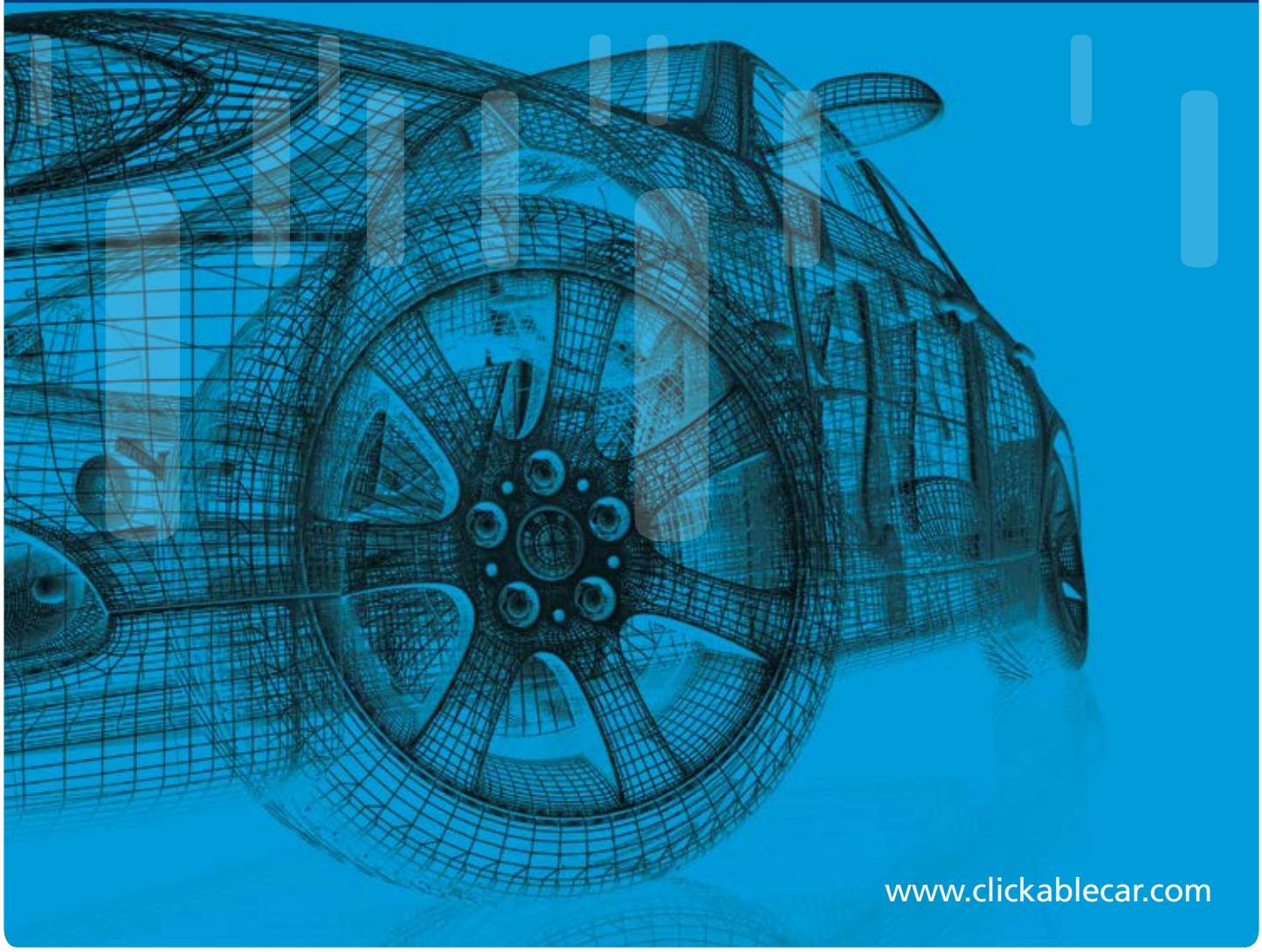




## Advanced Polyolefins for the Automotive Sector



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# Shaping what comes next

The company's *Amazing Chemistry* is applied at 55 manufacturing sites located across five continents. This manufacturing network has enabled the company to be a pacesetter in the Global Fortune 500 and to earn a listing in the S&P 500. In addition, LyondellBasell's proprietary technologies have stood the test of time. The company recently commemorated the golden anniversary for receiving a Nobel prize in chemistry; an honor awarded for historic work done to create modern catalysts and polymers essential in many end-use consumer goods.

LyondellBasell is widely recognized within the industry with sales of \$45 billion. It is one of the largest and most admired global chemical companies. In its own petrochemical sector, LyondellBasell is larger than Bayer and similar in size to Dow, based on market capitalization. LyondellBasell is listed on the New York Stock Exchange as LYB. Around the globe, wherever the quality of life is improving, LyondellBasell products are likely there. These products are the structural building blocks of countless goods – numerous products which make our lives easier,

safer and more enjoyable. Popular examples include computers, portable electronics, personal care items, food packaging, sports equipment, durable construction materials, piping, automotive components, biofuels, textiles and medical supplies.

Now more than ever, the world counts on the chemicals and the products that LyondellBasell delivers.

The Company's performance is buoyed by a dedication to operational excellence and also by the robust development of American shale gas

fields. These new natural gas energy fields provide advantaged feedstocks that elevate LyondellBasell's competitive manufacturing strength.

Now, around the world and around the Chemisphere, LyondellBasell people, plants and products lead the way in petrochemical safety, environmental stewardship, product innovation and sustainable performance.

To learn more about how LyondellBasell is shaping what comes next, visit [www.lyondellbasell.com](http://www.lyondellbasell.com)



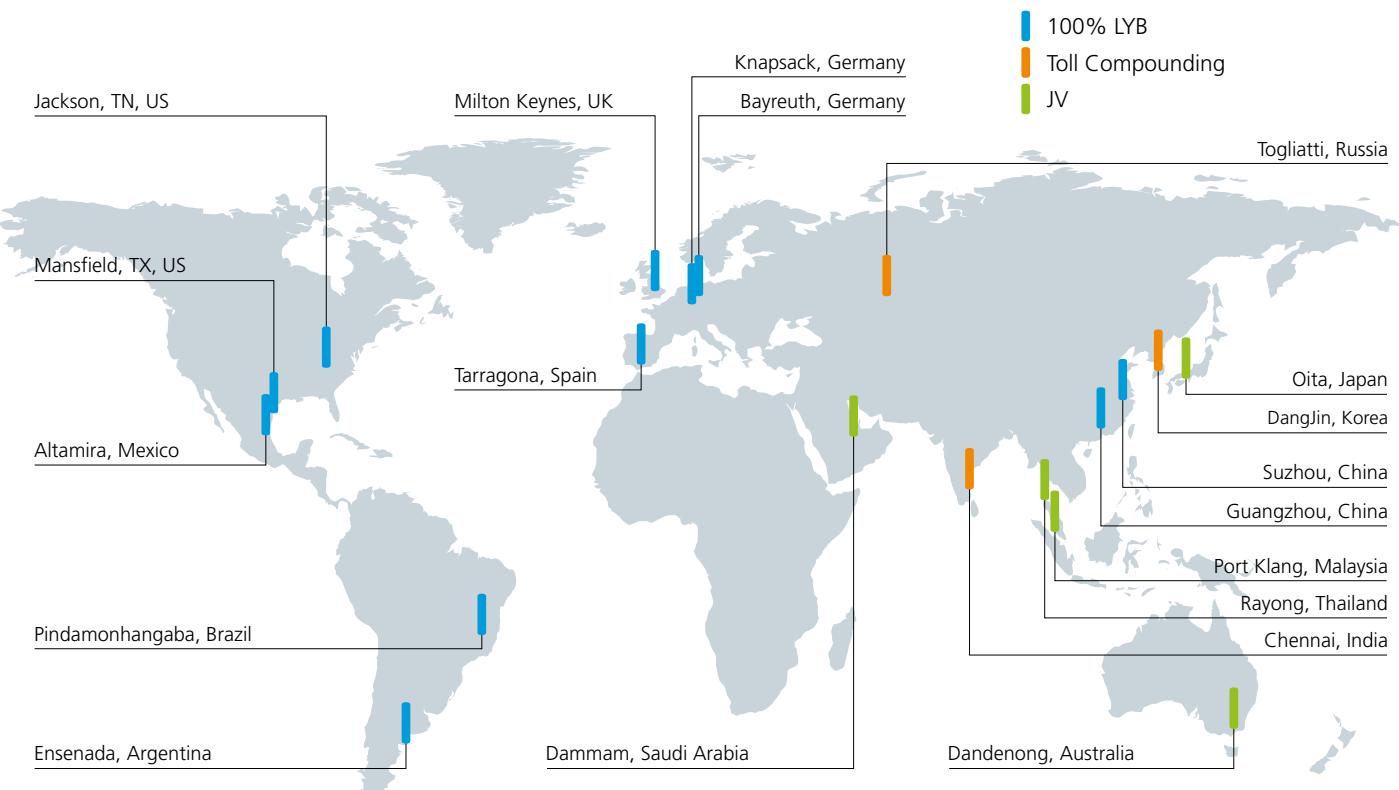
# LyondellBasell: a global polyolefins resource for the automotive sector

In response to customer requests for global support, LyondellBasell has invested in polypropylene resin and compounding plants around the world. The investments take two forms: 100% ownership of assets or the establishment of joint venture (JV) companies in Asia-Pacific.

Complementing the strength and infrastructure of LyondellBasell's wholly owned assets, the JVs add a strong regional influence and knowledge of local market conditions. JVs are licensed by LyondellBasell to produce the compounded grades required by specific markets. Operating in Thailand, Japan, Australia and Malaysia, these joint venture companies offer world-class facilities for the manufacture and development of Advanced Polyolefins (PP Compounds) products based on leading-edge olefin resin technology,

using locally available raw materials wherever possible. Because they operate independently (supported by LyondellBasell's global sales and technical staff), LyondellBasell's JV partners are able to implement decisions quickly.

This dual strategy of wholly owned assets and JV partners has been particularly effective for LyondellBasell's PP Compounds Group, which supports the global automotive industry by providing polypropylene compounded materials for a wide range of automotive components for today's modern cars.



# LyondellBasell: your preferred polyolefins supplier

The global automobile industry is changing rapidly, and, as a result, the role of raw material suppliers is being redefined.

Operating in an increasingly competitive business environment, there is a strong drive to cut costs and reduce time-to-market for new models. There is a drive to optimize the environmental aspects of the industry's products, while consumers expect enhanced safety standards, increased comfort and improved fuel economy with each model change.

## A paradigm shift in the automotive industry: a new type of supplier

LyondellBasell is helping the automotive industry meet these challenges by providing support for the design and development of components and sub-systems. In addition, LyondellBasell delivers cost-effective solutions that contribute significantly to the performance and success of our customers' end products. We are committed to our role as the global automotive industry's preferred polyolefins supplier.

## Local supply – global sourcing

Flexible manufacturing processes require reliable, responsive supplies at local levels. At the same time, materials consistency is important for customers with operations in different regional or continental markets. LyondellBasell's global polyolefins network has strategically located supply facilities that guarantee uniformity of specifications – wherever in the world materials are sourced.

## Adding value – intelligently

Ensuring that customers in the automotive industry benefit fully from leading-edge technology is a fundamental part of LyondellBasell's mission.

This is achieved in several ways:

### Strategic partnerships

The cost structure of new vehicles is largely determined in the initial design phase. As a result, by working with Tier-1s and OEMs in the design phase, LyondellBasell can help manufacturers create sustainable value that can be passed through to customers.

### Cutting development times

There is significant time savings in developing component engineering and materials simultaneously. At LyondellBasell's technical support centers, powerful computer analysis systems simulate the behaviour of complex components before they are prototyped. For example, mold performance can be predicted and optimized by modelling melt flow paths.

### Compliance testing

Where components must comply with national or international safety standards and OEM specifications, LyondellBasell's technical staff can implement all necessary test procedures.



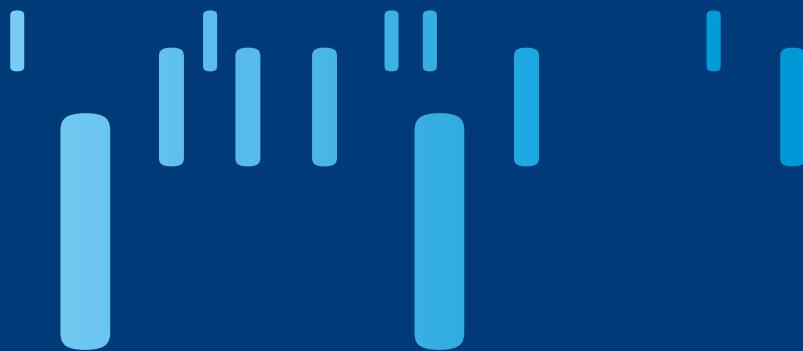
# State-of-the-art design & CAE support

LyondellBasell's experienced design engineers utilise the most advanced computer-aided engineering (CAE) techniques to provide automotive customers with superior parts and mold designs.

This sophisticated technology enables engineers to statistically simulate all phases of the molding process and the real working conditions of a part's life. Structural design by finite element methods helps identify the best options for designing a complex system such as an instrument panel assembly. Conditions such as static loads, vibration, thermal dilatation, possible creep effects (due to sunload) and spontaneous dynamic conditions (caused, for example, by head or pedestrian impact) are analysed by simulation software, taking into account the non-linear behaviour of the material's strain-rate and temperature dependence.



Process simulation helps engineers design molds and processing parameters, either in the early stages of the project (processing option feasibility, material selection) or in the final mold detail definition. For example, in injection molded applications, all phases of the process can be simulated, beginning with the filling and packing phase, continuing with the in-mold cooling process, and ending with post-extraction behaviour (shrinkage/warpage).



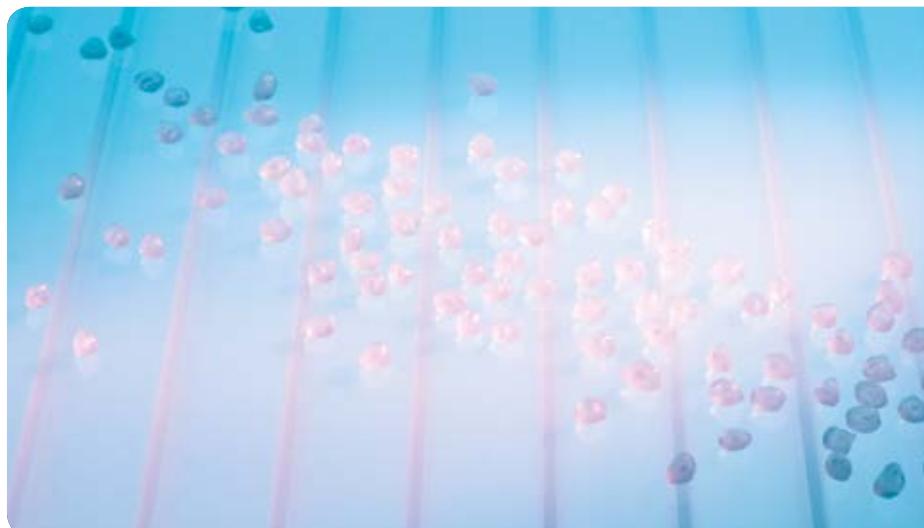
# LyondellBasell's Advanced Polyolefins Group: facing the automotive challenge

Polypropylene, which includes a family of enhanced reactor thermoplastic olefins (TPOs) and compounded grades, offers innovative solutions for a number of challenges the car industry faces today.

The versatility and economy of polypropylene creates opportunities for cost-effective and innovative design concepts that enhance passenger safety and comfort. PP's lower density contributes to improved fuel economy and reduced raw material costs. Additionally, PP's intrinsically superior noise, vibration and harshness (NVH) properties contribute to improved passenger comfort. The result: PP has become the most important thermoplastic material in an automobile, with an average utilisation of more than 50 kg per vehicle.

## Technology creates opportunities

The last two decades have seen steady growth in the quantity of polyolefin materials used by the automotive industry. This trend is driven by technological breakthroughs – many the results of LyondellBasell research – that dramatically extend the property range of polyolefins. LyondellBasell has developed a full range of technologies including gas-phase, *Spherizone* and *Spheripol* processes.



## Catalloy process technology

Some of the most exciting opportunities in polyolefin materials continue to emerge from LyondellBasell's *Catalloy* process. Using a series of independent gas-phase reactors and sophisticated catalysts, the *Catalloy* process allows in-reactor alloying and grafting using multiple monomer inputs. This produces materials over a much wider property spectrum – and with a high degree of consistency. Their wide range of highly balanced and tailor-made properties make these new materials of particular interest to automotive designers. The versatility of LyondellBasell's reactor grades can be further extended using a variety of additives and advanced compounding technologies, including state-of-the-art, in-line blending. Successful developments include lighter weight and scratch resistant dashboard grades and a broad spectrum of soft and rigid bumper materials that meet today's complex requirements on paintability, impact/stiffness balance and thermal expansion. Other new applications include body panel, under-the-hood, and soft parts replacing conventional synthetic leather or painted ETPs for automotive interior trims.



Product Trademarks	Typical Product Description	Main Applications
Hifax	Unfilled PP-Copolymers; 10–30% mineral filled PP-Homopolymers, elastomer modified; Copolymers	Bumper, grille, side cladding, rocker panel, fender, tail-gate, wire & cable
Hostacom	Unfilled PP-Homo-and Copolymers; High crystallinity PP-Homo-and Copolymers; 10–20% mineral filled PP-Copolymers; 10–30% mineral filled PP-Copolymers, elastomer modified; Multispot materials; 20–40% talc filled PP-Homopolymers; 20–40% glass reinforced PP-Copolymers	Instrument panel, console, interior trim, door panel, heater housing, battery support, headlight housing, front end, ventilator wheel, reservoir
Softell	Unfilled soft PP; PP 10–50% glass soft touch	Instrument panel upper, door panel, soft pad, interior trim, door handles



# Bumper systems: the evolution of the bumper

A bumper system's key function is to reduce damage by absorbing kinetic energy so that the load transmitted to the fascia car body is minimized. As a result, bumper systems have evolved into complex engineered systems. For over 30 years, LyondellBasell has pioneered the use of polyolefins for various types of automobile-related applications. Today, polypropylene-based materials are used to produce over 90% of all bumpers.

In addition to their safety function, bumpers form an important part of the overall 'look' of a vehicle. They are closely integrated into bodywork with painted-in body colors and are incorporated into lighting assemblies and grille work. With the advent of global platforms, the design and function of bumpers must often satisfy both local and international market requirements. Through advances in process technology, LyondellBasell offers automotive designers unprecedented opportunities.

## Advanced Polyolefins for the automotive sector: the zero-gap bumper

Because the zero-gap bumper closely follows the lines of the body fascia, it requires special material characteristics. Specifically, the bumper's thermal expansion must be as low as possible to avoid problems with differential

shrinkage. Specially tailored for bumper applications, reactor alloys fabricated through LyondellBasell's *Catalloy* process exhibit extremely low thermal expansion as well as an excellent impact/stiffness balance.

## Processability

Continuous improvements in the mechanical properties of bumper materials have enabled a progressive reduction in wall thickness. Thinner walls produce significant material savings for manufacturers, while creating lighter components that lower fuel consumption for the consumer. Making thin-walled moldings requires materials with extremely good melt-flow characteristics. LyondellBasell's bumper grades exhibit excellent processability as well as lower specific heat and higher thermal conductivity. The result is significant reductions in cycle times.

## Paintability

LyondellBasell's newest bumper grades exhibit improved paintability characteristics, enhancing surface finish and simplifying the manufacturing process. These developments have been driven by the latest regional trends in automotive components, including:

- The elimination of CPO primers in Europe and the move to water-based paints for cleaner production processes.
- Improved paint adhesion durability with various paint systems in Europe, North America and Japan.





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### Low thickness, high performance: next-generation bumper systems

The evolution of the modern bumper fascia is a classic 'less-is-more' story: the required mechanical performance is delivered by components using less material, thereby costing less to produce – while displaying significantly improved aesthetic appeal. One of the most significant factors behind this evolution is the development of materials with mechanical properties and processability that allow the amount of material used in a bumper system to be significantly reduced. The key is the design of the material and carefully selecting raw materials by LyondellBasell to achieve the high performance, high MFR, and lower density required by the next generation bumper.

To help our automotive customers get the very best out of these materials, LyondellBasell has developed considerable know-how, both at the component design and mold design stages.

We share our experience with customers through finite-element analyses to optimize the impact performance of a bumper system under development, as well as through mold-filling analyses and gate positioning advice.

These considerations are increasingly making the high performance new generation bumper material the solution of choice for bumper systems developed by automobile manufacturers around the world.



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# Exterior trim



## Side cladding and body panels

LyondellBasell's TPO materials have a number of excellent characteristics for use in side cladding. The material's low thermal expansion helps to prevent problems when cladding is securely anchored to a metal substrate. Additionally, the material's mechanical performance remains rigid with high impact resistance — even at low temperatures. Resistance to UV, heat and fuel gives rise to a long service life under severe environmental conditions. The molding of such large, thin-walled components is facilitated by the high melt flow characteristics of these resins.

## Other exterior trim components

LyondellBasell is currently applying its technology to satisfy other extremely demanding exterior trim applications such as integrated and painted rocker panels, fenders, tailgates and cosmetic covers like outer door trim. This new generation of polymers offers an exceptionally low co-efficient of linear thermal expansion (CLTE), close to that of aluminum, while resisting high mechanical strain. This unique balance of properties opens new market

development opportunities for vertical panels in body paint or molded-in color, with or without clearcoat.

## Dual injection – multi-function, one shot

Co-injection allows components to be created from two different but compatible materials in a single operation. An example of this technique is the cowl-vent grille separating the windscreen from the upper edge of the hood. The water-tight seal between the windscreen and the upper edge of the grille is conventionally made using a soft gasket glued to the grille. Now grille and gasket can be produced in a one-shot dual-injection molding operation. This approach combines a rigid structural section with a body-hugging seal into a single component that can be used for other exterior trim applications such as side cladding or mirror mounts.

# Instrument panels: the evolution of the dashboard

TPO materials have played a key role in the development of the instrument panel from a simple fascia to a set of complex multi-functional components incorporating a number of different sub-systems.

Material performance demands good dimensional stability, excellent impact behaviour, heat and scratch resistance, plus very good processability and lighter materials in order to meet the faster cycle time target of Tier-1s and the weight reduction target of OEMs. These targets not only address cost issues, but also contribute to the trend of reducing a car's fuel consumption and carbon emission. For over 30 years LyondellBasell has been a pioneer in the use of polyolefin-based materials for instrument panels, including the first PP-based dashboard on the Autobianchi.

## Rigid instrument panels

Rigid instrument panels used in more economical models are predominantly made of TPOs for several reasons. They offer excellent dimensional stability, impact behaviour, heat and scratch resistance, as well as the ease of processing needed to mold these large, complex structures. In addition, 'soft painting' techniques had been used to enhance their tactile characteristics. With use of new generation of *Softell* compounds it is possible to avoid any additional paintings. And this also reduces the odor and hazardous VOC emission in the car cabin.

## Soft instrument panels

As an alternative to the rigid panel, the soft panel dashboard structure offers a higher degree of comfort and is in keeping with the drive towards building passive safety features into automobile interiors. The growing versatility of polyolefins lends itself to constructing soft dashboards (partially or entirely) of TPO materials. This type of dashboard could consist of a rigid structural carrier *Hostacom* material with a foam structure and a soft TPO leather shell.

## Towards the all-TPO dashboard

Given the rapid development of TPO materials for interior trim applications, the mono-material instrument panel is becoming a reality. In addition to offering considerable cost/performance benefits to manufacturers and end-users, this development also facilitates recycling these large components. Specifically, soft instrument panels built from compatible combinations of materials can be recycled far more easily than dashboards currently made from combined materials.



# Interior trim

In car interior applications, safety, long service life and consistent appearance are vital. Rapid developments in polypropylene materials make PP-based resins the material of choice, because they are capable of fulfilling a large number of functional and aesthetic requirements while delivering considerable cost/performance benefits.

## Scratch resistance

Automotive interiors are often under considerable stress. Center consoles, glove-box lids and pillar trim need to resist many different mechanical stresses without damaging their appearance. In this context, scratch resistance is particularly important. LyondellBasell's material and technology developments successfully improve both the grain effect and material quality of scratch resistance. LyondellBasell's portfolio of scratch-resistant products includes mineral reinforced low-density grades with excellent impact/stiffness balance.



Due to their improved crystallinity and phase morphology, LyondellBasell's unreinforced high-strength polypropylene copolymers are more rigid than conventional PP-copolymers and demonstrate equal impact strength. Their heat deflection temperature and hardness are also greater, with values on the same level as talc-reinforced PP grades. In addition, their scratch resistance has been greatly improved: if the surface is damaged, no light colored reinforcement is exposed.

## Safety

Interior components addressing side-impact safety are of great importance to LyondellBasell. Side panels and trim on doors, pockets, consoles and pillars must resist splintering upon impact or upon deployment of side-impact airbags. To that end, LyondellBasell has introduced new PP grades that show low temperature impact, coupled with good rigidity and flowability, making them suitable for production of all of these components.

## Parts consolidation

New manufacturing techniques using LyondellBasell's TPO materials can significantly simplify assembly operations. For example, in low-pressure injection molded door panels, a section of TPO skin with a laminated foam backing that is placed in the tool with the ridge-filled polypropylene backing panel can be molded onto the back at low pressure. This simple one-step process can also be used for other components such as pillar trims and seat backs. TPO skins show extremely low fogging and very good thermal stability compared to conventional materials. Another technique successfully combines the injection of a reinforced polypropylene carrier and a soft-touch polypropylene cladding in a single operation to produce door panels. LyondellBasell has developed specially formulated Softell products for these applications.

## Multi-spot effects on PP compounds for automotive interior trim

Design and aesthetics are increasingly important factors in modern automotive interiors. Standards which were previously applied exclusively to luxury cars are now being introduced in mid-range and medium-sized family vehicles. Processing costs play a crucial role in this trend – the fewer processing stages there are, the more cost effective the components can be to produce. Today, materials for interior trim are typically talc-filled polypropylene compounds or high-crystallinity polypropylene. To achieve high surface quality, the parts are covered with textiles or film. To save manufacturers these additional production costs, LyondellBasell developed a new class of *Hostacom* compounds that simulates the appearance of textiles. The materials are, however, manufactured without any additional textile or film. Instead, this special effect, called 'multi-spot', comes from adding a small amount of fibre with specific color, length, diameter and shape to the compound. These new materials were designed by LyondellBasell to have very similar properties to conventional polypropylene compounds, especially with regard to



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the processing window. Trim made of these materials simulates the textile environment in color, contrast and surface texture, and can be injection-molded in one operation, so more costly methods such as in-mold lamination or post-mold decoration, such as flocking, spraying or laminating are not required.

## Perceived quality – making a critical difference

Increasingly standardized engineering, equipment and safety features make it necessary for car makers to seek new ways of differentiating their products. Surface quality and degree-of-fit with adjacent components are key elements in a customers' assessment. To add maximum value to the final product, LyondellBasell works closely with car makers, molders and designers to create superior color harmony with vehicle parts like interior trim to offer soft touch solutions.



# Under-the-hood applications

In under-the-hood applications, many innovations are being developed where moldings of PP compounds are loaded to the limits of their endurance, forming the cradle for many important future developments in compounds.

Through the integration of function, design, computation and acoustics, savings in weight and cost of up to 50% can be achieved. LyondellBasell is developing new polypropylene materials for applications in vehicle under-the-hood. For example, our *Hostacom* materials are not sensitive to vibration, retain good dimensional stability – even at high temperatures – are resistant to fuels and lubricants, and retain their functionality during their lifetime. New California, USA laws mandating a reduction in C-emissions require all vehicle parts be optimized. All of LyondellBasell's grades for under-the-hood have very low C-emissions and fogging values.



## Heater housings

The highly integrated, extremely complicated housings for heaters and air conditioning systems must withstand shock and vibration at operating temperatures up to 70 °C in continuous service. With temperature peaks up to 120 °C, parts must remain dimensionally stable for sealing and resist fuel and lubricants. Odorless, low emission *Hostacom* resins ensure that the heated air from the engine does not carry an unpleasant odor into the vehicle's interior, even in a new car. Talc-reinforced materials provide excellent sound barrier properties. This allows the heater housing unit to reduce the transmission of sound between the engine and passenger compartments. Filled PP compounds are being replaced by high crystalline PP (HCPP) to achieve weight reduction. LyondellBasell's new very high melt flow HCPPs allow for even more complex design of heater housings.



## Front ends

The most important customer performance requirements for front end module applications are very high stiffness and dimensional stability even under severe heat load.

A new generation of LyondellBasell polypropylene glass reinforced materials are replacing conventional metallic and plastic products, offering system suppliers potential cost savings and component weight reductions.

## Headlight housings

Today, headlights are integrated as a design feature of cars. Modern headlight housings are made from 30% glass fibre-reinforced PP. This material is used due to its high dimensional stability and good processability. Polypropylene materials also have the advantage of allowing design solutions that facilitate assembly.

## Battery supports and structural beams

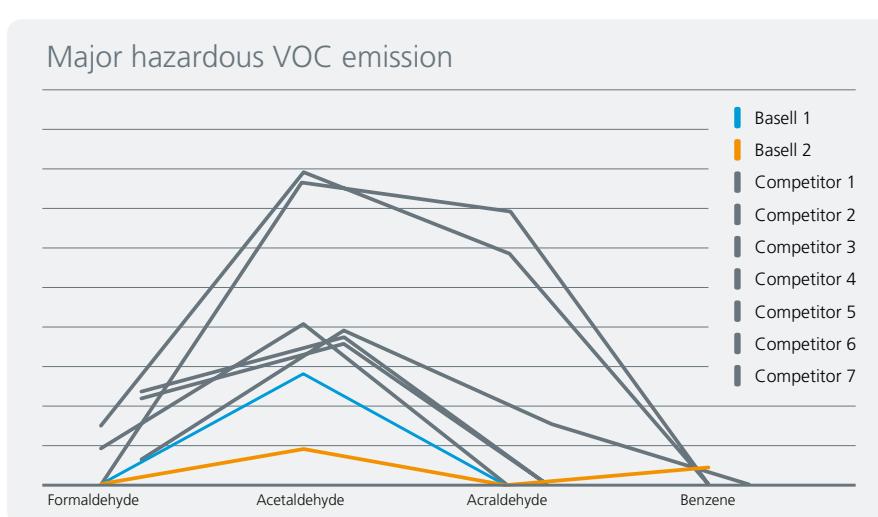
Dimensional stability and reduced warpage are extremely important for these applications. In addition to these well known advantages, easy processing is vital for such demanding moldings. LyondellBasell's materials meet these requirements.

## Reservoirs

Most under-the-hood reservoirs are made of PE or PP compounds because of the material's excellent chemical resistance, good stress-crack resistance, easy weldability and transparency.

# Meeting new VOC emission requirements

With an increasing health awareness both globally and in China, in order to avoid the major types of hazard volatile organic compounds (VOC) substance in vehicle cabin, some studies have been undertaken on how to control the car cabin air quality in recent years. In 2007, State Environmental Protection Administration of China (SEPA) released the regulation GB/T 27630-2011, a guideline for air quality assessment of passenger car. It is very likely this regulation could become a compulsory regulation, and eventually impact the world wide regulation.



Produced by LyondellBasell's unique compounding technology, the *Hostacom* "Low VOC" series new generation interior material leverage the world class technology and with specially designed recipe to produce the state of the art lowest level of PP compounding interior material that could help the OEMs successfully lower their major hazardous VOC emission and to be compliant with the regulation.

## LyondellBasell and the environment

The versatility of LyondellBasell's products and their wide range of properties and functionality enable mono-material design, which simplifies waste management, particularly at the end of a vehicle's useful life. Polyolefins contribute to resource optimisation. Applications produced with polyolefins provide benefits throughout their lifetime. LyondellBasell's highly advanced manufacturing processes are designed to minimize environmental impact in terms of emissions and energy efficiency. The extensive use of polyolefins in automobiles helps reduce weight and conserve fuel, as well as provide added

comfort and safety. LyondellBasell's products are used extensively in bumpers, dashboards and interior trim, as well as under-the-hood. Our state-of-the-art resins contribute to reducing vehicle weight, which is an important element in fuel conservation. Plastics reduce the weight of a modern car by 100–200 kg, saving an estimated 750 litres of fuel over the average lifetime of a car, and thereby reducing CO<sub>2</sub> emissions. Polyolefins make up approximately 50% of the plastics found in cars.

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visiting our website at: [lyondellbasell.com](http://lyondellbasell.com)

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