing challenges for high-voltage electricity supply, require new specialty polymers with unique property profiles. With excellent intrinsic material properties, such as volume resistivity, dielectric strength and a high comparative tracking index, Grilamid XE 10991 combines all required features for use as insulation material at high voltage levels.

The PA is readily processable, can be applied as a thin layer to automotive components and remains unaffected by the most stringent test conditions. Grilamid TR XE 10991 is available in the characteristic orange color-code (**Fig. 5**) used for high voltages and in many other colors on request. ■

Fig. 5. Orange has established itself as the color for high-voltage components in electric vehicles © hd3dsh; Adobestock