



Chemical webinar series

Rethink Recycle: Inspiring new solutions for recycled plastics

November 2020





Rethink Recycle





ExxonMobil

Every year
400m tons of plastic are produced



Every year
400m tons of plastic are produced



**100m tons
in use**



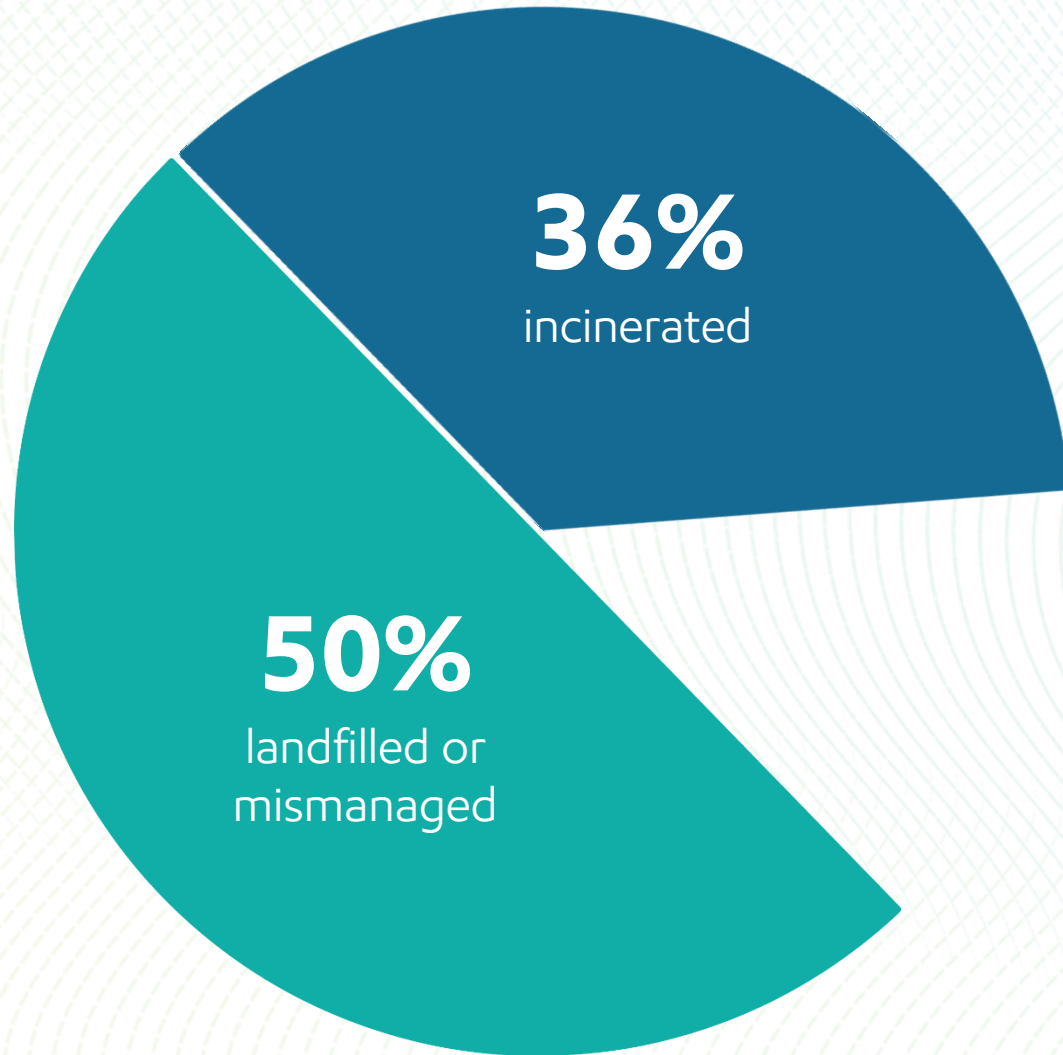
**300m tons
is waste**

300m tons of plastic waste

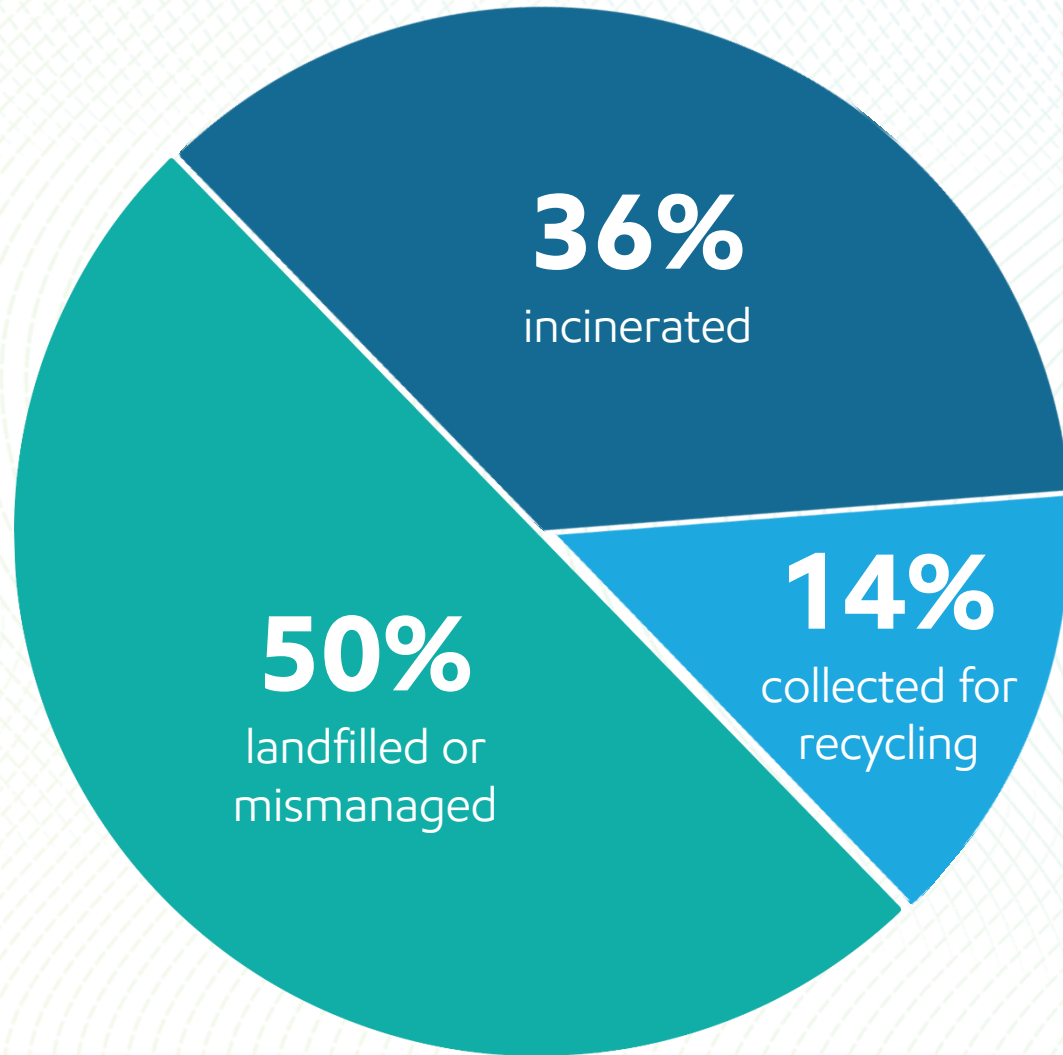
50%
landfilled or
mismanaged

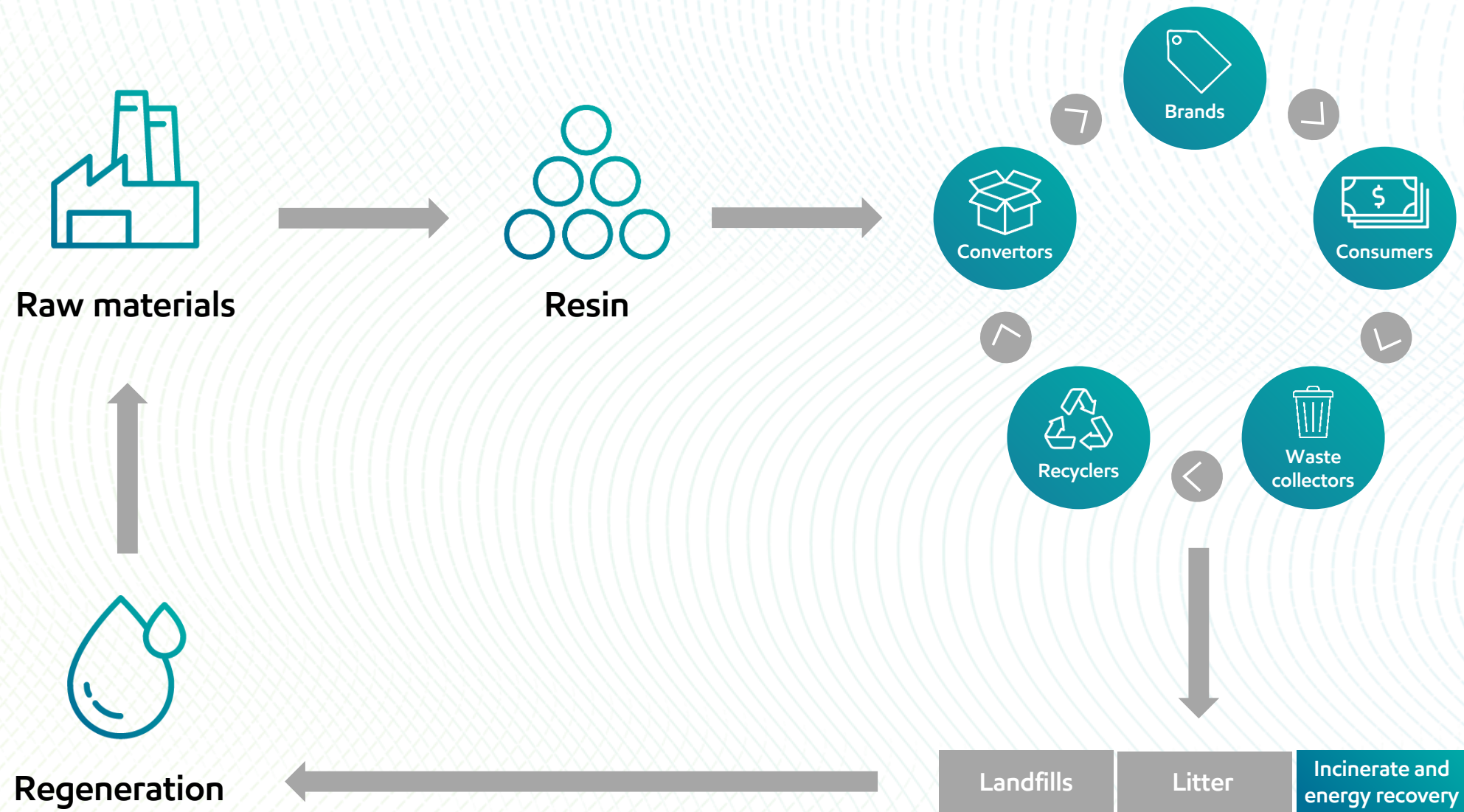


300m tons of plastic waste

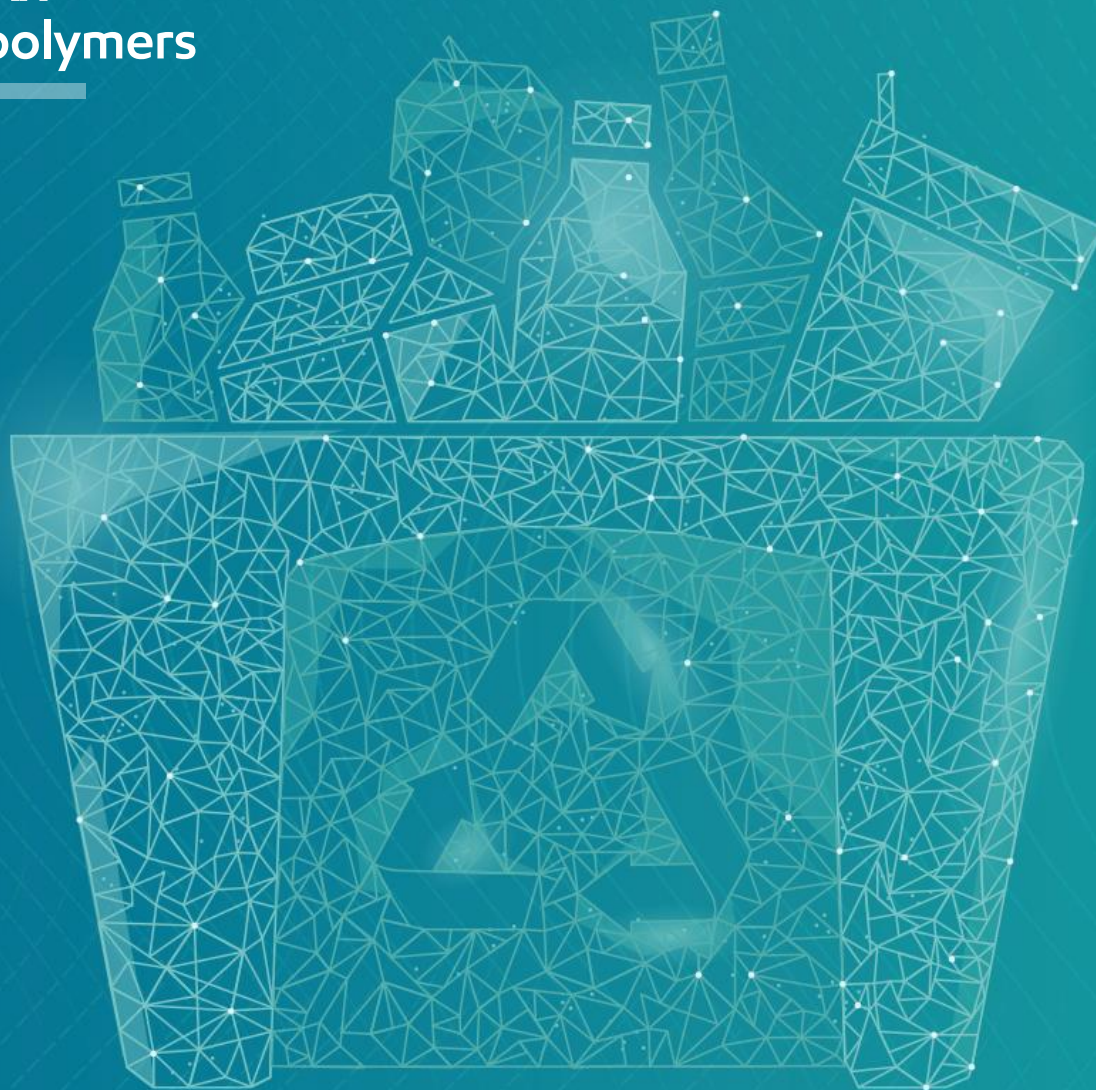


300m tons of plastic waste

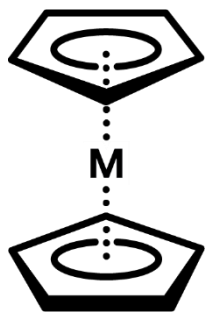




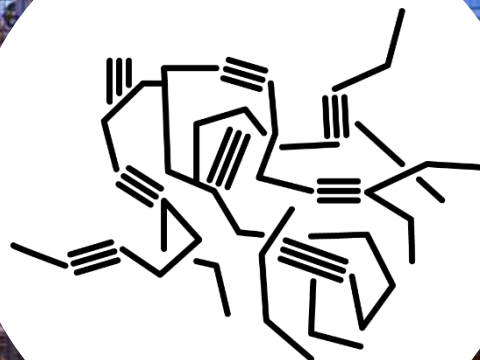
Vistamaxx™
performance polymers



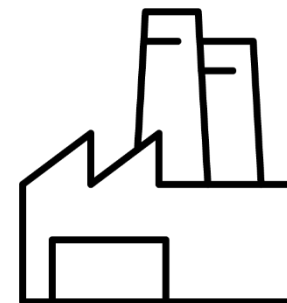
Vistamaxx™ performance polymers



Metallocene



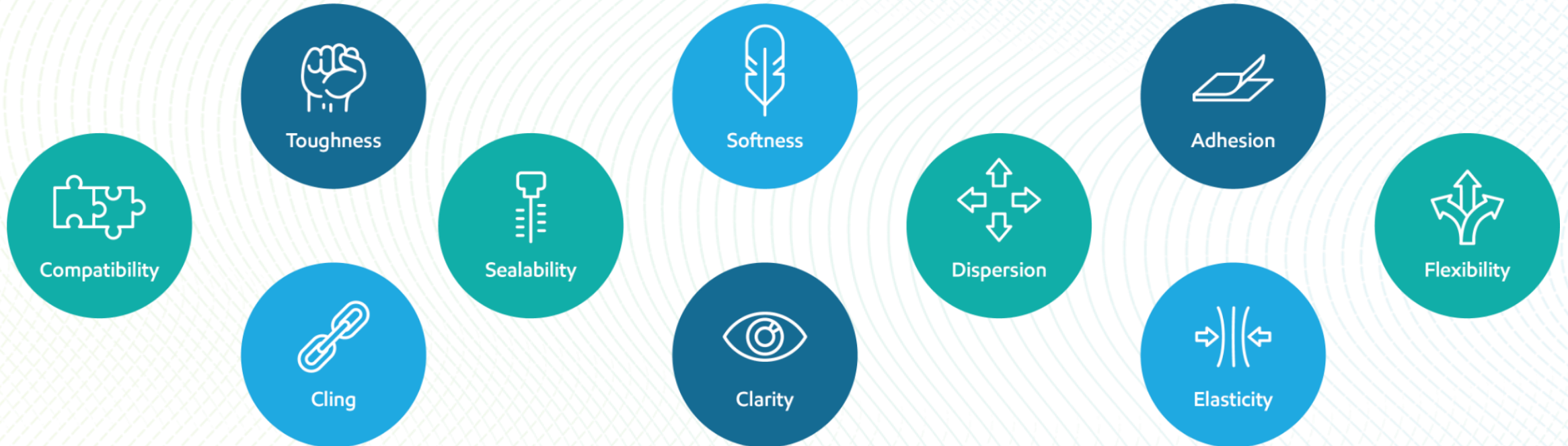
Semi-crystalline
copolymer



> 700 kT capacity

Expanding growth potential

Key attributes inspire innovative solutions



Vistamaxx™ performance polymers



Design
for recycling



Upgrade
of recycle

Vistamaxx™
performance polymers



Design for
recycling

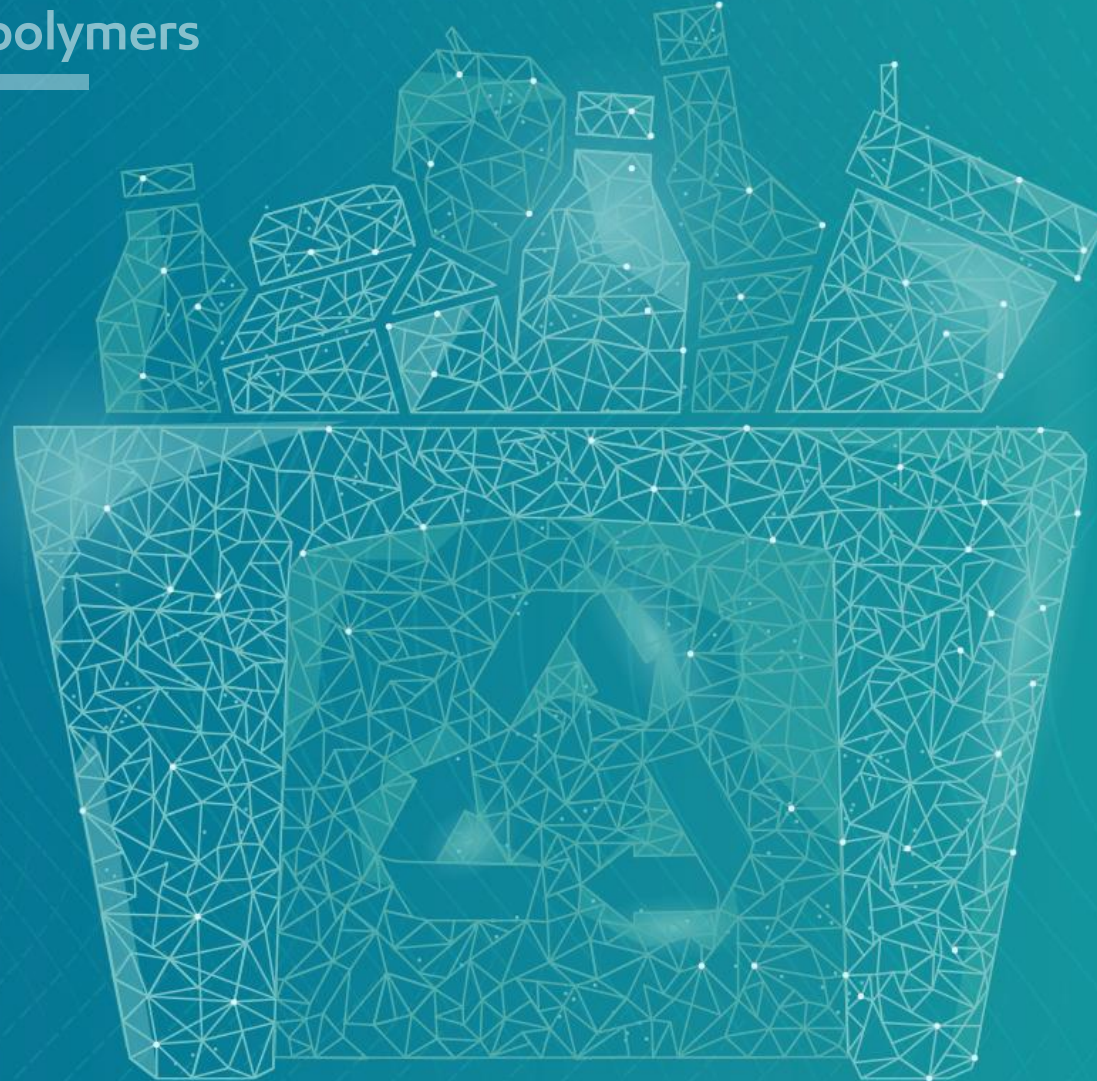


Enabling recyclability of multiple flooring systems



Vistamaxx™ performance polymers empower designers to consider end-of-product-life recycling.

Vistamaxx™
performance polymers



Design for
recycling

Upgrade of
recycle





Unlock new
applications



Increase
recycled content



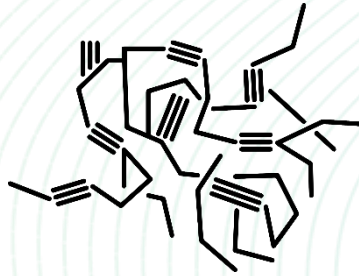
Reduce raw
material cost



**Let's take
a closer look**

Non-polar streams

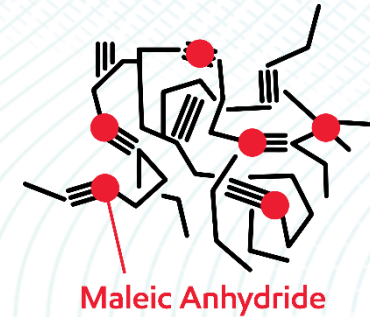
with Vistamaxx™
performance polymers



PE film
PP rigid
HDPE rigid

Polar streams

with MAH-grafted Vistamaxx™
performance polymers



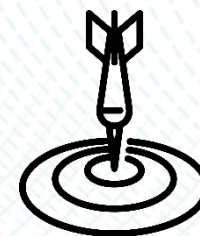
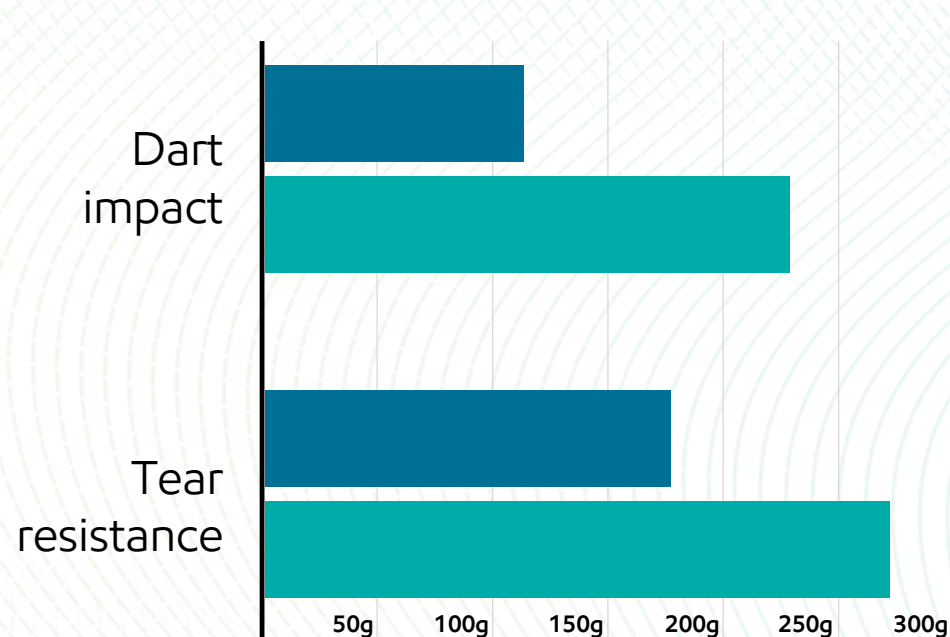
e.g. **Acti-Tech™ compatibilizers**
from Nordic Grafting Company

PA & EVOH barrier film
PET based

Upgrade of PE film recycled streams



Upgrade PE stream contaminated with PP in blown film



2X impact



+48% Tear resistance



Application case study - garbage bags

Industry challenges

- Difficult to balance cost and performance
- Market demand to incorporate more recycled plastics

Incumbent solution

- 60% LLDPE + 20% PIR/PCR PE + 20% Filler MB

Vistamaxx™ performance polymer solution

- 15% LLDPE + 60% PIR/PCR PE + 20% Filler MB + 5% Vistamaxx™ 6102

Key learnings

- Maintaining dart impact and tear resistance while reducing material cost
- Allowing higher percentage of recycled plastics, even with PP contamination



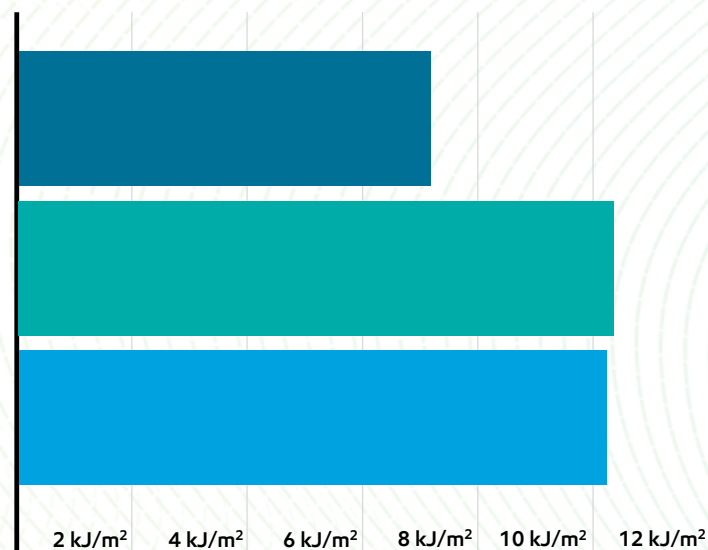
Case studies are based on industrial trials and learnings are believed to be reliable and representative. For optimized performance, comprehensive design of experiments is highly recommended. Please refer to general disclaimer at the end.

Upgrade of PP rigid recycled streams



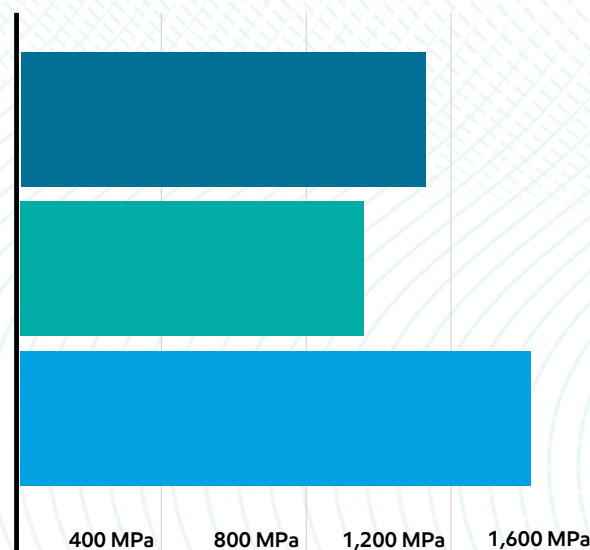
Upgrade PP stream contaminated with PE in injection molding

Notched charpy impact @23°C



+47% impact strength

Flex modulus



+15% flexibility

- Recycle reference
- Vistamaxx™ performance polymer solution**
Recycle + 5% Vistamaxx™ 6202
- Virgin ICP

Application case study – reusable crates & pallets

Industry challenge

- Process issues in manufacturing and low yield when using PCR
- Damages in service after recurring loads due to poor impact resistance

Incumbent solution

- 100% PCR PP

Vistamaxx™ performance polymer solution

- 95% PCR PP + 5% Vistamaxx™ 6202

Key learnings

- Optimized flow and broader processing window during compounding and injection molding process
- Improving impact strength and toughness while allowing higher percentage of recycled plastics, even with PE contamination



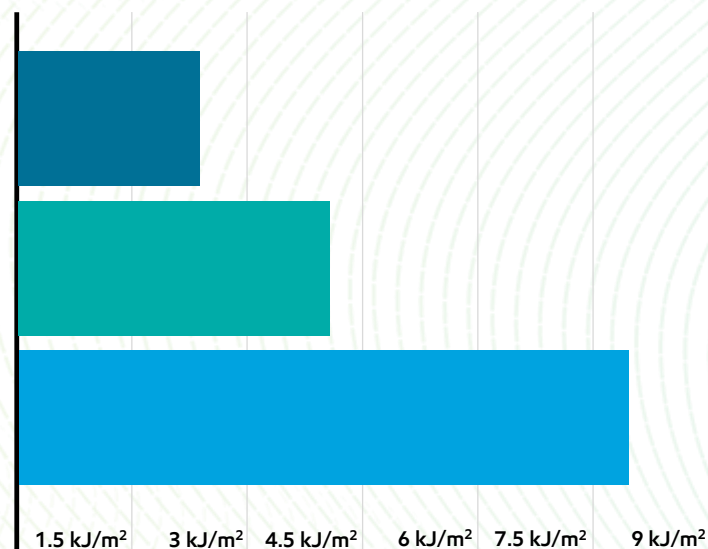
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Upgrade of HDPE rigid recycled streams



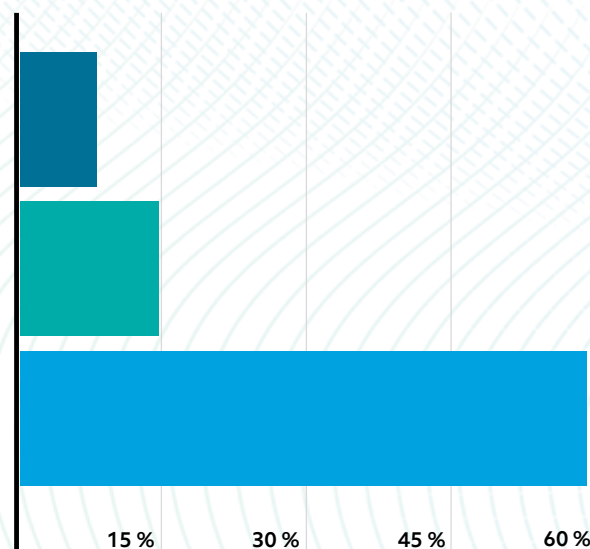
Upgrade HDPE stream contaminated with PP in blow molding

Notched charpy impact @23°C



+250% impact strength

Elongation at break

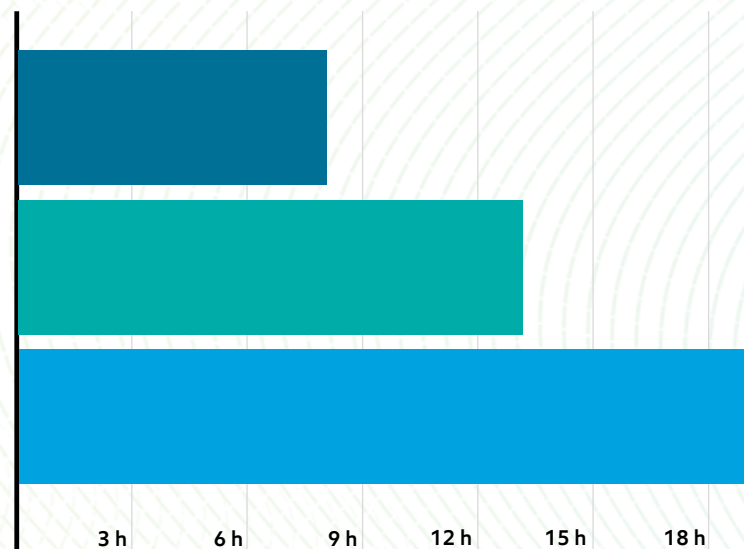


7X elongation

-  Recycle reference
-  **Vistamaxx™ performance polymer solution**
Recycle + 5% Vistamaxx™ 6102
-  **Vistamaxx™ performance polymer solution**
Recycle + 10% Vistamaxx™ 6102

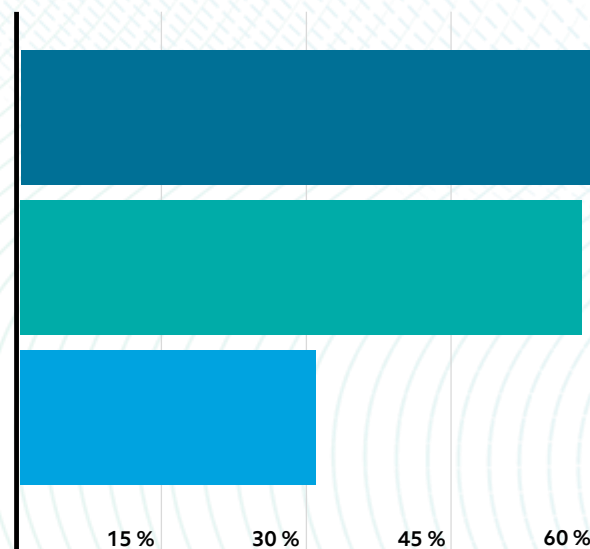
Improving ESCR of blow molded HDPE recycled streams

ESCR 10% Igepal @ 50°C f50



Extended part
life

Estimated cost savings versus virgin



Reduce raw
material cost

- Recycle reference
- Vistamaxx™ performance polymer solution**
Recycle + 5% Vistamaxx™ 3020FL
- 50/50 blend virgin / recycle reference

Case study: incorporating recycle

Attributes

- ESCR improvement, flexibility & impact

Description

- 5 U.S. Qts. monolayer blow molded HDPE bottle
- Customer requirements:
 - Incorporation of internal regrind and PCR
 - Survive transportation & stacking conditions with no cracks
 - Balance topline and ESCR

Incumbent solution

- Virgin HDPE combined w/ regrind and PCR HDPE
- Did not meet ESCR specifications demonstrated through leaks

Vistamaxx™ performance polymer solution

- Vistamaxx™ 3020FL + regrind + PCR + virgin HDPE
- Bottles met internal specifications for topline and increased ESCR

Why Vistamaxx™ polymers solution?

- Increase ESCR properties of the formulation
- Higher flexibility did not compromise topline requirements

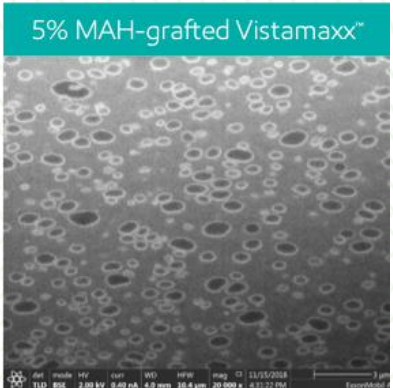
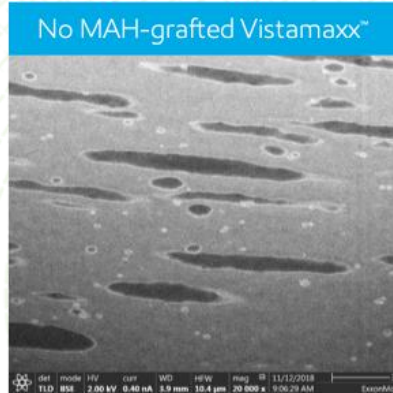
ExxonMobil



Trade of PA & EVOH
for film recycled streams

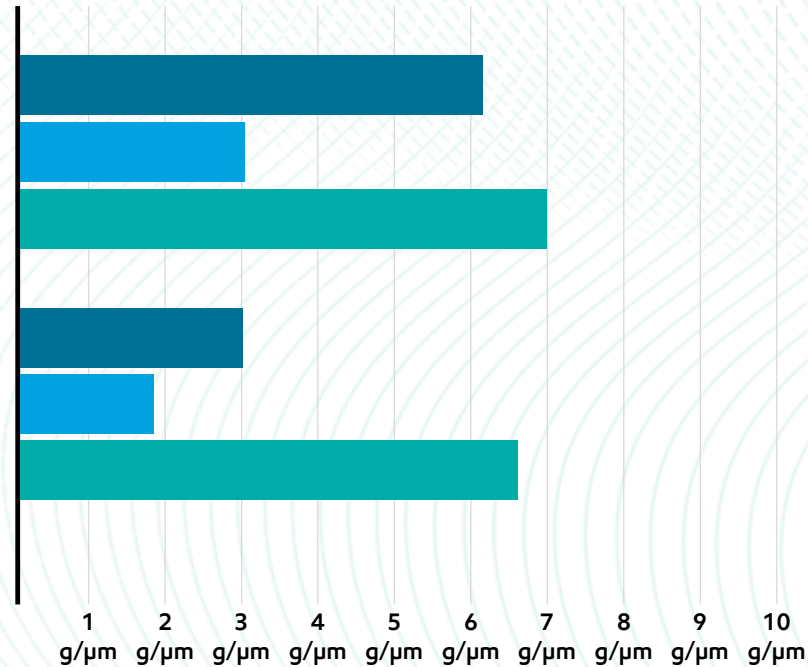


Upgrade PE/PA virgin blends in blown film

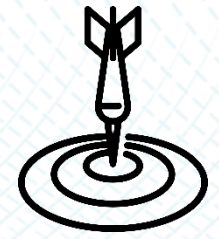


Elmendorf tear
resistance MD

Dart
impact



- PE virgin reference
- PE/PA virgin compound (71% PE / 29% PA)
- PE/PA virgin compound **with 5% MAH-grafted Vistamaxx™ performance polymers**



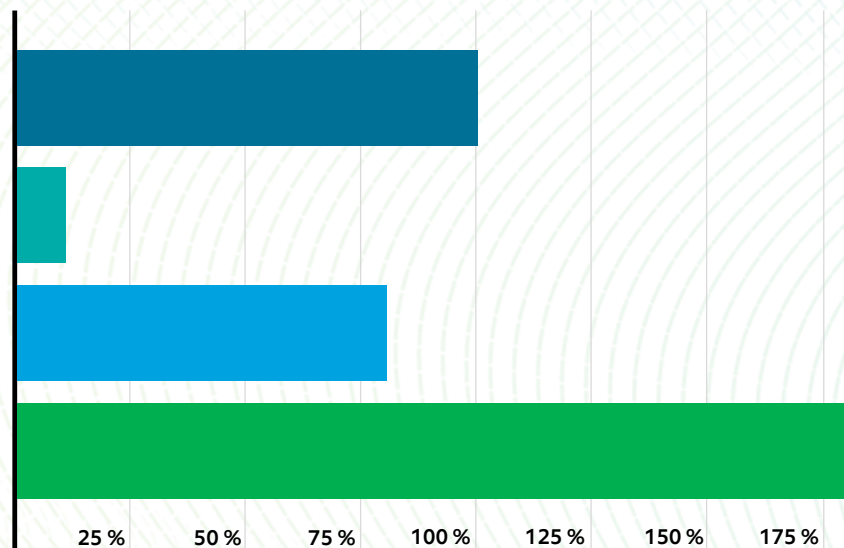
4X impact



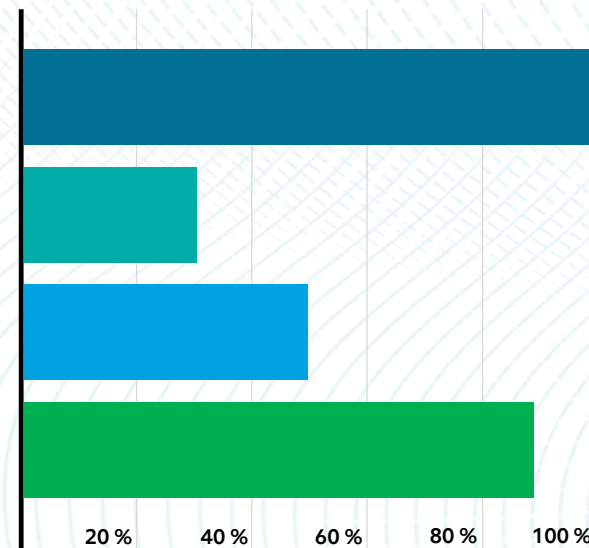
2X Tear resistance

Upgrade PE/PP/PA/EVOH recycled stream in blown film

Relative Elmendorf tear MD versus virgin C4 LLDPE¹



Relative cost versus virgin C4 LLDPE



¹Compatibility is reflected by Elmendorf tear in MD

- Virgin C4 LLDPE
- Barrier film recycle reference (30% PE, 40% PP, 25% PA, 5% EVOH)
- 92.5% barrier film recycle reference + 7.5% MAH-grafted Vistamaxx™ performance polymer
- 46.25% barrier film recycle reference + 46.25% Exceed™ 1018 performance polyethylene + 7.5% MAH-grafted Vistamaxx™ performance polymer

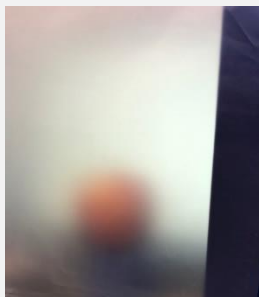
Improved opticals through compounding

Dry blend

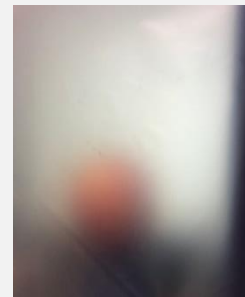
No Compatibilizer



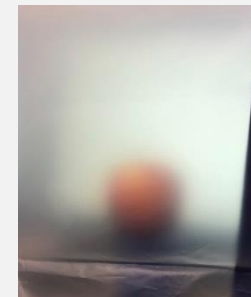
+ 5 % MAH-grafted Vistamaxx™
performance polymer



+ 7.5 % MAH-grafted Vistamaxx™
performance polymer

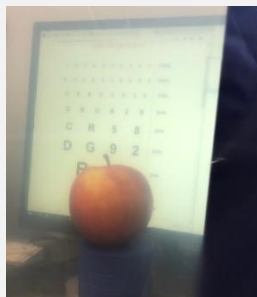


+ 15 % MAH-grafted Vistamaxx™
performance polymer

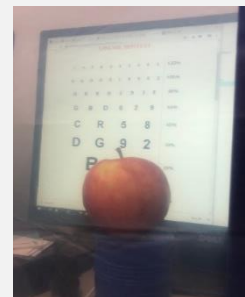


Compounded

+ 5 % MAH-grafted Vistamaxx™
performance polymer



+ 7.5 % MAH-grafted Vistamaxx™
performance polymer



All films are 50µm and monolayer

Compatibilizer was added to 60 % PE / 40 % PA barrier film recycled stream

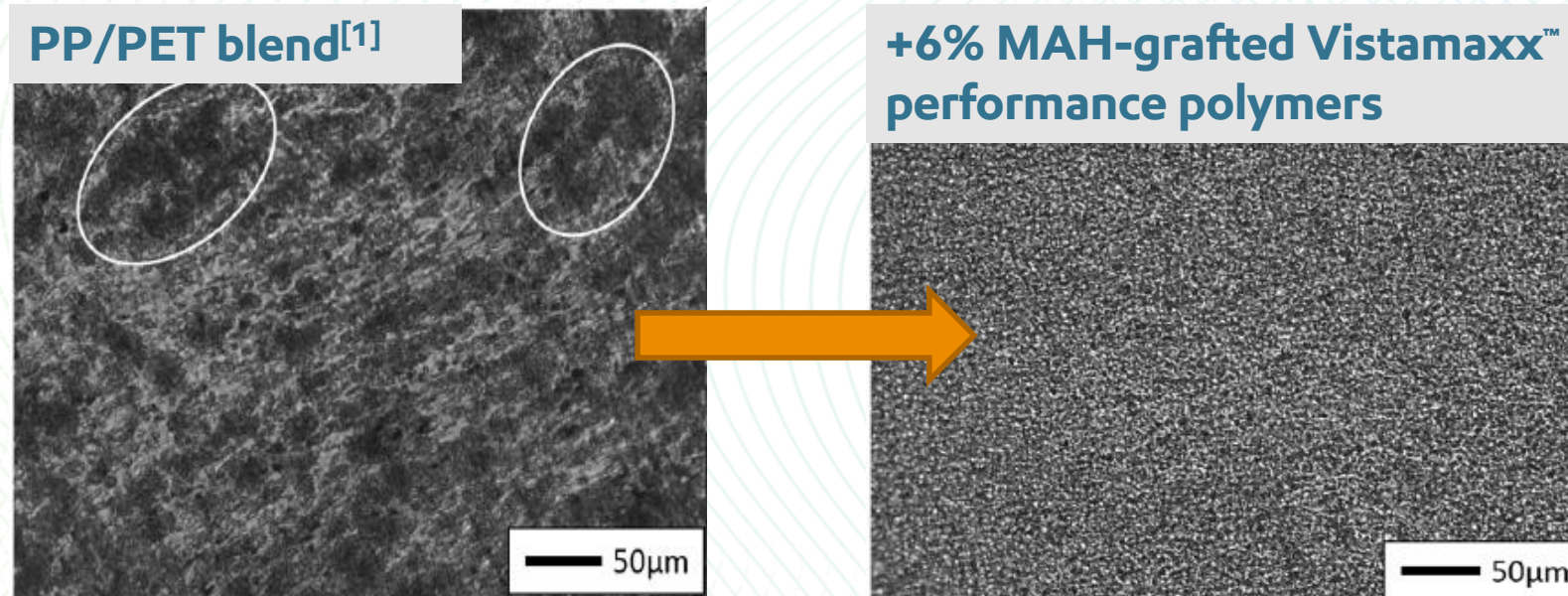
Upgrade of PET-based recycled streams



MAH-grafted Vistamaxx™ performance polymers upgrade PP/PET blends

Functionalization *enables alloy of non-compatible polymers*:

- Enhances & controls morphology
- Improves blend performance by chemical linking
- Increases performance of recyclates

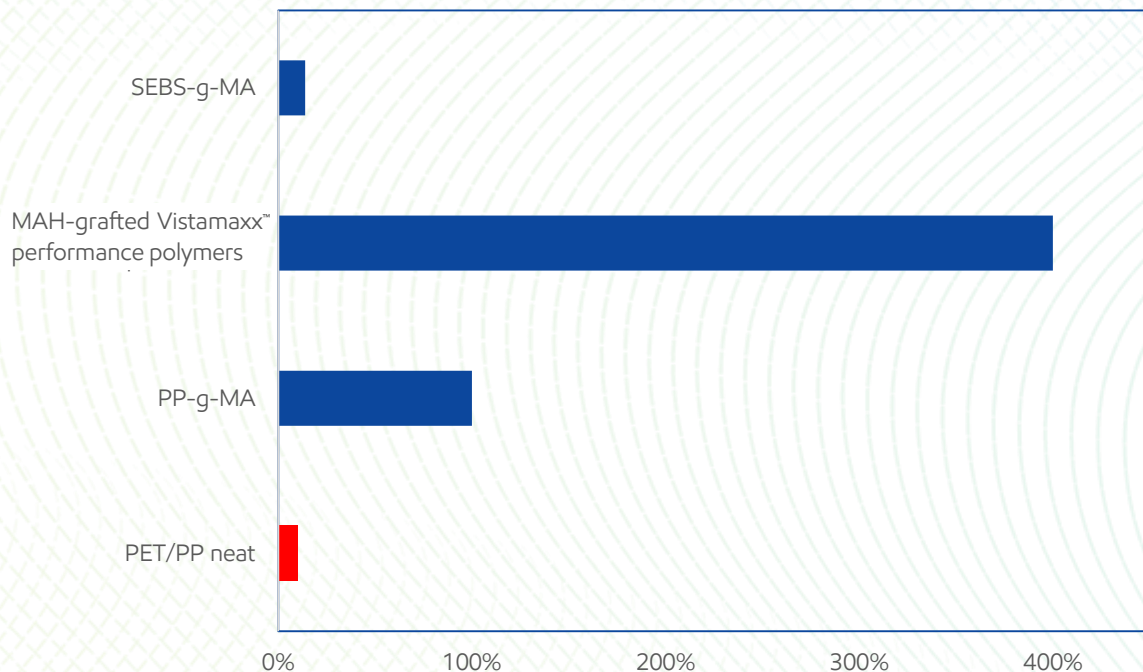


Images courtesy of Ghent University

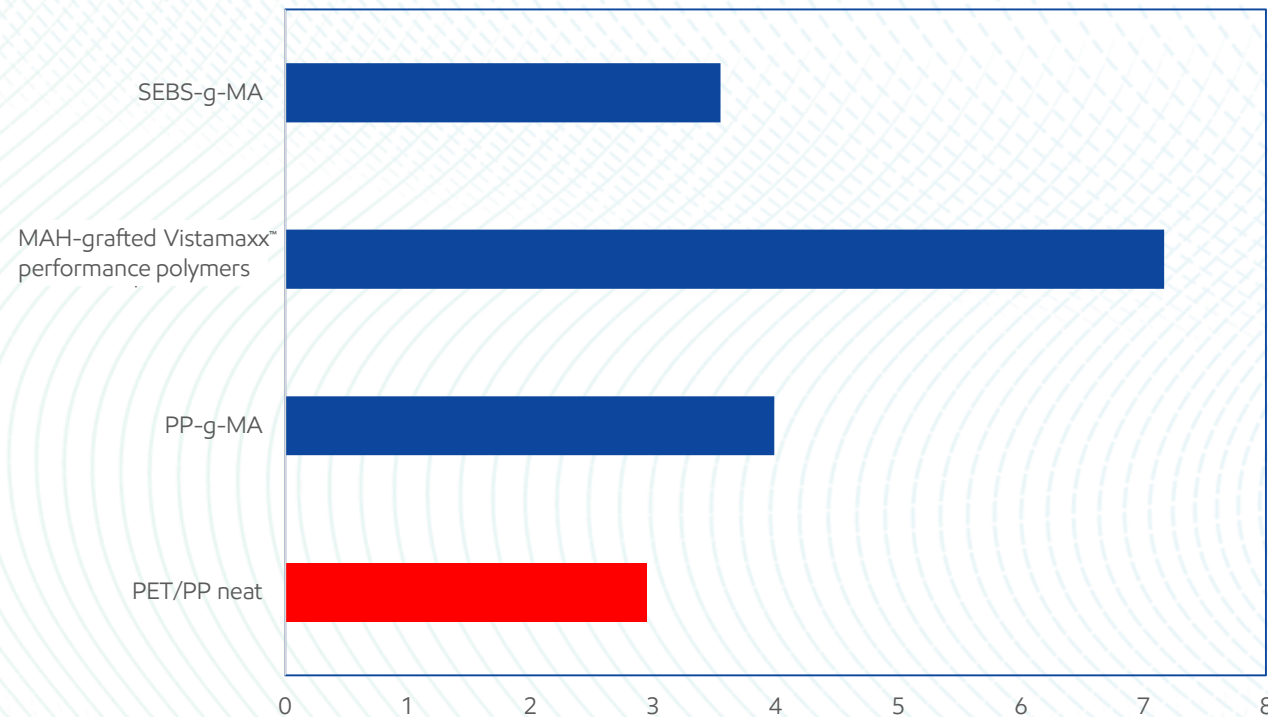
[1] Kuzmanović, M., Delva, L., Mi, D., Mi, D., Martins, C. I., Cardon, L., & Ragaert, K. (2018). Development of crystalline morphology and its relationship with mechanical properties of PP/PET microfibrillar composites containing POE and POE-g-MA. *Polymers*, 10(3), 291. <https://doi.org/10.3390/polym10030291>
PP/PET blend at 80 wt% PP and 20 wt% PET

MAH-grafted Vistamaxx™ performance polymers upgrade PP/PET blends

Elongation at break [%]

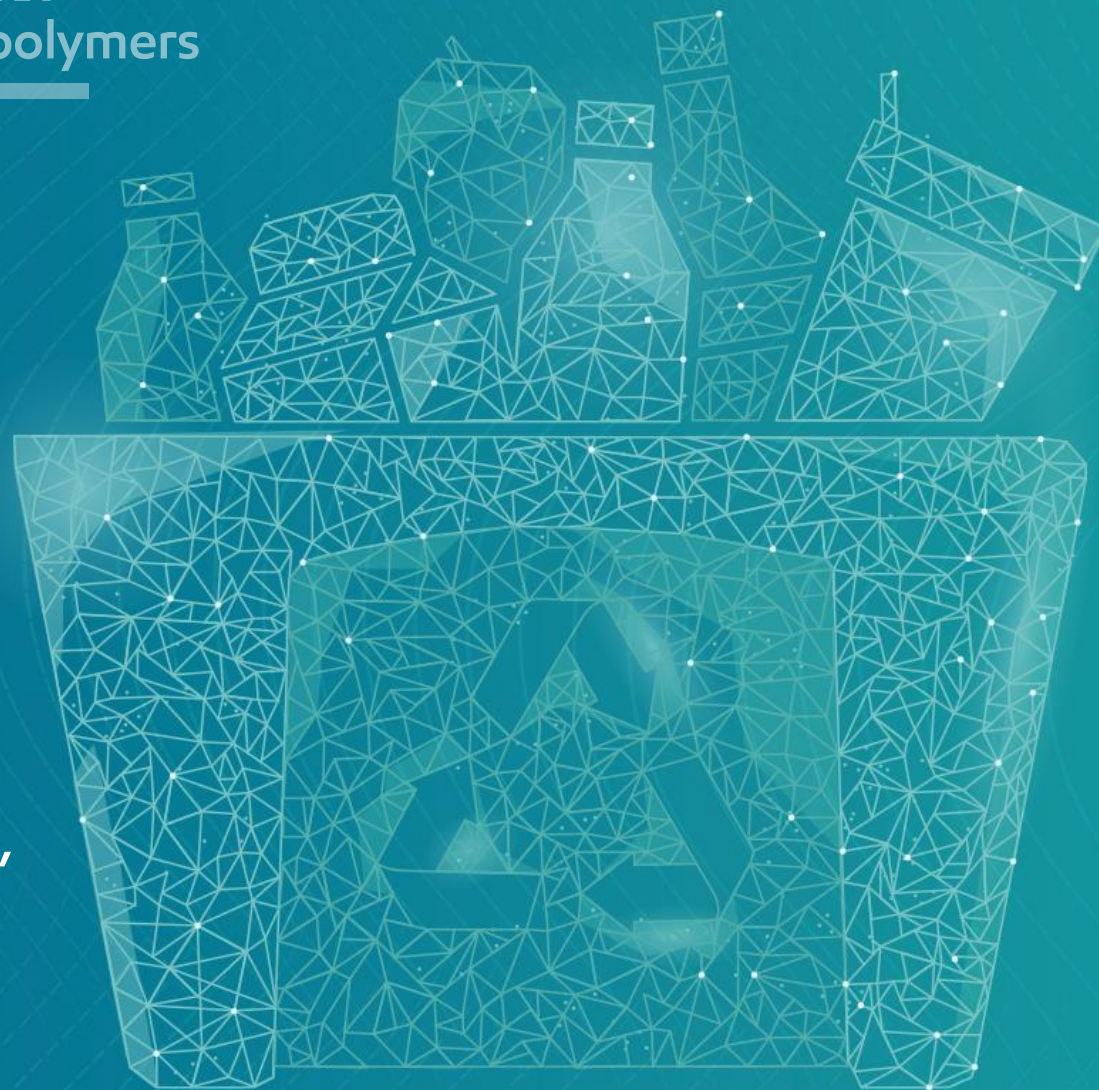


Notched Charpy impact [kJ/m2]



Functional evaluation of compatibilization systems for recycled PP-PET blends
L. Delva, M. Kuzmanovic, T. Wieme, N. Mys, K. Ragaert, PPS conference 2017, Mexico
PP/PET blend at 80 wt% PP and 20 wt% PET

Vistamaxx™
performance polymers



Design for
recycling

Upgrade of
recycle

Cleaner beaches,
useful products



Cleaner beaches, useful products



Vistamaxx™ performance polymers

Working together to Rethink Recycle

#RethinkRecycle

Vistamaxx™
performance polymers



exxonmobilchemical.com/rethinkrecycle

atandocabos.cl

erema.com

zaboplant.nl

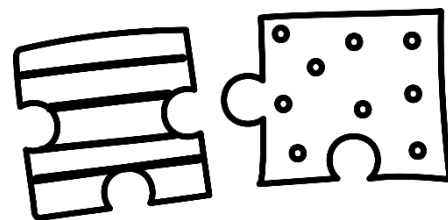
ExxonMobil



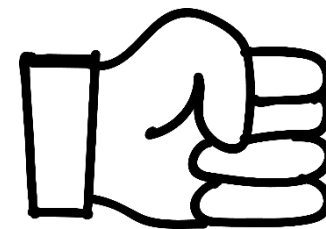
EREMA

Zabo Plant
LILIES FOR PROFESSIONALS

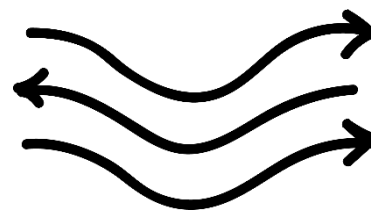




Compatibilizes
PP and PE



Up to 45% better
impact strength



Up to 40% better
flow rate



Unlocks new
product possibilities



Design
for recycling



Increased
recycled content



Lower
cost sources



High
performance



Chemical webinar series



Elvira Mitiukova
Key account manager



Martín Machado
Customer application development
engineer



Scan to contact an expert



Interested in learning more?
exxonmobilchemical.com/rethinkrecycle



Thank you for attending





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Test

Elmendorf tear strength

Impact resistance by free-falling dart: Method A and B

Microscopy FIB-SEM sample preparation

Flexural modulus

Notched Charpy impact

Melt flow rate

Gardner impact

Test method based on

ASTM D-1922-09

ASTM D-1709

- Stain with RuO₄
- Stuck to Al stubs with carbon tape and sputter coated with gold

ASTM D790

ISO 179

ASTM D1238

ASTM D5420