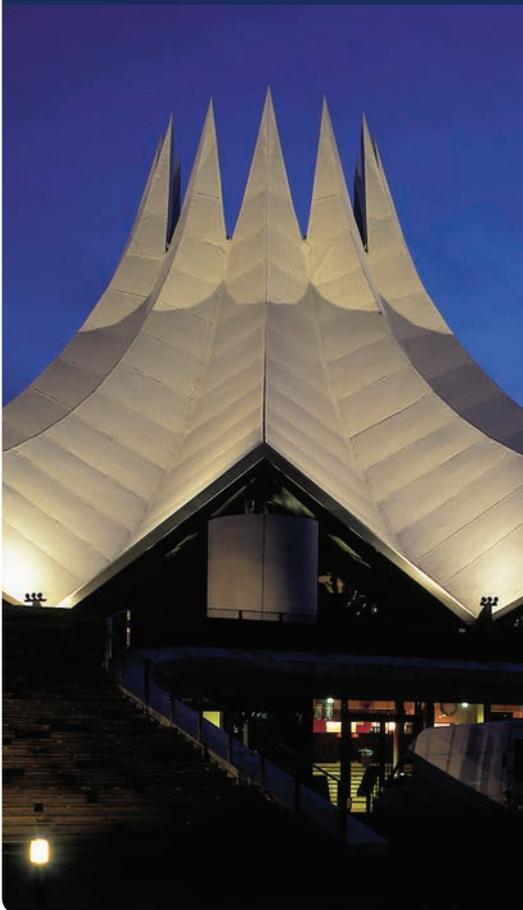


Catalloy TPO Resins

Amazing Then, Amazing Now





LyondellBasell: Shaping Tomorrow

LyondellBasell is the world's third-largest independent chemical company. Our vertically integrated facilities, broad product portfolio, manufacturing flexibility, superior technology base and reputation for operational excellence enable us to deliver exceptional value to our customers across the petrochemical chain – from refining to advanced product applications.

Essential Ingredients

We manufacture products and develop technologies that improve the quality of life for people around the world. Our products are the basic building blocks used to manufacture countless everyday goods such as personal care products, fresh food packaging, lightweight plastics, high-strength construction materials, automotive components, biofuels, durable textiles, medical applications and many others. With the help of LyondellBasell materials, thousands of products are made safer, stronger, more affordable and more reliable.

Experience and Long-term Commitment

The pioneering work of Karl Ziegler and Giulio Natta continues to shape and improve our lives. While working with LyondellBasell predecessor companies, these two fathers of modern polyolefins changed the world with their discoveries. Their achievement was recognized with the Nobel Prize in Chemistry in 1969. At LyondellBasell, their legacy of innovation lives on. *Catalloy* process technology, for example, was invented in the 1990's in Ferrara, Italy and was seen as a break through innovation. This process today produces a full range of advanced polypropylene products including in-reactor thermoplastic polyolefins. Since its introduction nearly 25 years ago, LyondellBasell *Catalloy* process technology has introduced many new and innovative grades, many still considered benchmarks in popular applications. Amazing then and amazing now - we are a technology-driven company powered by innovative thinkers. Watch as *Catalloy* process resins shape the face of tomorrow.

Thermoplastic Polyolefins (TPO) from the *Catalloy* process

LyondellBasell's proprietary *Catalloy* technology combines the advantages of polyolefins with those of elastomers. Their wide range of highly balanced and tailor-made properties makes these materials unique. *Catalloy* TPO resins can also be recycled to guarantee full sustainability throughout its life cycle – and beyond.

Catalloy is a multi-stage gas phase polymerization process, not just a resin or a product name. This process produces materials over a much wider property spectrum and with a high degree of consistency.

From the *Catalloy* process, LyondellBasell produces an innovative family of thermoplastic polyolefins (TPO). Using a series of independent gas-phase reactors with independent composition and sophisticated catalysts, the *Catalloy* process produces ex-reactor polymer alloy using multiple monomer inputs.

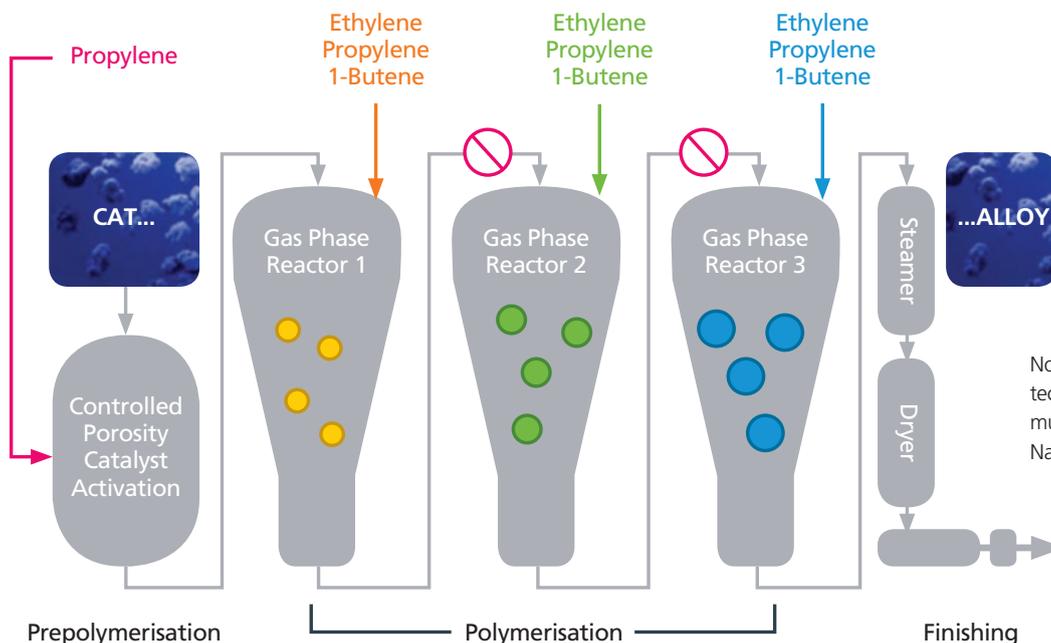
These advanced polyolefins are used by our customers as base materials, raw materials in compounds or as polymer modifiers. *Catalloy* TPO resins can be formulated to meet specific customer requirements and can deliver additional value in use, through:

1. **Cost performance** - offers replacement for higher priced flexible polymers or engineering resins with more cost efficient polyolefins.
2. **Differentiation** - brings cost benefits along the value chain and enables differentiation in end-use applications versus commonly used commodity materials.
3. **Properties modification** - modifies and enhances the properties of other polyolefins used in blown and cast films, textile, calendaring and extrusion thermoforming. They can also be injection molded, compression molded and used as building blocks for technical compounds.

rigid properties. Along with other characteristics such as impact resistance, dimensional stability, aesthetic and optics; the *Catalloy* process resins meet the requirements of many application fields.

Catalloy process resins are sold as easy-to-blend and easy-to-store pellets. With four manufacturing sites in Europe and North America, *Catalloy* sales and support teams have a global reach to serve customers worldwide.

In a comparison *Catalloy* with a standard polypropylene (PP), the *Catalloy* TPO resins covers a significantly broader range from very soft, without the use of plasticizers, to more



Note: Schematic overview of *Catalloy* unique process technology. Independent fluidized bed reactors with multi monomer capability exploiting spherical Ziegler-Natta high mileage catalyst with controlled porosity.

Adflex, Hifax, Softell and Adsyl: Unique Structures

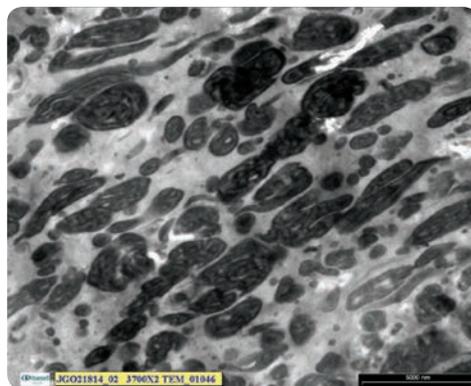
Unlike conventional TPOs that are merely mechanical blends of elastomers or plastomers in a polypropylene matrix, LyondellBasell TPO is an alloy of rubber and polypropylene produced simultaneously in the polymerization reactors. It creates a much better dispersion of the rubber in the material, which has a direct effect on the processing consistency and end-use properties.

As opposed to elastomers or plastomers, the *Catalloy* TPO resins do not necessarily require additional off-line blending with polypropylene, thus minimizing the complexity sometimes seen when handling these materials and managing the ensuing risk of inconsistencies in blends at the end-users.

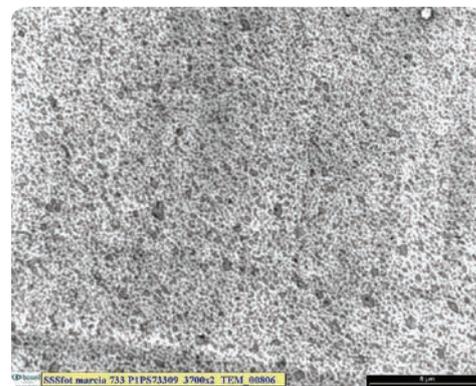
Manufactured using LyondellBasell's proprietary *Catalloy* process technology, the *Catalloy* TPO resin product families – *Hifax*, *Adflex* and *Softell* - enable the control of key properties such as:

- Low specific gravity
- Stiffness and impact balance
- Thermal resistance
- Low-temperature flexibility
- Optical properties
- Dimensional stability
- Softness
- Compatibility with polyolefins
- Easy processing

Ethylene Propylene Rubber Blend

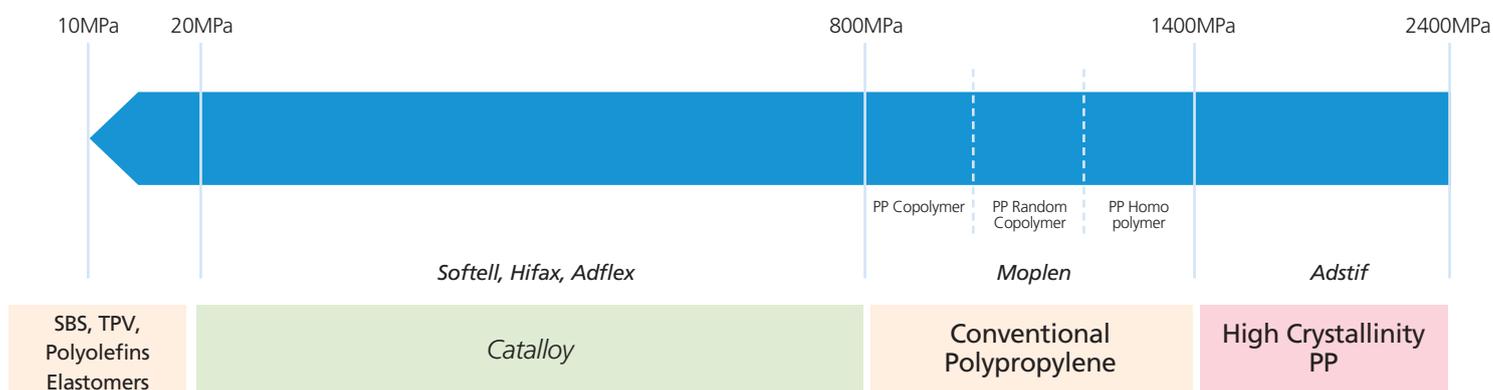


Hifax CA10A



Note: Transmission Electron micrographs (TEM) of *Hifax* CA10A and a mechanically compounded grade. The uniform dispersion of the amorphous rubber phase (dark areas) in the *Hifax* material, which yields more consistent processing and end-use properties.

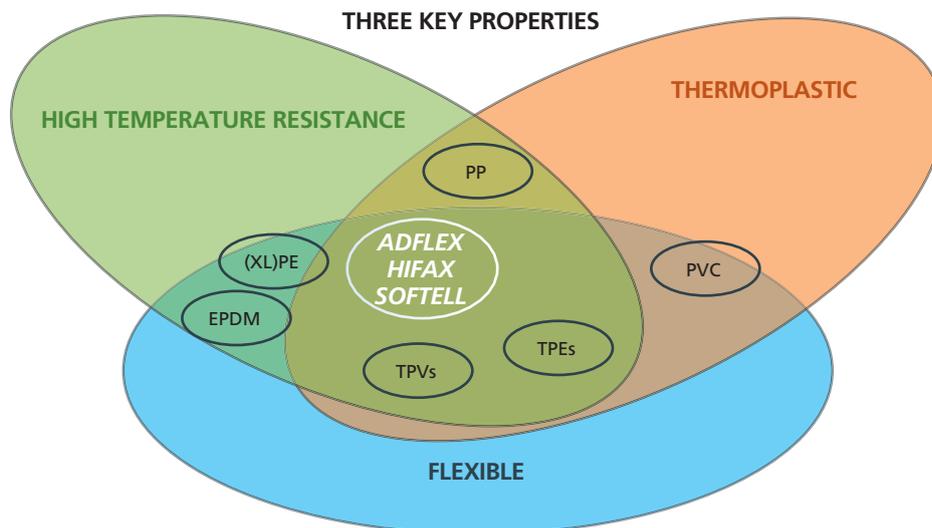
Flexural Modules



Also manufactured with the *Catalloy* process technology is the *Adsyl* product family for the packaging industry, which require low seal initiation temperatures (SIT), no stickiness, high clarity and additionally provide specific functional properties to the film surface.

All *Catalloy* resins can be easily shipped in bulk containers and stored in silos, making it an easy-to-handle product compare to conventional grades.

The *Catalloy* TPO resin product families – *Hifax*, *Adflex* and *Softell* – improve the processability in injection molding, sheet extrusion, thermoforming and blow molding operations. They enable the replacement of higher priced flexible polymers or engineering resins with more cost efficient polyolefins. Additionally they can be used to modify properties of other polymers used in technical compounds, extrusion, injection molding and other blended applications. The thermoplastic *Catalloy* resins offer very attractive properties including flexibility, high thermal resistance, haptics and processing.



Note: *Hifax*, *Adflex* and *Softell* versus other polymers comparing three key properties:

Catalloy resins are split into 4 product families:

HIFAX—Outstanding impact for industrial and exterior automotive applications.

Grades with an outstanding balance of mechanical performance, processability and aesthetics. Utilized by customers in building and construction applications (e.g. single ply roofing), industrial applications (e.g. wire and cable) and automotive applications (e.g. interior and exterior parts).

SOFTELL—New generation for industrial and consumer applications. Softness, flexibility and soft touch.

Combining toughness with flexibility, customers select these resins due to their resistance and elasticity. *Softell* resins provide an enhanced soft-touch feel and slip resistant grip used in electrical appliances and tools. Additional benefits include the ability to bond well with other polyolefins and additives and the capacity to effectively incorporate fillers.

ADSYL—Low seal initiation temperature resins.

Through different co-monomer compositions, *Adsyl* grades offer the marketing leading range of seal initiation temperatures combined with relatively high melting temperatures. The resulting favorable balance of thermal and mechanical properties outperforms standard polypropylene and polyethylene, making *Adsyl* low sealing temperature resins the materials of choice for bi-oriented polypropylene films (BOPP) as well as for cast and blown films.

ADFLEX—Very soft, flexible polyolefins.

Our *Adflex* family are very soft and flexible TPO resins used by a wide number of our customers in applications such as speciality films, as a blending partner to improve impact performance, extrusion coating, bitumen modification and consumer applications. In addition to enhanced flexibility, the *Adflex* resins exhibit excellent impact performance at low temperatures, outstanding haptic properties and soft touch.

Catalloy in Soft and Rigid Technical Compounds

LyondellBasell *Catalloy* TPO resins are used in many types of compounds and produced for a wide variety of applications. Whether a rigid, soft compound or a masterbatch, *Catalloy* enables customers to meet challenging requirements on performance, cost, recyclability and processability.



Soft Compounds

Hifax, *Adflex* and *Softell* resins are selected by customers for use in the formulation of soft compounds for a wide range of applications, as well as elastomer modification. These grades are well-known in the automotive industry for their very good impact resistance at low temperatures, good haptics, controllable gloss, flow-mark-free surfaces and controlled dimensional stability.

The *Catalloy* process resins exhibit very good compatibility with many TPEs (Thermoplastic Elastomers). Due to their relatively high melting temperature (up to 163 °C), softness and very good processability, these versatile, cost-effective resins are extensively used to improve thermal resistance, surface aesthetics and rheology.

KEY FEATURES

- Impact modification
- Thermal resistance
- Compatible with polyolefins (PE/PP)
- Durability
- Soft-touch enhancements
- Low-Gloss
- Improved tensile properties
- Improved processability
- High filler loading
- Recyclable
- Cost reduction
- Low voc
- Weight reduction

TYPICAL APPLICATIONS

- Automotive:**
 - Dashboard TPO skins
 - Door panel and armrest
 - Floor mat
- Flexible profiles:**
 - Flexible profiles
 - Flexible hoses and pipes
 - Roofing
- Foam sheet:**
 - High thermal resistant soft foam
- Consumer and Textile:**
 - High impact container lids
 - Soft touch textile and carpet
 - Artificial grass
- Wire and Cable:**
 - Industrial cable insulation and jacketing, compounds
 - Automotive T3 class cable
- Film:**
 - Soft touch, puncture resistant and transparent films



Rigid Compounds

Hifax, *Adflex* and *Softell* grades are used in the manufacturing of rigid compounds with low warpage (glass and natural fibers and reinforced compounds), improved heat resistance, high aesthetic (filled grades, automotive interior parts), durability (UV resistance) and also to control the shrinkage of the finished product (e.g. appliances, automotive, tools).

The opportunity to custom tailor these advanced polyolefins is particularly advantageous to converters who are producing materials where tight tolerances are required.

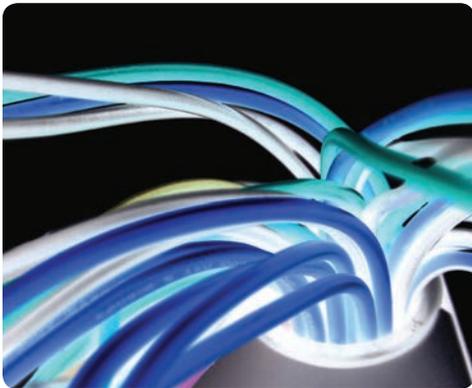
Catalloy resins open up new opportunities for the compounder, enabling him to develop differentiated performance products, while using a cost-effective *Catalloy* grade as an alternative to previously used commodity resins.

KEY FEATURES

- Excellent impact resistance/stiffness balance
- Improved impact at low temperature
- Durability
- Mold shrinkage adjustment
- Gloss modification and aesthetics
- Improved soft-touch performance
- Compatibility with wide range of polyolefins
- High melt strength
- Recyclable

TYPICAL APPLICATIONS

- | | | |
|---|--|---|
| Automotive interior: <ul style="list-style-type: none"> • Glove box • Side covers • Central console | Automotive exterior: <ul style="list-style-type: none"> • Side rails • Tailgate covers • Side cladding • Bumper | Consumer goods: <ul style="list-style-type: none"> • Tooling • Body care items |
|---|--|---|



Carrier, Masterbatches and Hyperfilled Systems

Special *Catalloy* process resins available in powder form have been successfully used in masterbatches and concentrates as a carrier for liquid additives such as peroxides which are physically absorbed into the mixture through simple dry-blending.

KEY FEATURES

- Low density
- Compatibility with wide range of polyolefins
- High filler loading
- Low Tm carrier
- Porous carrier for liquid additives
- Easy processing
- Softness
- Recyclable

TYPICAL APPLICATIONS

- Wire and cable
- Flame retardant materials
- Pigments and additives
- Natural fibers



Catalloy: Utilized in a wide range of market segments

The *Hifax*, *Adflex*, *Softell* and *Adsyl* families of reactor-made polyolefins produced by LyondellBasell's proprietary *Catalloy* technology have become industry benchmarks. These grades offer optimum, well-balanced properties and performance characteristics for durable applications in building and construction, but also applications including automotive (interior and exterior), consumer products, packaging, electrical appliances, toys, sporting goods. Learn more about the wide range of market segments supplied with *Catalloy* resins.



Building, Construction and Infrastructure

Single Ply Roofing – Waterproofing membranes produced using *Catalloy* thermoplastic polyolefins are recognized in the industry as tough, versatile materials, combining ease of installation, durability and long service life. For more than 20 years, LyondellBasell's thermoplastic polyolefins have been specified by customers for waterproofing membranes.

Geomembranes – *Catalloy* TPO resins are used in geomembrane applications because of their unique combination of durability, flexibility, barrier properties, thermal resistance, dimensional stability, plasticizer-free design and environmental resistance.

Bitumen Modification for roofing and paving – *Catalloy* TPO resins are used as additives for bitumen modification with proven long-term performance. Key features of the resins for these applications are temperature resistance from very low to elevated levels improving the cold bending property of bitumen even after thermal and UV aging.

Wire and Cable – The unique balance of high temperature performance and flexibility offered by *Hifax* and *Softell* grades is widely recognized by producers of compounds for wire and cable applications. Product flexibility and toughness are maintained even when highly loaded with mineral fillers, such as in non-halogenated, flame-retardant versions.

Soft Sheets and Profiles – *Catalloy* process technology offers products suitable for the extrusion, calendaring and extrusion blow molding of very soft film and sheet as well as for injection molded parts. It combines outstanding low stiffness, excellent low hardness and very good impact resistance. One of the typical applications are soft profiles for windows.

Interior and Exterior Pipes – *Hifax* and *Softell* resins can be used as cost saving material for the production of flexible pipe connection ring (compound or co-extrusion). *Catalloy* resins are also used for producing liners for 'cured in place pipe' rehabilitation projects.



Automotive

Interior Applications – Controllable gloss, good aesthetics and low CLTE are typical requirements for components found in the interior compartment. Using compounds based on *Hifax* and *Softell* resins, console, pillar trim, interior flooring, soft grips and TPO skins for dashboard and door panels are produced.

Exterior Applications – Due to their specially designed compositions, *Hifax* and *Softell* resins are well-known in the industry for their excellent impact resistance at low temperatures, flow-mark free surfaces and low shrinkage in applications such as bumpers, side cladding and front grills.



Consumer Goods

Achieve higher performance by utilizing reactor-grade *Adflex*, *Hifax* or *Softell* resins in blends with other polyolefins. Modification with these specialized resins can enhance the cold-temperature impact performance of transparent applications while retaining clarity. They also offer an attractive haptic and soft touch surface.



Textile and Carpets

Due to the very low flexural modulus, our customers have found significant advantages in combining *Adflex* grades with standard PP to soften yarns and filaments used in textile applications increasing the end user's comfort.



Electrical Appliances

The *Hifax* and *Softell* resins are known for their contribution to the aesthetic value and quality of thermal resistant compounds. The *Catalloy* TPO portfolio offers a wide range of properties that meet our customers' requirements. Each offers new opportunities to develop sophisticated compounds used for production of large parts with optimum dimensional stability, good processing, and low warpage.



Packaging

Flexible Packaging – *Adsyl* products with a low seal-initiation temperature and excellent hot tack strength for higher speed form-fill-seal packaging are used for flexible food packaging. In co-extruded BOPP, cast film, and double bubble applications, *Adsyl* is used as skin layer material.

Rigid Packaging – *Hifax* and *Adflex* grades are used in the manufacture of rigid molded goods. They can be used alone or blended with other polymers to improve heat resistance, clarity, durability and elastic recovery of the finished product.

Industrial packaging – Incorporating *Catalloy* TPO resins with other polyolefin resins into a film structure, the resulting high performance films can be tailor made to meet specific requirements: puncture resistance at low temperature, excellent tear resistance, high stretching ratio, increased strength and excellent processability. Typical applications include stretch hoods, heavy duty bags, non-fusion shrink hoods or IBC liners.

LyondellBasell: Your Preferred Global Supplier





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