

Developing electromobility

High-performance polymers for a mobile future



Electromobility – transportation concept with potential

The future of public and individual road transportation is facing far-reaching changes and great challenges. Mobility concepts with alternative drive systems that are capable of significantly reducing the CO₂ emissions in road traffic are being discussed worldwide. Electromobility has gained enormous significance in this field since it wins through with further advantages like high acceleration, low harmful substances and noise emissions. Developers are working at full speed to eliminate the greatest weak point of current electric-powered vehicles – the lack of range of the battery. Research in this area is still at the hub of the development process. Therefore hybrid technology (gasoline or diesel units plus electro motor) currently acts as a bridging technology: Thus the advantages already stated come into play when the electro motor is switched. At the same time, this new technology is being field tested in interaction with other vehicle components to drive greater improvements.

Individual and efficient

Nobody questions the need for individual mobility – whether with

a personal vehicle, with public transportation or a combination of both. However this mobility must be made more efficient with regard to energy assumption in order to reduce the burden on the environment. Therefore innovative overall concepts are needed particularly in urban environments: The use of electric bikes and motorbikes or electric-powered cars can be encouraged by locating recharging stations at many community facilities and P&R car parks. Commuters can take electric-powered buses to their destination while their vehicles are being recharged.

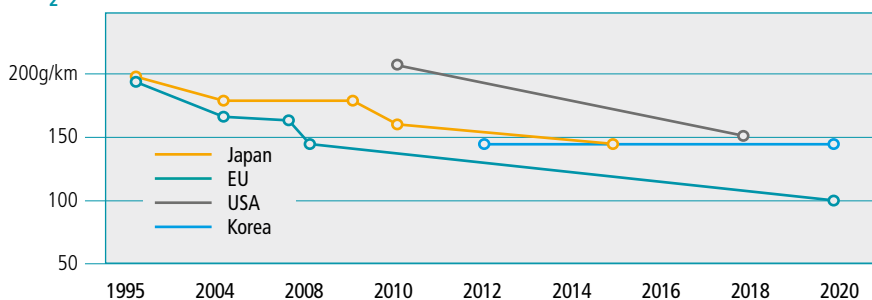
The trend: Automakers are focusing on small vehicles in developing zero-emission automobiles since these have inherently lower energy requirements and are therefore especially suitable for electro motor drive. Manufacturers of large executive cars are mainly relying on hybrid technology to reduce the very high energy consumption of conventional fuels – gasoline and diesel engines – by switching to electro motors. The key to success in energy efficiency is the use of particularly robust and reliable components that are also

extremely light. New materials are increasingly shifting into the focus of research with the latest high-performance polymers and fiber composites leading the way.

Materials for sustainable mobility concepts

Ticona is optimally geared up to these challenges: The company provides its partners and customers with a number of highly specialized engineering polymers with outstanding properties like impact strength, flexibility, stability as well as chemical, UV and temperature resistance. Not only material properties but also processing techniques (blow molding, thermoforming, injection molding), assembling processes (gluing, welding) and surface design (laser marking, printing, metal coating and varnishing) have been evolved. Equipped with these material properties, technological developments and know-how, Ticona is able to conjointly develop custom fit, energy efficient and lightweight components which meet these requirements.

CO₂ emission



E-Mobility in overview

- + The advantages: No exhaust fumes, high acceleration, low-noise
- + The challenge: Integration of electrical and information technology as well as electronics in vehicle technology
- + Ticona polymers: High electrical requirements, optimum mechanical properties

The future of electromobility – and its plastics



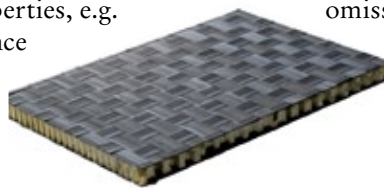
Automakers are still facing numerous challenges in the further development of electromobility. Ticona supports its customers and partners with innovative high-performance polymers: The special properties of the various polymers permit use under the hood (high temperatures), in the vehicle interior (low-odor) and also exterior applications



(UV and weathering resistance). In addition to this, all the materials used in vehicles need exceptional mechanical properties to withstand the sudden impacts and vibrations. All the plastics in hybrid vehicles also have to be resistant against aggressive chemicals such as oils, coolants or brake fluids. Along with these issues, there are also requirements for good electrical properties, e.g. a high resistance against

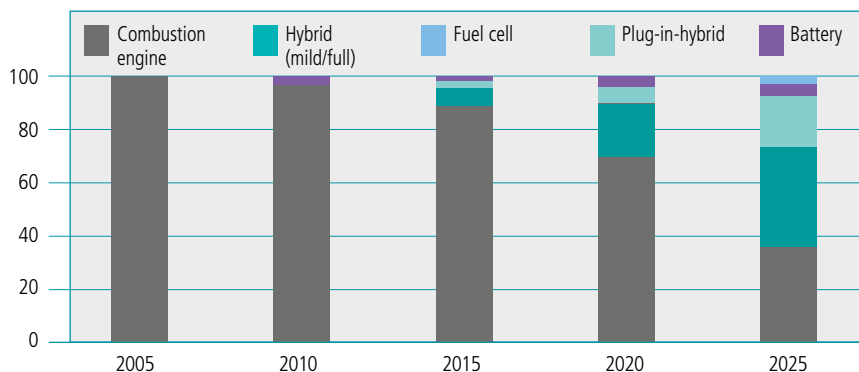
short circuiting (CTI) and a high surface resistance.

Ticona plastics help replace metal and ceramic materials thus reducing weight in structural components (brackets, frames), blow molded components (pipes) and precision components (lense and LED holder). The integration of many functions enables innovative solutions and omission of manufacturing steps which can lead to cost reduction.



Global automobile market

Development of engine types up to 2025 (CAR Univ. Duisburg-Essen)



Specific materials for your product success:

Fortron® PPS

The linear Polyphenyl sulfide Fortron® PPS has long been in use successfully in vehicle technology. It delivers excellent properties even at high temperatures and is therefore the perfect substitute for metal in many cases. Brackets for the power electronics in hybrid and electric-powered vehicles are made from Fortron® PPS particularly due to the low coefficient of expansion which remains constant over a wide range of temperatures. Fortron will increasingly become the material of choice for coil carriers, valve and pump housings.



- High rigidity, hardness and dimensional stability
- Inherent flame retardancy and can be used at up to 260 °C
- Low water absorption and creep
- Outstanding chemical and oxidation resistance within broad temperature ranges

Vectra®/Zenite® LCP

The liquid crystal polymers Vectra® LCP and Zenite® LCP have found their way into automotive electrical systems, due to the additional safety and comfort systems, in many ap-

plications (in particular in sensors and plug connectors). This means that there will be additional requirements for energy-efficient vehicles (engine, lights and high-voltage) which can only be fulfilled efficiently with Vectra®/Zenite® LCP.



- Resilient up to 240 °C, briefly up to 340 °C
- Inherent flame retardancy
- Low coefficient of expansion
- Excellent dimensional stability
- Very good chemical and oxidation resistance
- Ideal for electric and electronic components

Thermx® PCT

Thermx® PCT (PolycyClohexylene-dimethylene Terephthalate) has very good electrical properties in addition to excellent thermal properties. The high dielectric strength is of great benefit for applications in electric-powered cars. With its outstanding colorability and consistent color stability at high temperatures Thermx® fulfills the high demands for LED sockets.



- Continuous use temperature of up to 150 °C, briefly 255 °C
- High dielectric strength
- High resistance to tracking (CTI) > 600V
- Excellent adhesion to filling compounds and adhesive systems
- Good dimensional stability

Celstran® LFT

Celstran® LFT can be used in many applications and is particularly suitable for load-bearing parts in electric-powered cars due to the combination of stability and impact strength. The long fiber-reinforced plastic is not only perfect for the battery holders and the battery housing but also for floor plates and instrument panels. The high energy absorption capacity ensures that vibration and impacts are not transmitted to susceptible parts like the battery and thus increase safety. Celstran® LFT is also very temperature resistant. The right design and corresponding Celstran® grade achieve high strengths and these, in turn, mean that metals can be replaced allowing a weight reduction in components of 30 %.

Innovative solutions by great material range



- Low creep, low warpage, low shrinkage
- High dimensional stability
- Impact strength twice as high as short fiber-reinforced materials
- Integration of functions

Celanex® PBT

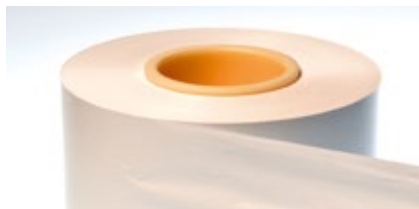
Celanex® PBT (Poly butylene terephthalate) is qualified for all kinds of plug connectors in road and rail vehicles due to its superior dimensional stability. Experience to date concerning the suitability of PBT for electric housings in vehicles (ABS-ECU, ACU/ Airbag Control Unit, etc.) is already being transferred to other components like start-stop systems and is going into production with Celanex®.



- Superb dimensional stability (no water absorption)
- Excellent rigidity and heat distortion resistance
- Robust and resilient
- High continuous use temperature
- Easy to process
- High surface quality

GUR® UHMW-PE

The ultrahigh molecular weight polyethylene GUR® UHMW-PE is predestined for applications in electric-powered cars based on its particularly low weight. It can be used amongst others for battery separators.



- Membrane extremely high strength
- Especially light
- Good electrical properties

Hostaform® POM

Electromobility opens up further potential for Hostaform® POM in addition to the already well-known applications. On the one hand in signal transmission applications in automobile electronics such as in switches, controllers, plug connectors and in sensors; and on the other hand as extremely media-resistant material in forced air systems and cooling of battery packs in HVAC systems.



Ticona has developed its own range of products for low-emission applications with the Hostaform® XAP® grades and has pioneered POM applications in automobile interiors. These include in particular comfort elements such as window regulators and locks, infotainment or construction materials for fastening elements such as clips and retainers. Specialty grades with, for example, improved sliding properties, UV resistance or reinforced with long or short fibers make Hostaform® the ideal candidate for small structural components such as in car seats or in visible moldings like loudspeaker grilles as well as in exteriors as slide sections for bumpers.

- Good thermal stability, continuous use temperatures between -40°C and 100°C (unfilled)
- Outstanding long-term performance and high dimensional stability due to superb creep resistance
- Good conducting and non-conducting properties (CTI 600)
- Excellent chemical resistance (pH > 4 to 14) and impact strength
- Very good sliding friction properties in contact with other polymers and metals
- Easy processing and process control due to flow-optimized grades
- Possibilities to coat and laser mark

On the way into the electromobile future

Almost all innovations in vehicles today take place in electrics/electronics in which plastics are a principal driver of development. As one of the world's leading suppliers of engineering polymers, Ticona is well-positioned to offer engineers and developers a solution even in complicated application matters.

And in doing so the company demonstrates its pioneering spirit again and again. The best example of this is the UC? – the new concept vehicle from the creative car developer Rinspeed from Zumikon in Switzerland; Ticona significantly contributed to its development.

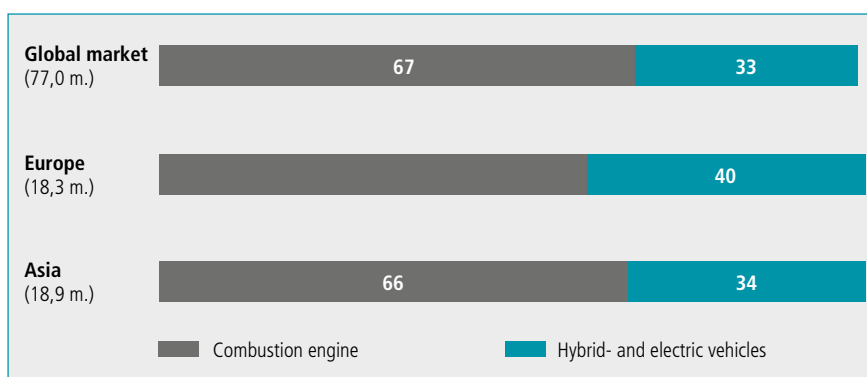
„UC?“ – range thanks to plastic

The model project entitled UC? for Urban Commuter was presented at the Geneva International Motor Show in 2010: A two-seater car designed for use in the city with electric drive and high-tech materials under the hood. And these materials are instrumental in the UC? demonstrating high performance. A sandwich board made from Celstran® LFT from Ticona with a polypropylene honeycomb core in the trunk of the small electric car ensures stability. The same material is used in the support structure for the batteries where it ensures safe holding of the heavy battery. In addition the plastic reduces the overall weight of the vehicle due to its low deadweight thus ensuring lower electricity consumption. Neither do the high temperatures under the hood present a problem to the long fiber-reinforced thermoplastic which retains its excellent product properties even in hot environments.



Electric vehicles

Estimated share of new registrations in 2020 in percent



Scenario: Oil price at 110 US \$; Government target: One million electric vehicles on German roads up to 2020 (Source: McKinsey)



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Mobility concept included

The special feature of the UC? is not only its low deadweight which permits a comparatively high range of 120 kilometers per battery charge but also the associated mobility concept combining individual and public passenger transportation. The Urban Commuter is primarily designed for urban traffic. Travel over further distances is achieved in this concept by changing to rail.

A custom railcar to be developed specially accommodates the UC? and even charges the battery during the journey to permit resumption of driving at the destination. This mobility concept and the electric car with greater range are still a long way off. However thanks to new technologies, high-performance materials and lighter plastics we are coming closer to this aim via hybrid vehicles.

Joint development

The collaboration between Ticona and Rinspeed in UC?

- + Many years of collaboration in process and component development
- + Great range with comparatively small battery thanks to light plastics
- + Long fiber-reinforced thermoplastics from Ticona with enormous lightweight design potential

First-hand polymer know-how

Ticona, a business of Celanese Corporation, is one of the world's leading manufacturers of engineering polymers. The company has been an innovative partner to major carmakers and suppliers to the automobile industry for decades. Ticona has also been committed to the development of alternative drive concepts for many years and has remarkable know-how and high-performance polymers developed specially for this field.

Ticona is more than just a materials supplier. As a manufacturer of plastics, Ticona offers its customers comprehensive technical service. Along with intensive project consulting, this also includes support in the selection of materials, the design of components and molds, CAE calculation and the optimization of production processes.

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