Modified Polyphenylene Ether (PPE)

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Blends based on polyphenylene ether (PPE) combine the properties of plastics such as polypropylene, polystyrene and polyamide with the familiar high heat resistance, high dimensional stability and good hydrolysis resistance of PPE. Applications are to be found primarily in the automotive sector.

Modified PPE blends are well known for their high heat resistance, high dimensional stability, very low water absorption and good hydraulic stability. Polyphenylene was discovered and developed by GE Plastics in the USA back in the 1960s, and introduced into Europe and Asia under the trade name Noryl at the end of that same decade.

(PP+PPE) Blends for Scratch-resistant Parts

(PP+PPE) blends (grade: Noryl PPX) are the latest in the line of PPE blends developed by GE Plastics. The development engineers at GE Plastics succeeded in combining previously incompatible particles of polyphenylene ether (PPE) with a base polypropylene to give a material blend. A new patent-pending technology for the blending formulation gives the material particularly balanced properties.

The new material fills the gap between the basic properties of polyolefins and the stronger performance characteristics and attributes of engineered plastics. It can be an ideal replacement for traditional materials such as TPO, polyamide and steel, because its high stiffness, toughness and heat resistance allow new design freedom across a number of markets.

Prior to this, design engineers requiring a wide range of stiffness, toughness and temperature extremes had to play a balancing act, sacrificing one material attribute for another. The range of (PP+PPE) blends gives designers greater freedom of design without sacrificing these critical benefits for applications such as automotive bumper fascias and front-end modules, food trays, fluid-handling parts and power tools. These materials are available in unfilled and glass reinforced grades and have been positioned for food packaging, fluid engineering, and exterior and interior automotive applications.

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(PP+PPE) blends also form the basis of a new product line of high-quality injection moulded transport cases to meet the requirements for the effective transport of sensitive and expensive equipment. The cases will be used to safeguard mobile equipment used by the video, broadcast, electronics and aerospace industries, as well as law enforcement and emergency services and the military. These applications demand a material that can give long-term performance. In addition to the properties already mentioned, the material has excellent aesthetics to create a good-looking exterior appearance for the cases.

Automotive engineering: The combination of impact and heat resistance, greater rigidity at elevated temperatures, plus improved creep and scratch resistance, makes PP/PPE blends suitable materials for exterior car body parts, such as ground-effect components.

Car dealers and car-tuning companies are taking advantage of these material properties to give popular vehicles a special, customised look with spoilers. They have specified a (PP+PPE) blend which provides impact resistance at cold temperatures, ductility and chemical resistance for their lower rocker panels and front and rear bumper spoilers. Parts made of these blends are also easier to paint.

Other automotive applications are under development for instrument panels, bumper fascias, wheel covers and spoilers. These materials are generally well-suited to bumper fascias on account of their high stiffness, low-temperature ductility after painting and high modulus, which is 30 to 50 % greater than TPO (Fig. 1). High elongation, low specific gravity and long-term heat resistance provide the opportunity to consolidate parts through a multifunctional front-end design, which can result in significant weight and cost reductions.

Other applications: (PP+PPE) blends can also be used instead of glass fibre reinforced plastics in a new environmentally-compatible system where the large, thermoformed twin-walled parts need to withstand exposure to outdoor elements. These temperature extremes do not present a true challenge to the material on account of its properties. In future, the material's added strength and performance will enable the customer concerned to double the height of the system to 3.60 m.

(PP+PPE) blends can be a good choice for food transport applications. Material properties such as low-temperature toughness and high heat resistance, durability, cleanliness, and peel performance can help reduce costs in a large number of areas. The increased life of food trays in fast-food restaurants is one example here. Alongside this, there are a large number of other potential fields of use, such as power tools and fluid-technology applications. The combination of good heat resistance, high chemical resistance and almost no moisture absorption gives the freedom to design increasingly more compact, more powerful tools, since plastic components can be placed closer to the motor. All these properties, plus the material's low specific gravity and good dimensional stability can lead to life-cycle cost reduction in fluid handling applications.

(PA+PPE) Blends Suitable for On-line Painting

The (PA+PPE) blends that GE Plastics introduced in the mid-1980s have now acquired a significant market share, particularly in the automotive industry for parts requiring high impact strength and on-line or in-line painting. The resin's high heat resistance allows it be used in paint ovens. Over the past few years, conductive (PPE+PA) blends have been introduced that offer electrostatic painting without requiring the use of conductive primers. The material has also been shown to be suitable for powder coating, thus opening up a whole range of potential applications outside the automotive sector.

GE Plastics is continuing to develop new (PA+PPE) blends, focusing mainly on conductive, higher-heat, lower-CTE materials for larger vertical car body panels requiring low tolerancing. These improvements, however, are achieved at the expense of toughness and the challenge to combine high heat with high impact. The first results are very promising and a real breakthrough in the area is expected shortly. Two further areas of investigation are high flow to enable moulding of very large panels or thin-walled fuse boxes, and methods to ensure robust adhesion to a large variety of paints. New technologies in (PA+PPE) blends are being explored for the development of halogen-free and red phosphorus-free flame retardants for the electrical and electronics industry.

(PA+PPE) blends combine the dimensional stability, low water absorption and heat resistance that are typical of the PPE polymer, with the chemical resistance and flow of polyamides. The result is an extremely chemically-resistant material with the stiffness, impact resistance and heat performance required for on-line painting. The low density of the unfilled materials can provide part-weight savings of up to 25 % over glass or mineral-filled resins.

The blends offer broad resistance to commonly-used everyday chemicals, such as fuels, greases and oils. In addition, these materials are resistant to detergents, alcohols, aliphatic and aromatic hydrocarbons and alkaline chemicals. Where an application requires exposure to, or immersion in, these or other harsh environments, prototypes or suitably stressed samples of the material should be tested under the actual operating conditions.

Automotive industry: With the development of vertical body panels in the second half of the 1980s, (PA+PPE) blends started to come into their own as an attractive material compared to steel in terms of total system costs. A strongly contributing factor to this development was the introduction of the conductive (PA+PPE) blends that have made it possible to apply fenders to the body-in-white without the need to pre-apply a conductive primer to the plastic part.

Since the first commercial front fenders were produced at the end of the 1980s, the trend has accelerated, with several standard vehicles now equipped with fenders made of this material. Most of the key automobile manufacturers have programmes with such developments for one or more of their models. The automotive fit of (PA+PPE) blends is not limited to fenders and has recently been extended to exterior body panels requiring either very high stiffness and/or high heat, such as tank flaps or front grilles (Fig. 2).

Other automotive applications are under the bonnet, such as fuse boxes, timing belt and engine covers and also air ducts. The key drivers are the low moisture absorption, good thermal and chemical resistance, dimensional stability and high heat resistance of (PA+PPE) blends. These blends offer an up to 30 % density advantage over other semi-crystalline materials which require higher reinforcement loadings for dimensional stability. (PA+PPE) blends have further advantages in terms of less wear on processing equipment.

The high heat-resistant materials are also eminently suitable for powder coating applications, because curing temperatures for these materials are often close to 180 °C. This allows a plastic part to be painted together with a metal one, ensuring an excellent colour match. The conductive materials show very good paint transfer efficiency, minimising paint loss and ensuring good coverage.

(PS+PPE) Blends for Improved Processability

Polyphenylene was initially used as a pure resin, but research showed that blending with polystyrene (PS) improved processability. (PS+PPE) blends offer heat resistance, dimensional stability and also flame retardant properties without the use of halogens or red phosphorus to meet the high standards of ECO labels such as the Blue Angel and TCO. These materials were first used in a variety of applications in the electrical industry, and since then have penetrated the automotive, fluid engineering and computer industries.

Automotive industry: (PS+PPE) blends have been used in car interiors since the early 1970s when they were originally employed as a substrate material for hard-feel, uncovered instrument panels. When the trend moved to soft-feel instrument panels, these materials suffered with regard to their adhesion to soft-feel foams. This limitation was overcome in the early 1990s, and since then the material has been specified in several cars. (PS+PPE) blends offer low density and high heat/stiffness properties and are also suitable for thin-wall moulding.

Instrument panels are no longer a one-shot moulding but are complex components built up of several parts. The structural part which is the upper carrier has to take the main load and is therefore made of a glass reinforced (PS+PPE) blend, while the lower carrier is produced in unreinforced, impact-modified (PS+PPE) systems. These blends are also attractive for uncovered parts in car interiors because of their scratch resistance and inherently low-gloss surface, which helps reduce the hindrance from sunlight reflection. Recently, materials have been developed with significantly lower emissions and smell, thus contributing to a cleaner, healthier environment.

Television sets: Television sets are another application where (PS+PPE) blends have been employed for many years and are still the material of choice with growing opportunities for their use. In Europe, (PS+PPE) blends are used in TV back plates and bezels, and special high flow materials are available that meet the European IEC 65 standard. Individual resin grades pass the UL94 V-0 fire behaviour standard which is used by OEMs striving for a higher fire safety. All TV applications require a certain level of flame retardancy and this can be achieved in modified PPE by using additives that do not contain halogens or other potentially harmful components.

(PS+PPE) blends are also used in interior parts, such as deflection yokes and fly-back transformers requiring a material with a high RTI (relative temperature index) as well as good electrical properties and low moisture absorption. The blends are also used in the internal frames, but as this application is less demanding, a recycled product with a lower heat resistance is often used.

Custom-engineered products: New developments in existing (PPE+PS) blend technologies are largely focused on developing special custom-engineered products that offer good flow, high-precision moulding and high dimensional stability with a low coefficient of thermal expansion over a wide temperature range. This includes dual reinforcement techniques with synergistic effects, such as glass fibres and mica or carbon fibres for applications such as high-precision chassis and construction parts for the electrical and computer industry, including chip carriers and pen bodies.

Technological progress in glass fibre reinforcement will enable materials to be developed with an improved weld line strength, especially after dynamic pressure cycles in hot water. First materials are now available and have been successfully used in fluid engineering applications.

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Fig. 1. Bumper fascias in a (PP+PPE) blend still display high elasticity even after painting

Fig. 2. The body panels of the Beetle in (PA+PPE) blend offer high stiffness, impact strength and heat resistance

Fig. 3. Parts in (PA+PPE) blends offer dimensional stability and chemical resistance