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Advancing Possible

Advancing the Circular Economy with *Catalloy* produced grades

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Agenda

- LyondellBasell at a glance
- Challenges with post-consumer recycling streams
- *Catalloy* process: new resin approach
- New *Hiflex* product range as compatibilizer for improved impact properties
  - Mechanical properties and microscopic evidence
- *Adflex* Z101H
  - High flow for Injection Molding processes
- *Hifax* X 1956 A for improved surface aesthetics
- Conclusions

LyondellBasell – A Global Leader

LyondellBasell

# 1	# 2	# 3
PP COMPOUNDS, POLYOLEFIN LICENSING Globally POLYETHYLENE Europe	POLYPROPYLENE, PROPYLENE OXIDE, OXYFUELS Globally ETHYLENE, PROPYLENE, STYRENE North America	POLYETHYLENE + POLYPROPYLENE Globally ACETIC ACID POLYETHYLENE North America

$37 B

REVENUE
LTM 2Q19

MANUFACTURING SITES & JOINT VENTURES IN

24

COUNTRIES

SALES IN

>100

COUNTRIES

Source: LyondellBasell and industry consultants. Product rankings are as of December 31, 2018.

Advancing Sustainability

SERVING CUSTOMER NEEDS AND ADDRESSING SOCIETAL DEMANDS

SUSTAINABLE AND CIRCULAR PRODUCTS

Advancing sustainable technologies to create profitable business opportunities

qcp · MoReTec · Circulen

PLASTIC WASTE IN THE ENVIRONMENT

Developing and deploying meaningful solutions through our leadership in the Alliance to End Plastic Waste

ALLIANCE TO END PLASTIC WASTE

CLIMATE CHANGE

Achieve a 15% reduction in CO_2 equivalent emissions per ton of product by 2030

Circular Steam Project

Challenges with PP/PE post-consumer recycling

A major portion of polymer waste streams in the recycling industry is a combination of high-density polyethylene (HDPE), low-density polyethylene (LDPE) and polypropylene (PP)

Owing to their similar density, separation of these materials is complicated in the recycling stream

Besides the technical challenges, further segregation by resin type is economically impractical. Results are hence mix feed streams consisting of PP/PE blends

Depending upon the quality of the recycled feed and owing to the incompatibility between the two materials these blends of PP/PE may yield only limited mechanical properties or exhibit bad aesthetics

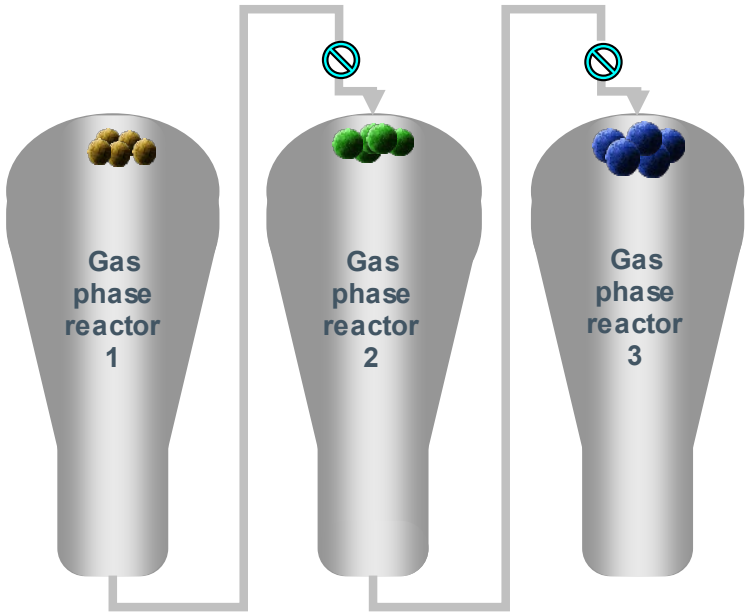
Advancing the circular economy with *Catalloy* produced grades

- Selected ***Catalloy*** produced grades enable to unlock waste potential by improving the mechanical properties and surface aesthetics of recycled materials
- ***Catalloy*** produced grades can expand the application options of recycled material

Catalloy technology for the production of thermoplastic polyolefins

- ***Catalloy*** **technology from LyondellBasell is a highly efficient closed-cycle process for the production of polypropylene based, thermoplastic polyolefins**

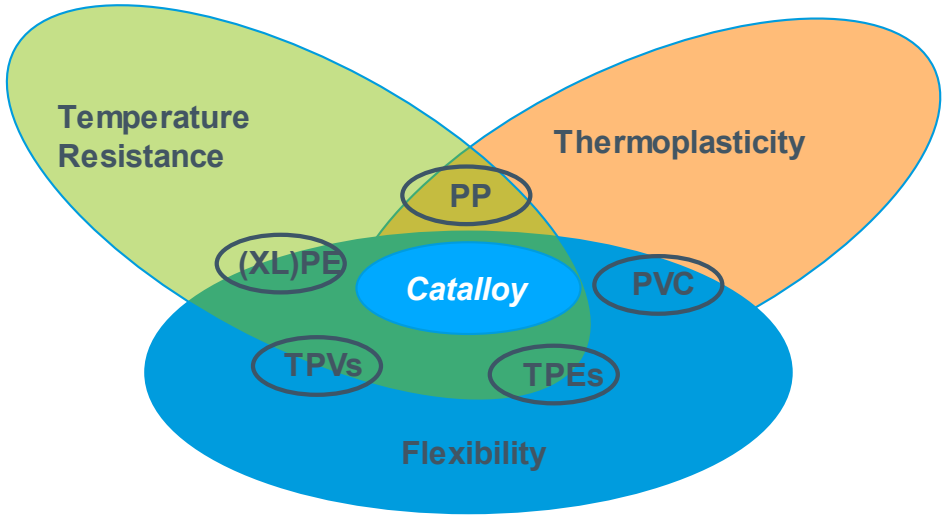
- ***Catalloy*** **produced grades main features**
  - Low density
  - Free flowing pellets/ easy handling
  - Natural color
  - No odor
  - Reduced emission
  - Low level of volatile (VOC) emission and fogging (FOG)
  - Free of plasticizers



Catalloy **technology - an outstanding process to produce polypropylene based thermoplastic polyolefins**

Catalloy produced grades: Advancing the profile of polypropylene properties

- *Catalloy* produced grades offer a unique set of properties that can outperform other polymers
- They can be utilized in all major conversion processes, including compounding, due to their softness and compatibility with other polymers
- These features allow customers to meet challenging requirements on recyclability and upcycling



***Catalloy* produced grades offer an advanced properties profile to boost upcycling**

Advancing the circular economy: Upcycling by improved mechanical properties

The new *Hiflex* family as compatibilizer for improved impact strength

- ***Hiflex* CA 7700A**
- ***Hiflex* CA 7800A**

Hiflex range*:* Advanced *Catalloy* produced grades

The *Hiflex* product range comprises a new generation of *Catalloy* produced grades that offer:

- Easy handling and storage
- Good mechanical properties balance at high/low temperatures
- High compatibility with both PE and PP
- Available in natural color

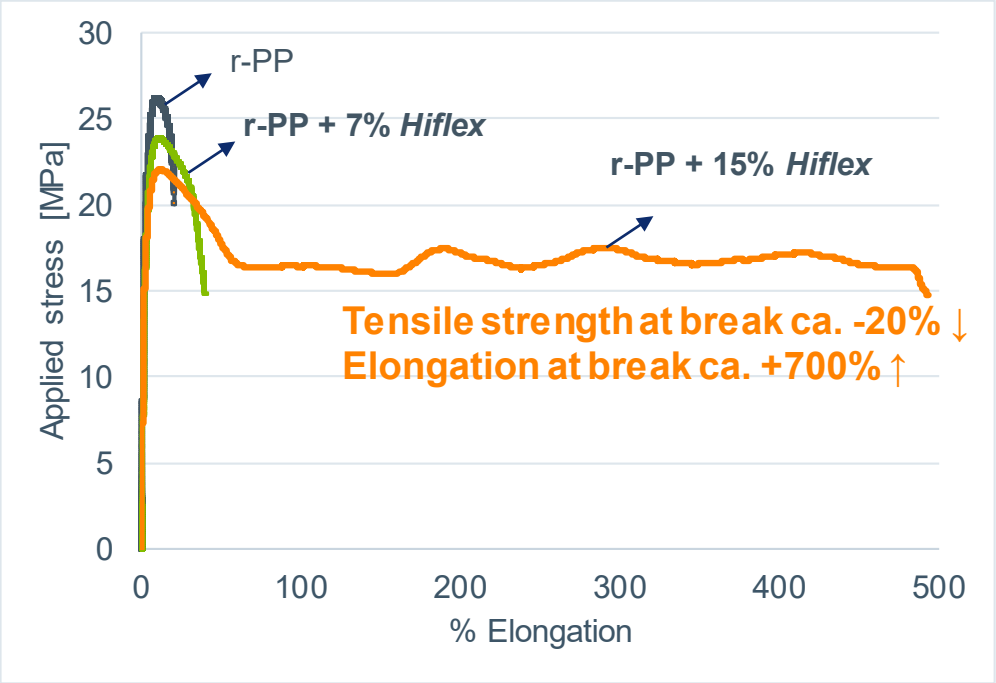
Hiflex	CA7800A	CA7700A	
Typical Properties	**Value**	**Value**	**Unit**
Density (ISO 1183)	0.88	0.88	g/cm³
MFR (ISO 1133 - 230°C/2.16 kg)	1.2	1.4	g/10 min
Flexural Modulus (ISO 527)	210	170	MPa
Notched Charpy Impact Strength – 20°C (ISO 179 1A)	85	NB	kJ/m²
DSC Melting temperature	161	143	°C

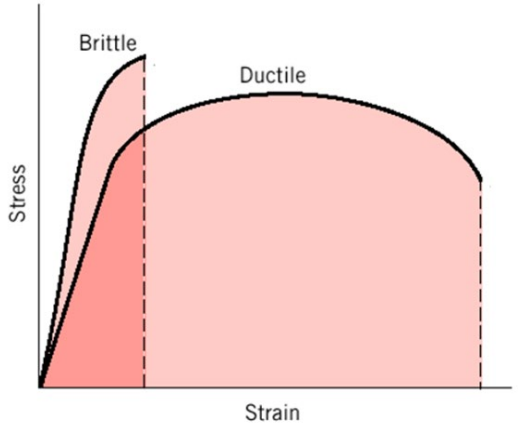
NB = No break
For TDS of LYB grades, please visit www.lyb.com

The new *Hiflex* product range combines high PP/PE compatibility with balanced mechanical properties

Effect of *Hiflex* grade on post-consumer recycled product: Improved impact strength

- **Tensile curves of post consumer recycled PP with different amounts of *Hiflex* grade**

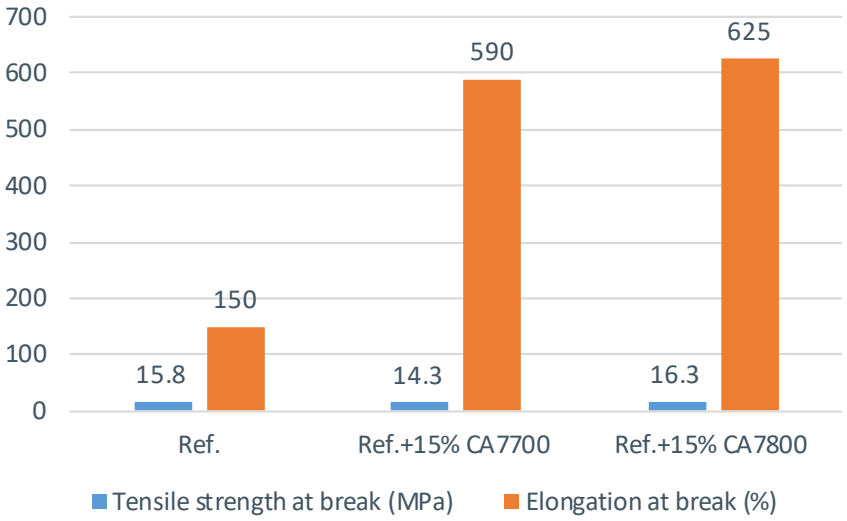


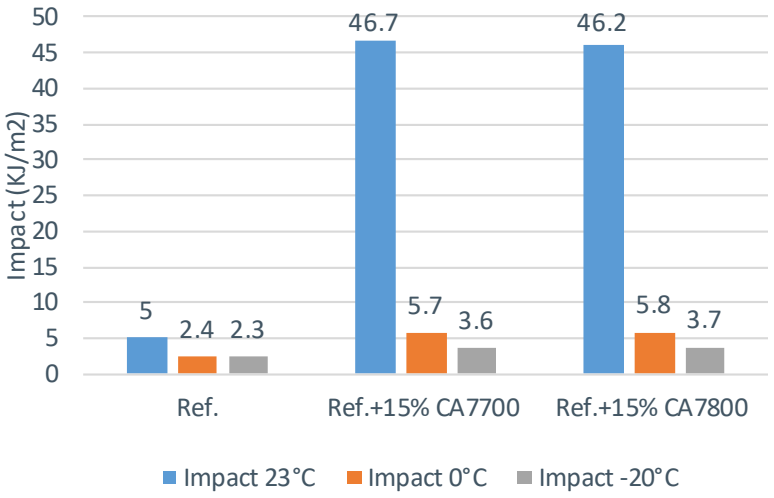


Courtesy of Revet S.p.a. (Pontedera - Italy)

- **Addition of *Hiflex* grade leads to a more ductile behavior**
- **Significant improvement in elongation at break observed upon adding 15% *Hiflex* grade**

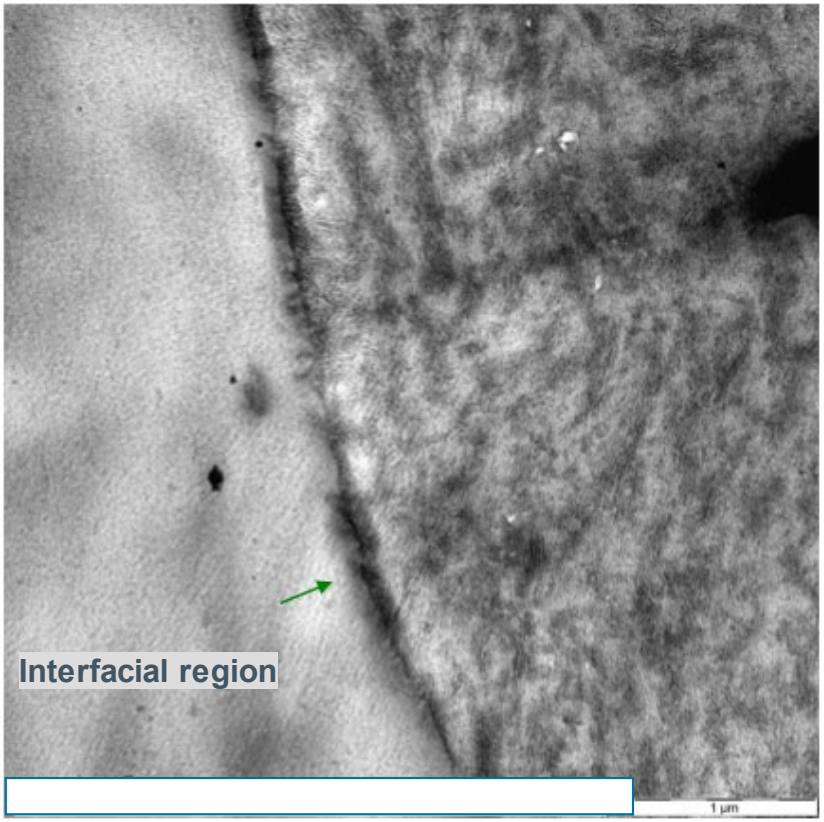
Hiflex grades as PP/PE compatibilizer : Improved impact strength



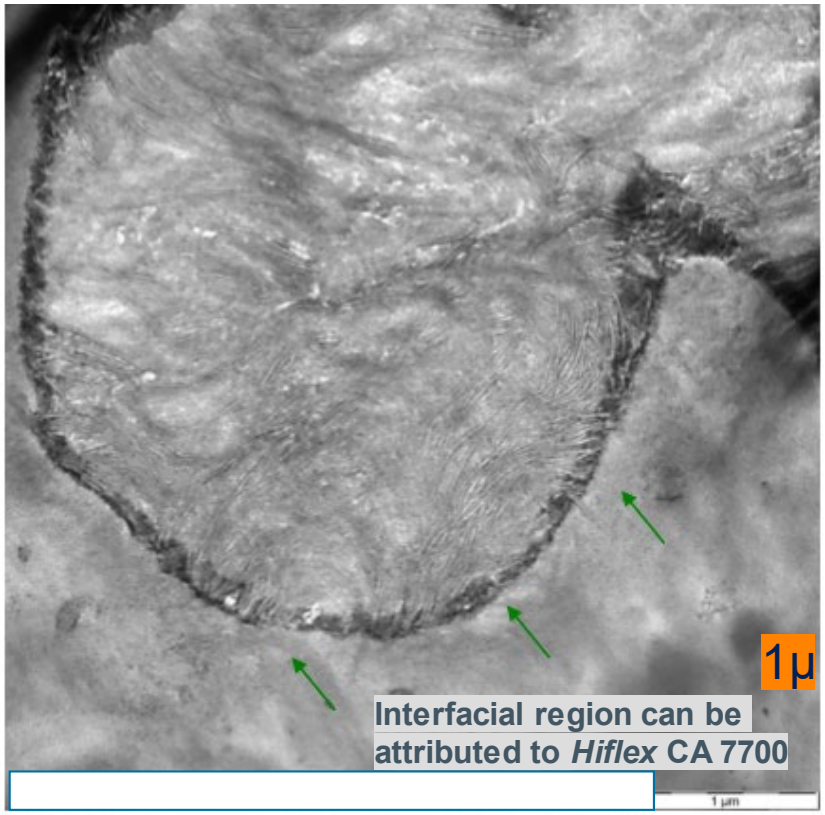


- **A 50/50 blend of PP Homopolymer and HDPE was taken as reference followed by the addition of 15% *Hiflex CA* 7700 A or *Hiflex* CA 7800 A**
- **Addition of *Hiflex* grades leads to a more ductile behavior with significant improvement in impact resistance especially at room temperature**

Hiflex CA 7700 A as compatibilizer: Transmission Electron Microscopy (TEM)



PP/PE Blend



PP/PE Blend + 15% *Hiflex* CA 7700

Hiflex CA 7700 A seems to be present in the interfacial region forming a bridge between PP and PE

Advancing the circular economy: Upcycling by high flow

***Adflex* Z101H as high flow compatibilizer for improved mechanical properties**

Adflex Z101H: High flow compatibilizer

- ***Adflex* Z101H**
  - High flow for demanding injection molding processes
  - Good compatibility with both PE and PP
  - Very good impact resistance at low temperature
  - Excellent tensile properties
  - High filler loading for good color dispersions

***Adflex* Z101H**		
Typical Properties	**Value**	**Unit**
Density (ISO 1183)	0.88	g/cm³
MFR (ISO 1133 - 230°C/2.16 kg)	27	g/10 min
Flexural Modulus (ISO 527)	80	MPa
Notched Charpy Impact Strength – 20°C (ISO 179 1A)	100	kJ/m²
DSC Melting temperature	142	°C

For TDS of LYB grades, please visit www.lyb.com

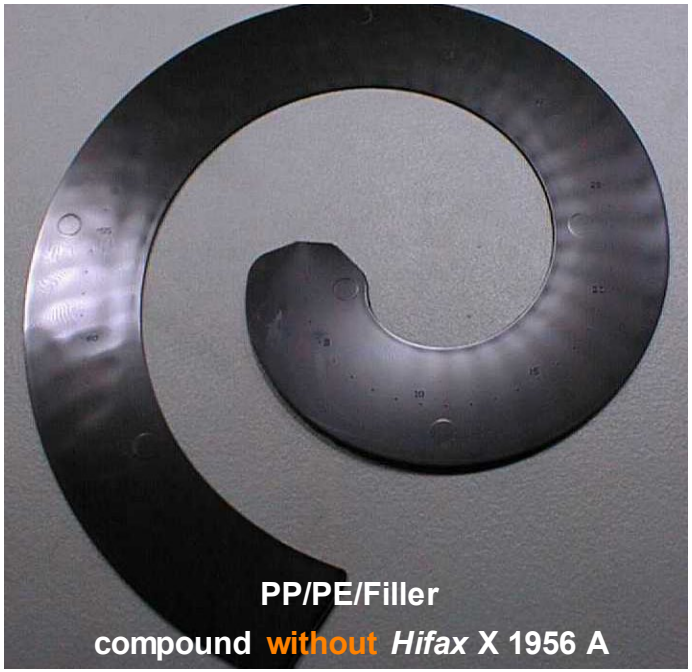
These are typical property values not to be construed as specification limits

Advancing the circular economy: Upcycling by improved aesthetics

Hifax **X 1956 A grade for improved surface aesthetics**

Hifax X 1956 A : Improved surface aesthetics of recycled products

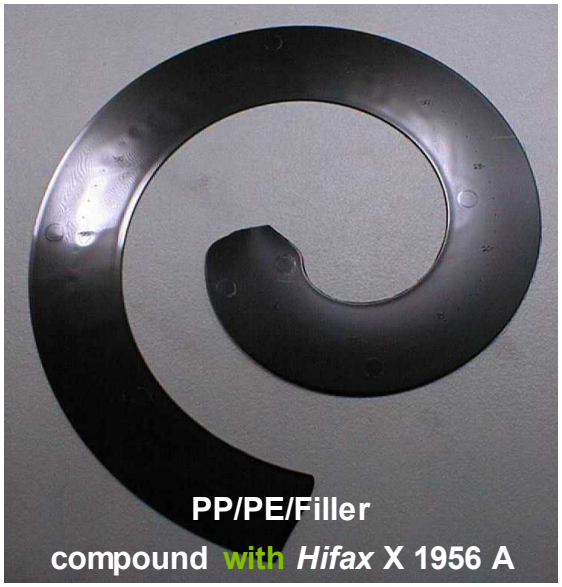
- **Flow Marks**
  - Asynchronous "Tiger Stripes" is a known surface defect that appears during injection molding of large parts especially when different materials are compounded, as it happens with recycled feeds



***Hifax* X 1956 A: a functional modifier for improved surface aesthetics**

Hifax X 1956 A : Improved surface aesthetics of recycled products

- **The *Catalloy* produced grade *Hifax* X 1956 A:**
  - Maintains the impact/ stiffness balance of the compound
  - Drastically improves the surface aesthetics of the moulded part, allowing the access to high value applications
  - Improvement is already visible from 5% addition



***Hifax* X 1956 A**		
Typical Properties	**Value**	**Unit**
Density (ISO 1183)	0.88	g/cm³
MFR (ISO 1133 - 230°C/2.16 kg)	0.9	g/10 min
Flexural Modulus (ISO 527)	800	MPa
Notched Charpy Impact Strength – 20°C (ISO 179 1A)	10	kJ/m²
DSC Melting temperature	163	°C

For TDS of LYB grades, please visit www.lyb.com

These are typical property values not to be construed as specification limits

***Hifax* X 1956 A: a functional modifier for improved surface aesthetics**

Conclusions

- *Catalloy* produced grades are polypropylene based thermoplastic polyolefins and hence recyclable
- *Catalloy* produced grades *Hiflex* CA 7700 A and *Hiflex* CA 7800 A act as compatibilizer in recycled PP/PE blends, delivering a significant improvement in the impact resistance for the final item
- *Adflex* Z101H is an excellent alternative compatibilizer for good improved impact strength when high flow is requested by the injection molding process
- In value added applications when surface aesthetics of finished products is a key property, *Hifax* X 1956 A from *Catalloy* technology can be the product of choice
- Addition of grades from *Catalloy* technology in recycled PP/PE blends may improve circularity and upcycling of products and expand the application options

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