cataloy
MAXIMIZED RESINS

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Catalloy Process Resins

Advanced Reactor TPO Technology

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LyondellBasell: Shaping What Comes Next

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 1963. At LyondellBasell, their legacy of innovation lives on. *Catalloy* process technology, for example, was invented in 1990 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 countless 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.

Reactor Thermoplastic Polyolefins (rTPO) from the *Catalloy* Process

LyondellBasell's proprietary *Catalloy* technology creates reactor thermoplastic polyolefins that combine the advantages of polyolefins with those of elastomers. Their wide range of highly balanced and tailor-made properties make these materials unique. *Catalloy* rTPO resins can also be recycled to guarantee full sustainability throughout your product's 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.

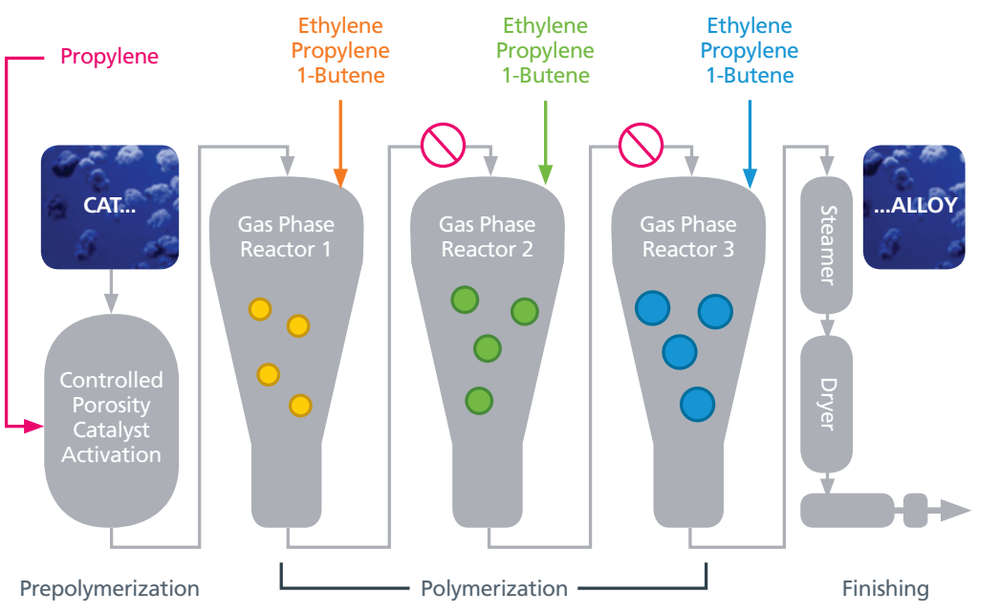
From the *Catalloy* process, LyondellBasell produces an innovative family of reactor thermoplastic polyolefins (rTPO). Using a series of independent gas-phase reactors with independent composition and sophisticated catalysts, the *Catalloy* process produces a polymer alloy using multiple monomer inputs.

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

1. **Cost performance** - replacement of 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. **Property modification** - modifies and enhances the properties of other polyolefins used in blown and cast films, textile, calendaring and extrusion thermoforming. *Catalloy* rTPO can also be injection molded, compression molded and used as building blocks for technical compounds.

Comparing *Catalloy* with a standard polypropylene (PP), the *Catalloy* rTPO resins cover a significantly broader range from very soft (without the use of plasticizers) to more rigid properties. Along with other characteristics such as impact resistance, dimensional stability, aesthetic and optics; *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 North America and Europe, *Catalloy* sales and support teams have a global reach to serve customers worldwide.



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

Adflex, Hifax and *Adsyl:* Unique Structures

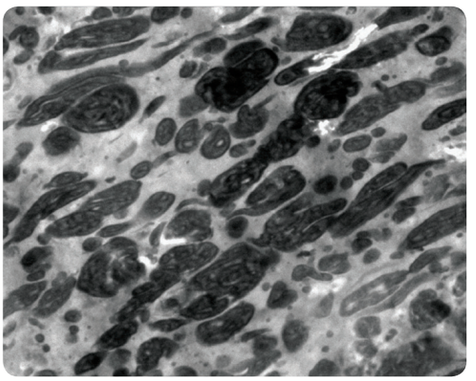
Unlike conventional compounded TPOs that are merely mechanical blends of elastomers or plastomers in a polypropylene matrix, *Catalloy* rTPO is an alloy of rubber and polypropylene produced simultaneously in the polymerization reactors. It creates a much better dispersion of the rubber in the material,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

As opposed to elastomers or plastomers, the *Catalloy* rTPO resins do not necessarily require additional off-line blending with polypropylene, thus minimizing the complexity sometimes seen when handling these materials and managing inconsistencies with off-line blending.

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

- Low Density
- Stiffness and Impact Balance
- Thermal Resistance
- Flexibility
- Low-Temperature Impact
- Optical Properties
- Dimensional Stability
- Tear and Puncture Resistance
- Softness
- Compatibility with Polyolefins
- Easy Processing

Conventional mechanically-compounded TPO

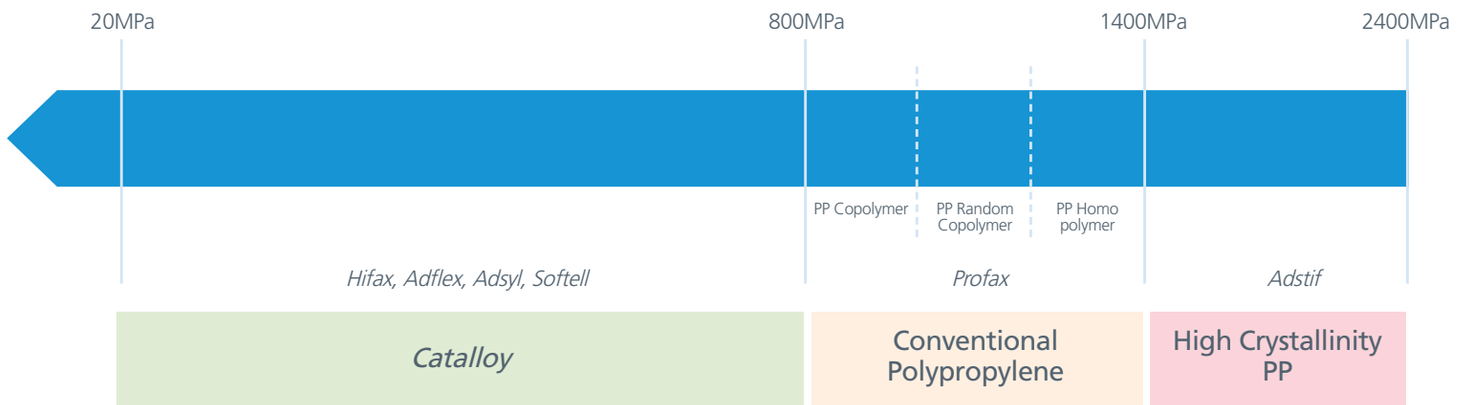


Hifax CA10A *Catalloy* rTPO

Photos taken at 5 micrometer resolution.

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* CA10A material yields more consistent processing and end-use properties.

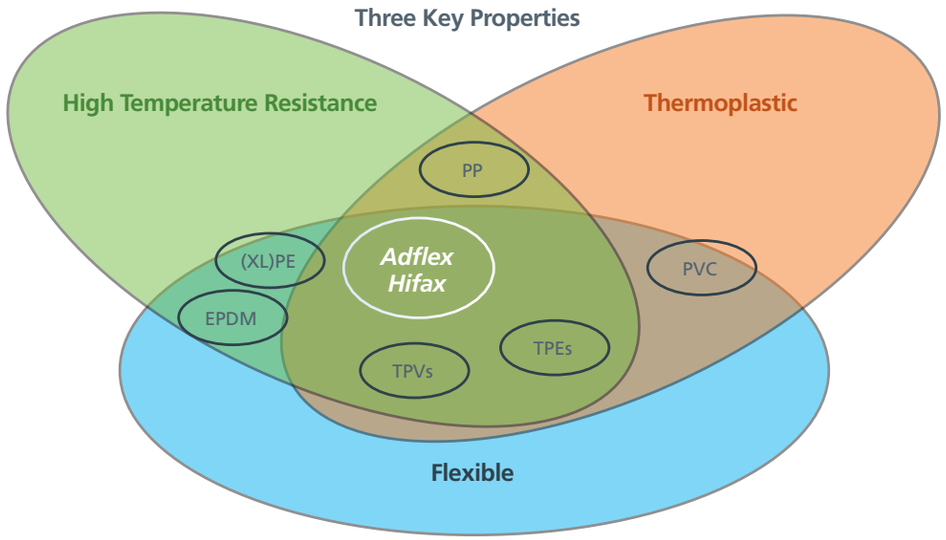
Flexural Modulus



The *Catalloy* rTPO resin product families – *Hifax* and *Adflex* – can be utilized in all major conversion processes such as injection molding, blow molding, sheet extrusion, thermoforming, compounding, extrusion coating and film applications. 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. *Catalloy* rTPO resins offer very attractive properties including flexibility, high thermal resistance, impact resistance, haptics and easy processing.

The *Adsyl* product family of *Catalloy* process resins is used for the packaging industry, which requires low seal initiation temperatures (SIT), no stickiness, clarity and high gloss. *Adsyl* resins also provide specific functional properties to the film surface.

All *Catalloy* process resins can be easily shipped in bulk containers and stored in silos, similar to conventional polyolefins.

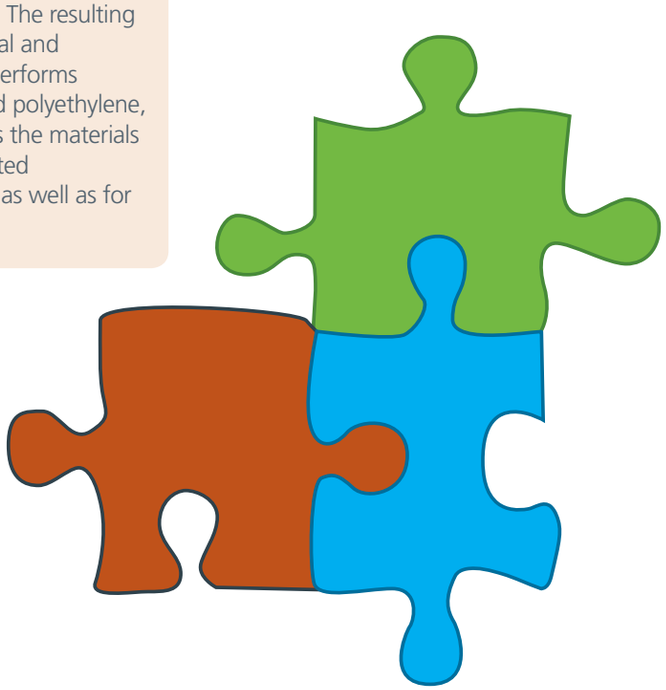


Note: *Hifax* and *Adflex* versus other polymers comparing three key properties: high temperature resistance, thermoplastic and flexible properties.

Three Key Properties

Adsyl – Low Seal Initiation Temperature (SIT) resins

Through different co-monomer compositions, *Adsyl* offers the market-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-SIT resins the materials of choice for biaxially-oriented polypropylene (BOPP) films as well as for cast and blown films.



Adflex – Very soft, flexible rTPO grades

Our *Adflex* products are very soft and have flexible rTPO resins used by a wide number of our customers in applications such as specialty films, stretch hoods, as a blending component to improve impact performance, extrusion coating, textiles, bitumen modification and consumer applications. In addition to enhanced flexibility, the *Adflex* resins exhibit excellent impact performance at room and low temperatures, outstanding haptic properties and soft touch.

Hifax – Outstanding impact for industrial and exterior automotive applications.

Hifax resins offer an outstanding balance of mechanical performance, processability and aesthetics. *Hifax* resins are selected by customers for 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).

Catalloy in Soft and Rigid Technical Compounds

LyondellBasell *Catalloy* rTPO resins are used in many types of compounds and produced for a wide variety of applications. In soft compounds, rigid compounds and masterbatches, *Catalloy* enables customers to succeed when faced with challenging requirements for performance, cost, recyclability and processability.

Soft Compounds

Hifax and *Adflex* 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 room and low temperatures, good haptics, controllable gloss, grain retention and controlled dimensional stability.

Catalloy rTPO resins exhibit very good compatibility with other polyolefins and many TPEs (Thermoplastic Elastomers, notably styrenic-based products). 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 impact properties.

KEY FEATURES

- Impact Modification
- Thermal Resistance
- Polyolefins Compatibilizer (PE/PP)
- Durability
- Soft-Touch Enhancements
- Low Gloss
- Improved Tensile Properties
- Improved Processability
- High Filler Loading
- Recyclable
- Cost Reduction
- Low VOC
- Weight Reduction
- Softness
- Flexibility

TYPICAL APPLICATIONS

Automotive:
- Soft Dashboard TPO Skins
- Door Panel and Armrest
- Floor Mat

Flexible Profiles:
- Flexible Profiles
- Flexible Hoses and Pipes
- Roofing Membranes
- Geomembranes

Foam Sheet:
- High Thermal Resistant Soft Foam

Consumer and Textile:
- High Impact Containers & Lids
- Soft Textile and Carpet Backing
- Artificial Grass

Wire and Cable:
- Industrial Cable Insulation and Jacketing, Compounds
- Automotive T3 Class Cable

Film:
- Soft Touch Cosmetic Bottles
- Stretch Hood

Rigid Compounds

Hifax and *Adflex* grades are used in the manufacturing of rigid compounds with low warpage (talc, glass and natural fiber reinforced compounds), improved heat resistance, flow-mark-free (anti-tiger striping) surfaces, high aesthetic (filled grades, automotive interior parts), durability (UV resistance, when properly stabilized) 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 may be required.

The *Catalloy* process resins open up new opportunities, allowing compounders to develop differentiated performance products, using a cost-effective *Catalloy* rTPO as an alternative to previously used commodity resins.

KEY FEATURES

- Optimum 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
- High Filler Loading

TYPICAL APPLICATIONS

Automotive Interior:

- Glove Box
- Side Covers
- Central Console
- Pillars

Automotive Exterior:

- Side Rails
- Tailgate Covers
- Side Cladding
- Bumpers

Consumer Goods:

- Tooling (Soft Touch)
- Body Care Items
- Residential Flooring
- Profiles

Carrier, Masterbatches and Hyperfilled Systems

Special *Catalloy* process resins have been successfully used in masterbatches, concentrates, as well as being 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 Polyolefins
- High Filler Loading
- Porous Carrier for Liquid Additives
- Easy Processing
- Softness
- Recyclable

TYPICAL APPLICATIONS

- Wire and Cable
- Flame Retardant Materials
- Pigments and Additive Carriers
- Fibers

Proven Performance with *Catalloy* rTPO in Single-Ply Roofing

Membrane producers depend on *Hifax* and *Adflex* to meet the needs of today's demanding waterproofing applications. Offering optimum flexibility, easy installation and environmental benefits, it's no surprise that *Hifax* and *Adflex* are the most widely used single-ply roofing materials in North America. The vast majority of the billions of square feet of TPO membranes installed on North America roofs have been produced using *Hifax* and *Adflex*. With more than 20 years of proven reliability, roofing produced using *Hifax* and *Adflex* has been in service longer than any other TPO.

Unlike conventional TPOs that are merely mechanical blends of elastomers in a polypropylene matrix, *Hifax* and *Adflex* are alloys of rubber and polypropylene produced simultaneously in the polymerization reactor. Manufactured using LyondellBasell's proprietary *Catalloy* process technology, these reactor alloys feature uniformly dispersed rubber within the crystalline matrix, enabling control of key properties such as:

- Stiffness and Impact Balance
- Thermal Resistance
- Low-Temperature Flexibility
- Product Grades Available In a Variety of Melt Flow Rates
- Low Density
- Dimensional Stability
- High Filler Loading
- Durability
- Wide Welding Window

Reduce environmental impact and save costs with *Hifax* and *Adflex*

White, sun-reflecting TPO membranes installed on roofs offer energy-saving potential and reduced environmental impact. With numerous installation and end-use performance benefits, TPOs are recognized by single-ply roofing producers as the industry's most cost-effective white roofing membrane. With *Hifax* and *Adflex* rTPO, membrane converters, installers and end-users can:

- Achieve optimum flexibility without plasticizers
- Attain lower density that helps reduce weight and transportation energy consumption
- Easily recycle membranes during production and at the end of life
- Produce white membranes that can meet or exceed ENERGY STAR ratings by increasing sunlight reflectivity which reduces internal building temperatures
- Install membranes that are hot-air weldable, eliminating the need for solvents or adhesives

Catalloy Flexible Polypropylene for Geomembrane Applications

Hifax and *Adflex* flexible polypropylene resins are utilized by customers in geomembrane applications due to the unique combination of mechanical toughness, flexibility, barrier properties and environmental resistance they possess. Customers have found that these products, when used as building blocks, form the critical backbone of their geocomposite compounds.

Due to their high levels of rubber content, *Hifax* and *Adflex* resins can be combined with other polyolefins, mineral fillers and stabilizers without a significant reduction in mechanical properties. Their crystallinity is very low, providing outstanding resistance to environmental stress cracking even at elevated temperatures.

Hifax and *Adflex* resins can be processed using popular sheet conversion processes such as round die extrusion, horizontal slot die extrusion, calendaring and extrusion coating. Membranes produced from *Hifax* and *Adflex* rTPO resins may also be recycled for use in alternative markets or utilized for energy production by incineration.

BENEFITS

- Plasticizer-Free
- Low Density
- Wide Welding Window
- High Flexibility
- Resistant to Root and Hydrostatic Puncture
- Formability to Soil Movements
- Can Be Modified With UV Stabilizers for Excellent UV and Thermal Characteristics
- High Tear Resistance
- Good Dimensional Stability
- High Friction Angle

Catalloy Process Resins for Rigid Packaging

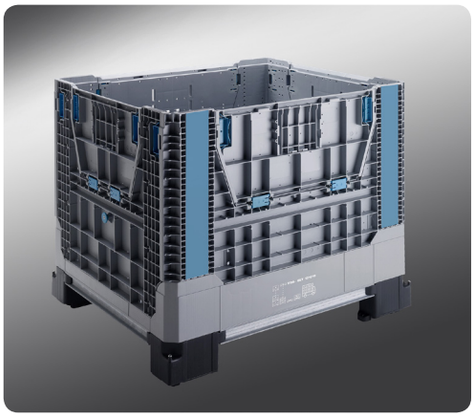
Hifax and *Adflex* resins enhance the performance of rigid and flexible molded goods.

Higher performance can be achieved by utilizing *Hifax* and *Adflex* resins alone or in blends with other polyolefins. Modification with *Catalloy* rTPO resins in extrusion blow molding and injection molding can enhance the cold-temperature impact performance of transparent applications while retaining clarity. *Hifax* and *Adflex* resins can offer attractive haptic properties and a soft touch surface with controllable gloss. Impact resistance and squeezability can also be enhanced by blending *Hifax* and *Adflex* resins with other polyolefins in molding, extrusion, or laminated flexible tubes for personal care products.

Hifax and *Adflex* grades can also be used in the manufacture of injection molded containers, crates and bins to improve the impact resistance. They also can offer low warpage, dimensional stability, flexibility, and a tight fit when used in lidding applications. Improved heat resistance, toughness, durability and elastic recovery are other features that can be enhanced with the use of *Hifax* and *Adflex* grades.

Blow Molding / Soft Touch

Injection Molding



Flexibility / Clarity

APPLICATIONS:

- Soft Bottles
- Flexible Tubes
- Houseware Containers and Lids
- Pails
- Crates, Pallets and Bins

BENEFITS:

- Impact/Stiffness Balance
- Thermal Resistance
- Room and Cold Temperature Impact
- High Softness
- Soft Touch
- High Clarity
- Extreme Toughness
- Dimensional Stability

Catalloy Process Resins for Flexible Packaging

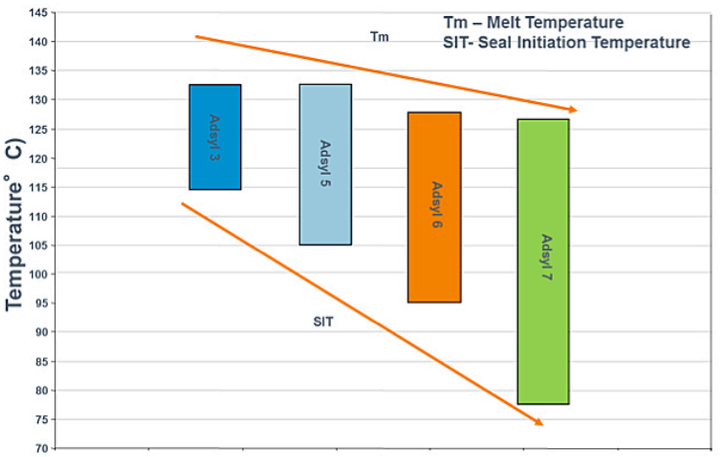
Adsyl - Enhanced Sealing Performance Beyond Random Copolymer PP

Adsyl grades are Propylene + Ethylene + Butene based random copolymers (Raco) and terpolymers with relatively high co-monomer ratios that deliver improved sealing properties by reducing seal initiation temperatures.

Broad range of specialty PP resins to meet your more demanding requirements:

- Seal Initiation Temperature (SIT) from 115 °C down to 75 °C SIT to Meet Your High Speed Packaging Needs
- Low SIT/Broad Heat Seal Range
- High Hot Tack/Heat Seal Strength
- High Speed Processing
- Good Optics
- Functional Polymers for Surface Layers Suitable for Metallization, Printing and Coating

Processable as heat seal and bonding layers in multiple film fabrication operations including: Biaxially Oriented Polypropylene (BOPP) Film, Cast Film and Blown Film. End use fabrication operations include Horizontal Form Fill and Seal Equipment (HFFS); Vertical Form Fill and Seal Equipment (VFFS).



APPLICATIONS INCLUDE:

- Food Packaging
  - o Snack Bag & Bar Wrappers, Stand-Up Pouches and Hanging Pouches
- Clear Overwraps
- Bottle Labels
- Breathable Films
  - o Increased Gas Permeation For Controlled Atmosphere Packaging (Pre-Packaged Salads & Vegetables)
- Breathability Without Need For Micro-Perforation
- Extended Shelf Life
- Tailored Permeability For Produce That Require Different Transmission Rates

CATALLOY PROCESS RESINS PROVIDE:

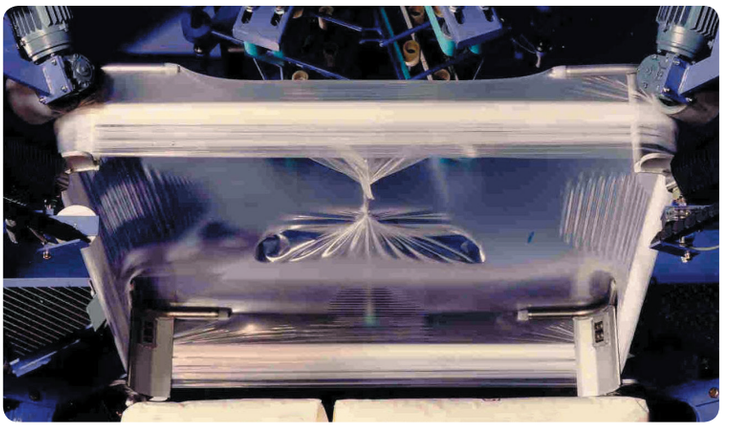
- Heat Resistance to Allow For Autoclave and Retort Sterilizable Applications (Medical Waste Bag, etc.)
- Low Modulus and Soft Touch Properties (Thermal Blankets, Diaper Film, etc.)
- Modifier for PP and PE Property Enhancement:
  - o Excellent Toughness
  - o Stiffness/Impact Balance
  - o Elastic Recovery
  - o Broad Working Temperature Range (High Temperature Resistance / Low Temp Impact)
  - o Compatible with PE and PP (Blends/Co-extrusion)

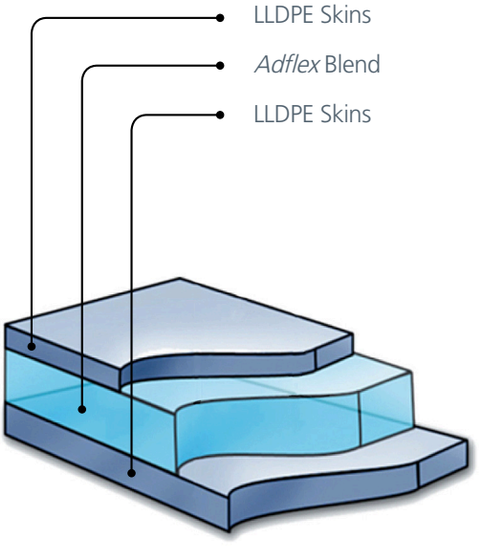
Proven Performance for Product Protection

Enhanced Stretch Hood Film Solutions

The demand for stretch hood packaging film continues to grow in established and new markets globally. Stretch hood packaging provides enhanced load stability and five-sided protection for pallet load unitization. Manufacturers require stretch hood films that deliver high levels of safety and product protection, whether pallets are being shipped across town or halfway around the world.

LyondellBasell resins are used to produce stretch hood films for some of the most demanding commercial applications. By combining film design and manufacturing know-how with the right polymer materials, you can develop stretch hood solutions your customers can trust.

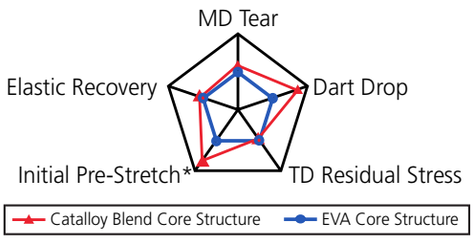




Why Customers Prefer *Adflex* For Their Stretch Hood Films

- High Elasticity and Stretchability
  - Versatile Film Design for Broad Range of End Uses
  - Vertical Stretch For 3D Stability
  - Broader Operating Window to Meet the Demands of High-Speed Wrapping Processes
- Robust Puncture and Tear Strength
  - Improved Load and Product Protection
  - Wider Product Size Range From Fixed Extrusion Assets
- High Elastic Recovery
  - Secure, Tight Loads With Good Aesthetics
- Compatible With Polypropylene and Polyethylene
  - Application-Specific, Multilayer Film Design Options
- Homogenous Reactor Polymer
- Easy Processability and Reliable Performance
- High and Low-Temperature Resistance
  - Wider Seasonal and Geographical Performance
- Lower Density, Higher Stretch and The Right Thickness Combine to Deliver a Cost Competitive Packaging Solution

Films Produced With *Catalloy* Process Resins Provide Superior Elastic Recovery And Toughness At High Pre-stretch



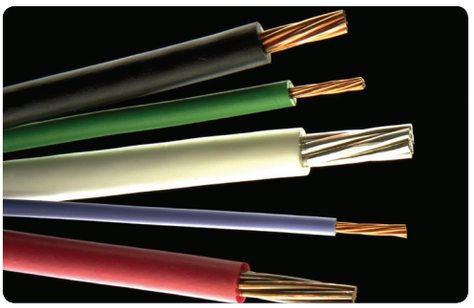
Automotive

- Interior Applications – Controllable gloss, good aesthetics, grain retention, ductile behavior in impact tests, and low CLTE are typical requirements for components found on the interior compartment. Compounds based on *Hifax* and *Adflex* resins are used to produce consoles, pillar trims, interior flooring, soft grip knobs and skins for dashboard and door panels.

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

Bitumen Modification for Roofing and Paving

Catalloy TPOs 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 bend properties of bitumen even after thermal and UV aging.



Wire and Cable

The unique balance of high-temperature performance and flexibility offered by *Hifax* and *Adflex* 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 nonhalogenated, flame-retardant versions.

Soft Sheets and Profiles

Catalloy process technology offers products suitable for the extrusion, calendering 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 is soft profiles for windows.

Flexible Pipes and Hoses

Hifax and *Adflex* resins can be used as cost saving material or as a performance enhancer of flexible pipes and hoses. *Catalloy* process resins are also used for producing waterproofing liners for 'cured in place pipe' water- proofing applications.

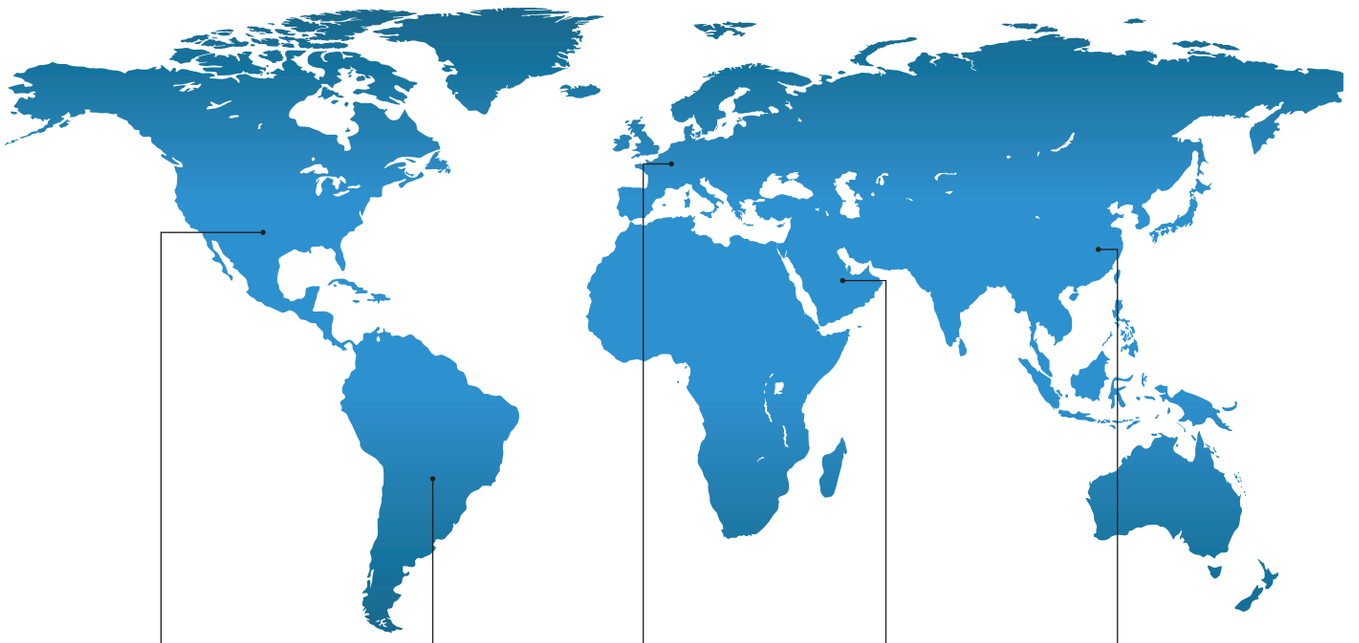
Textile and Carpets

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. *Adflex* materials are also used in carpet backing applications thanks to their ability to accept extremely high filler loading levels while maintaining physical properties, as well as their improved dimensional stability compared to PE-based materials and their waterproofing characteristics.

A world-wide company with regional support

LyondellBasell is one of the world's largest plastics, chemical and refining companies. We produce materials that are essential to shaping what comes next - in electronics, food packaging, construction materials, automotive components, motor fuels, textiles, medical supplies and more.

The Company's Amazing Chemistry is applied at 57 manufacturing sites located across five continents and in 18 countries.



North America
- USA
  - Illinois ■
  - Iowa ■
  - Louisiana ■
  - Michigan ●
  - New Jersey ■
  - Ohio ■ ●
  - Tennessee ■
  - Texas ■ ▲ ●
  - Houston ⬢
- Mexico ■ ▲

South America
- Brazil ■

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- China ■ ▲
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- S. Korea ▲
- Malaysia ▲
- Thailand ■ ▲
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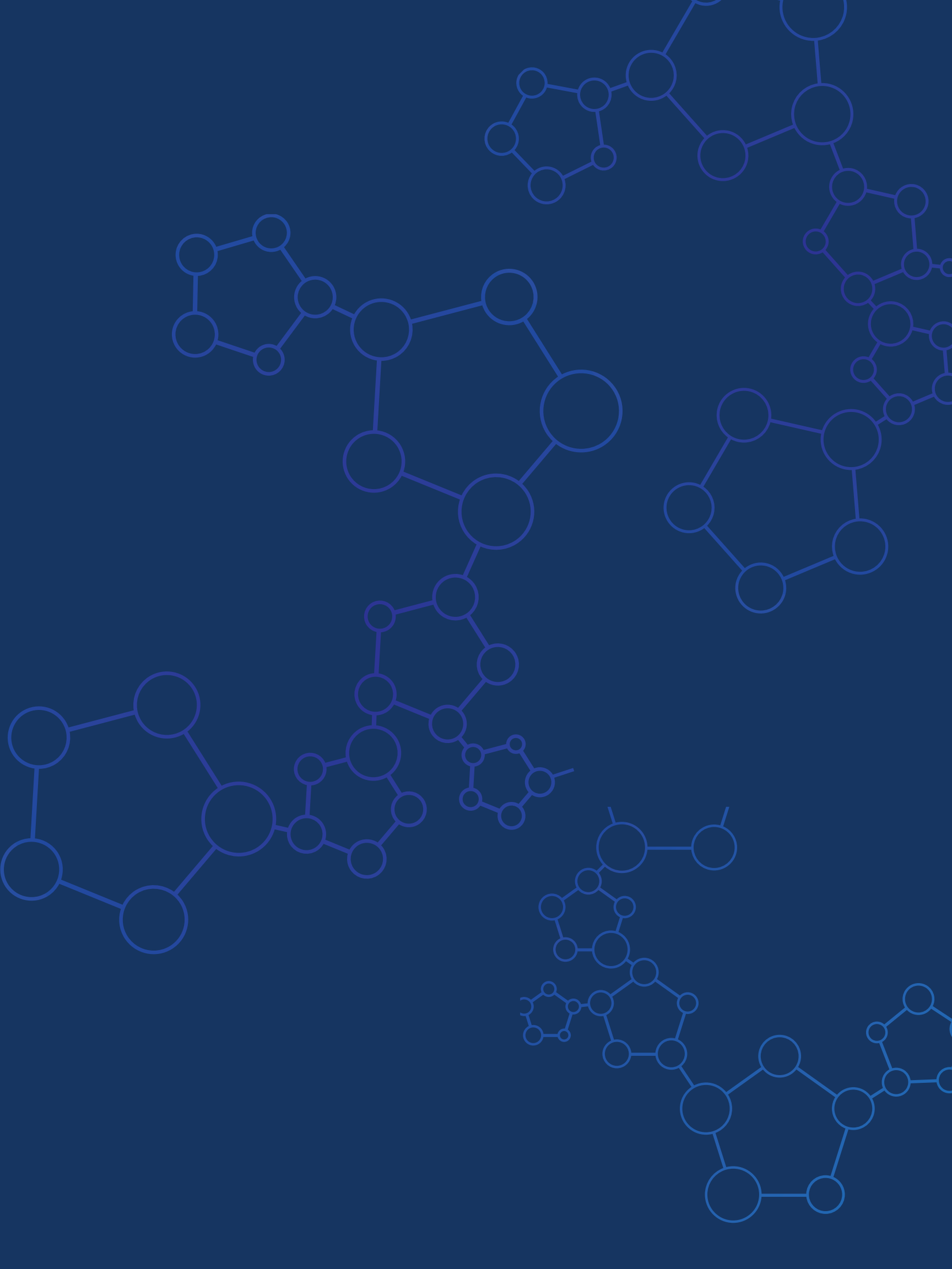

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For more information on the *Catalloy* family of products please contact Catalloy@lyb.com or visit lyb.com

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