



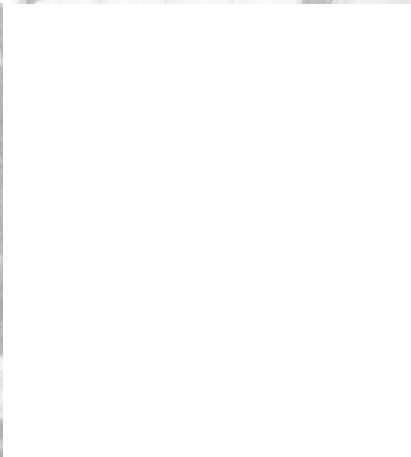
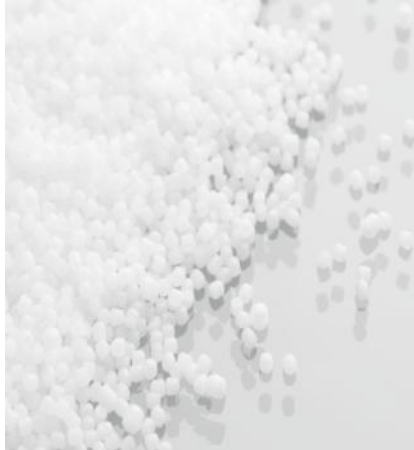
Talent | Technology | Trust™

# **Advanced Ziegler-Natta Catalyst Tools to Empower Polypropylene Innovators**

Manu Rego  
John Kaarto  
Amaia Montoya

2017 SPE International  
Polyolefins Conference

Houston, Texas USA  
February 2017



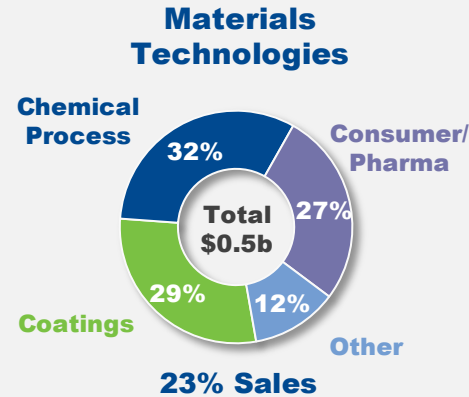
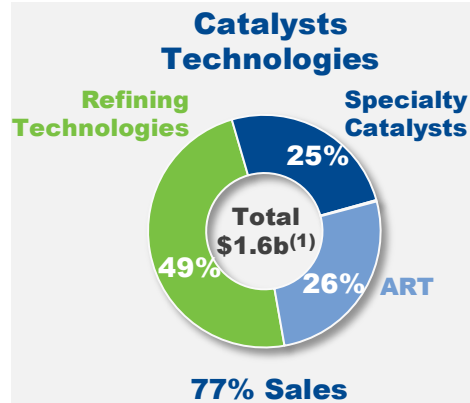
# Outline

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- Grace at a glance
- Grace Catalyst Technologies
- Grace approach to innovation and product development drivers
- Grace PP ZN catalyst development tool box
- Grace PP catalyst portfolio
- Innovation Showcases
- Conclusions



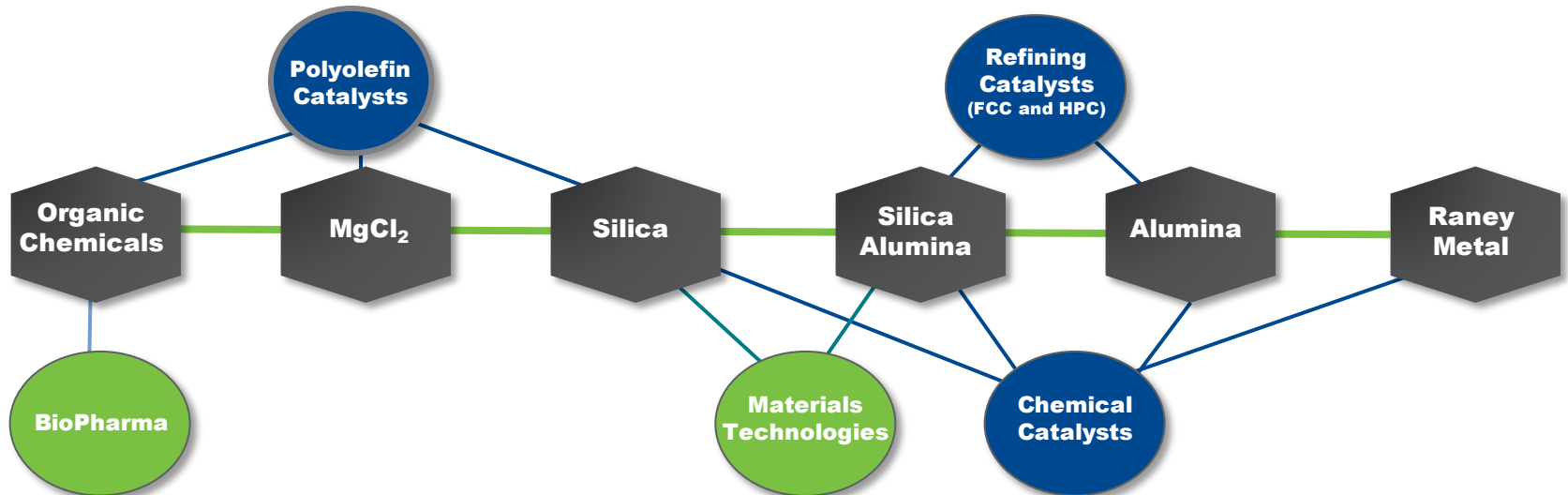
## We Are a \$2 Billion Technology Leader...



### Leadership Positions

- #1 in FCC catalysts
- #1 in resid hydroprocessing catalysts
- #2 in hydrocracking catalysts
- #1 in polyolefin catalysts
- #2 in polypropylene process technology licensing
- #1 in specialty silica gel, pioneer in multiple segments

## ...Connected Through our Materials Science Expertise



## Product Offering

### Refining Technologies (RT)

- FCC catalysts and additives for petroleum refiners

### Advanced Refining Technologies (ART)

- Hydroprocessing catalysts

### Specialty Catalysts (SC)

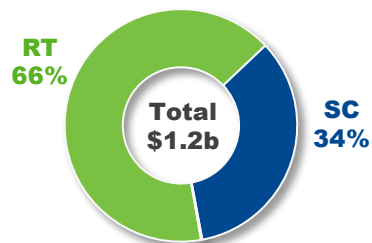
- Catalysts, supports, and technology licensing for polyolefins and specialty chemicals

### Key Industries

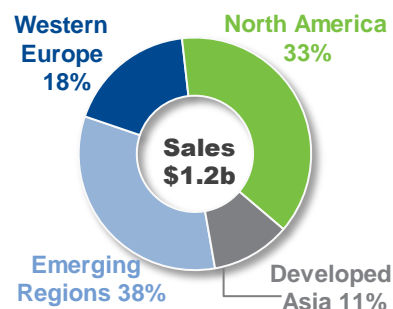
- Oil Refining
- Petrochemicals and Biochemicals
- Polyolefins

### 2015 Sales

#### By Product



#### By Region



## Applications

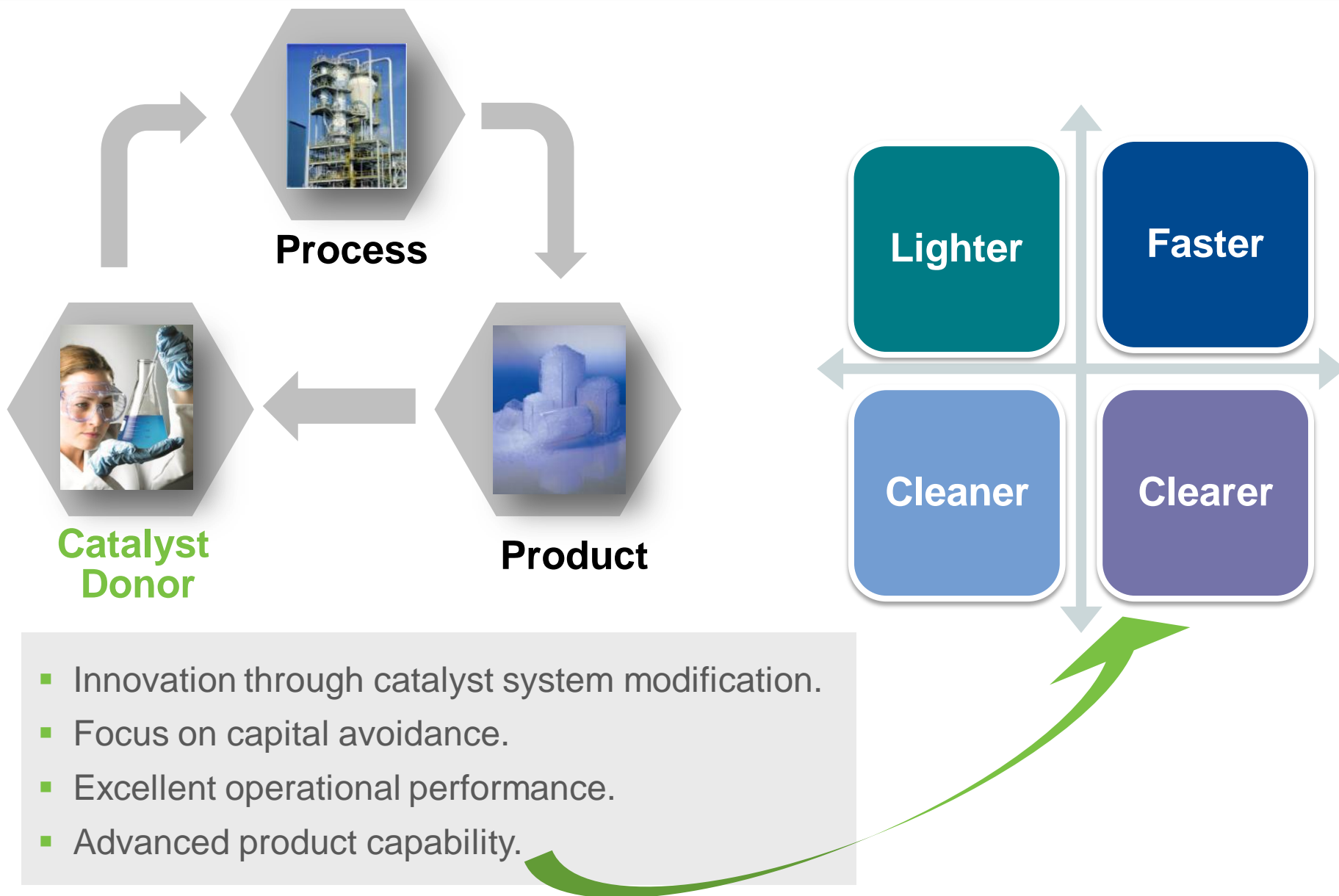
Refining	FCC	★
	HPC EB Resid	★
	HPC FB Resid	★
	HPC Distillate	○
	HPC Hydrocracking	●
Specialty	Polyethylene (PE) Catalyst	★
	PE Catalyst Support	★
	Polypropylene (PP) Catalyst	★
	PP Process Technology Licensing	★
	PE / PP Single Site Catalyst	●
	Chemical Catalysts	○
Future	Zeolite Technology	★
	MTO Catalysts	○

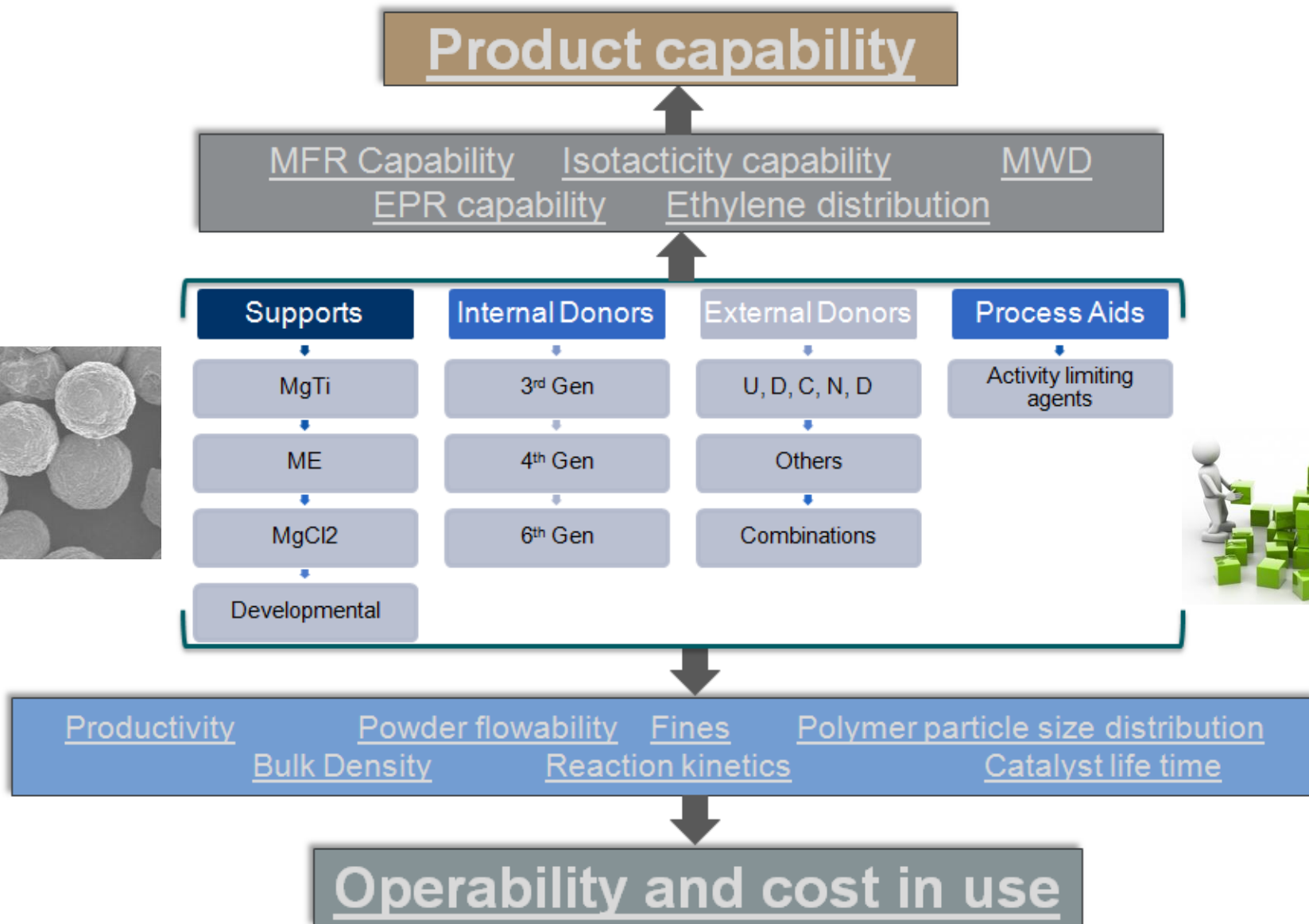
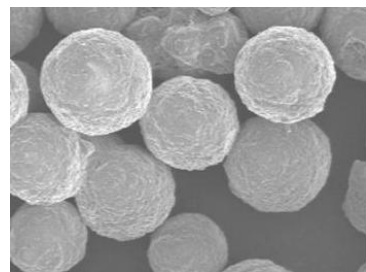
★ Technology Leader

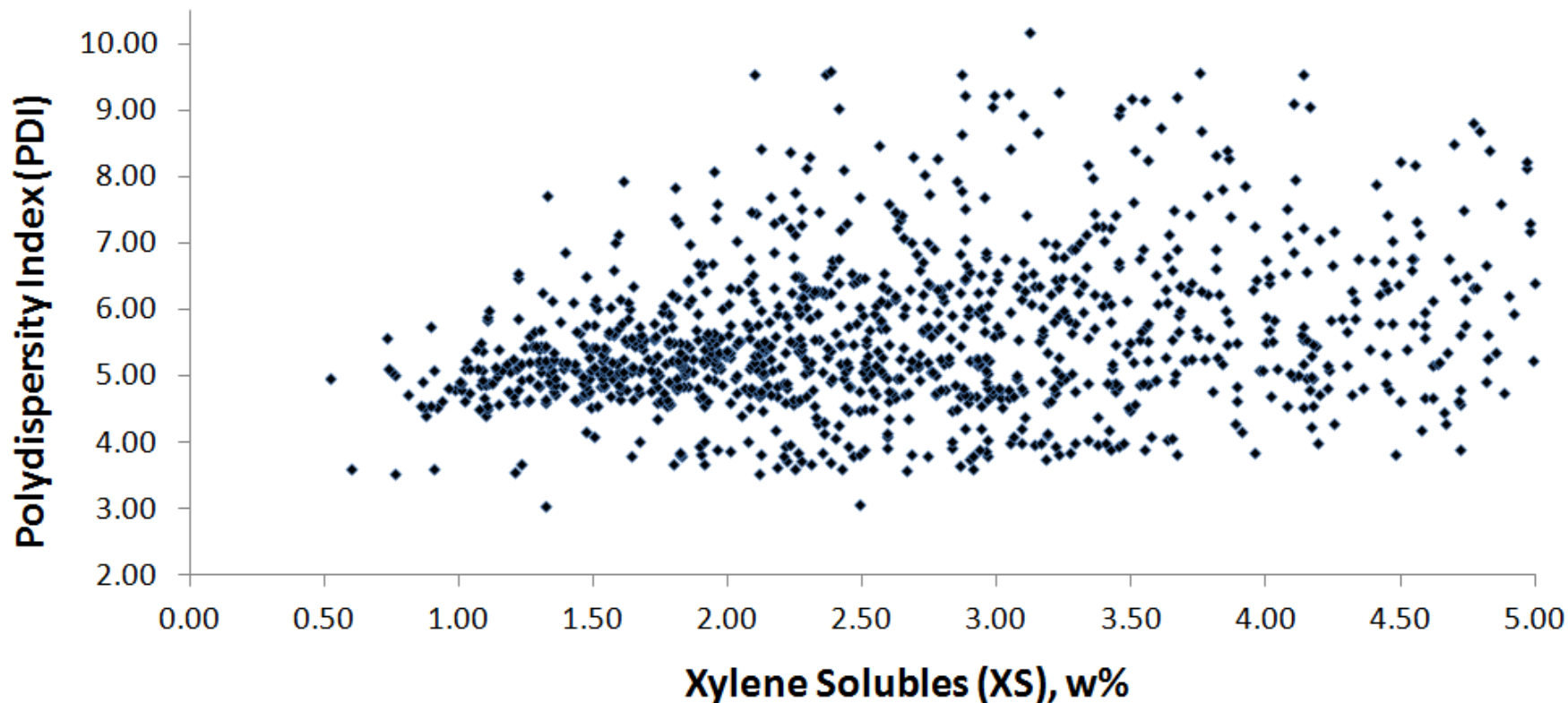
● Strong Position

○ Developing Position

# A strong portfolio getting stronger.







**Shotgun plot with GRACE non-phthalate internal donor capabilities**

## POLYTRAK<sup>®</sup> Catalyst

- 4<sup>th</sup> generation technology
- Used in bulk and gas phase processes
- Homo- and co-polymer capability

## LYNX<sup>®</sup> Catalyst

- Broad portfolio of catalysts
- Used in gas phase, as well as bulk processes
- Homo- and co-polymer capability

## SHAC<sup>®</sup> Catalyst

- Family of catalysts, optimized for use in UNIPOL<sup>®</sup> processes
- Homo- and co-polymer capability

## CONSISTA<sup>®</sup> Catalyst

- 6<sup>th</sup> generation technology; high yield
- Offerings for gas phase polymerization processes
- Non-phthalate with improved resin performance

## HYAMPP<sup>®</sup> Catalyst

- 6<sup>th</sup> generation technology; high yield
- Offerings for bulk (liquid) polymerization processes
- Non-phthalate, with improved resin performance

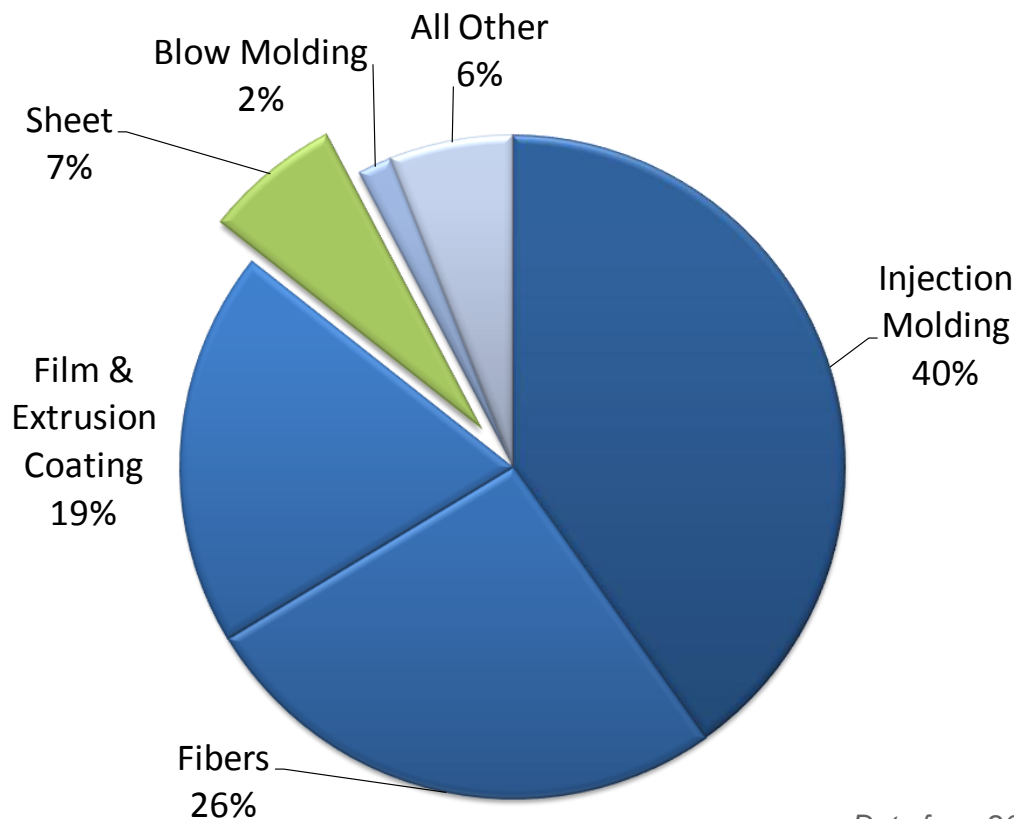


## Custom Polypropylene Catalysts

- Vast experience in scale-up and supply of customer-specific
- Polypropylene catalyst products



## Global Consumption PP, 2015

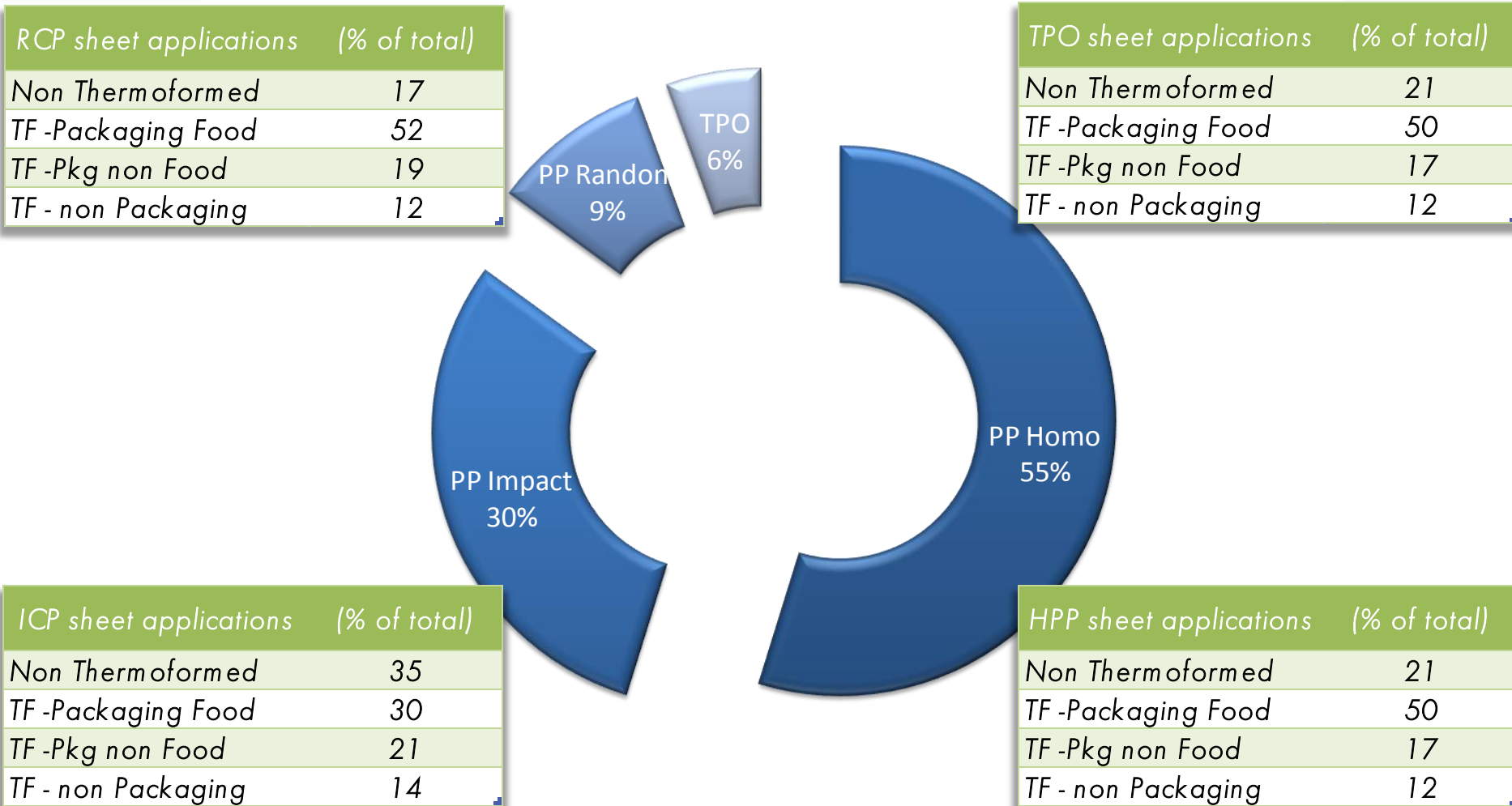


*Data from 2015 PP Townsend report*

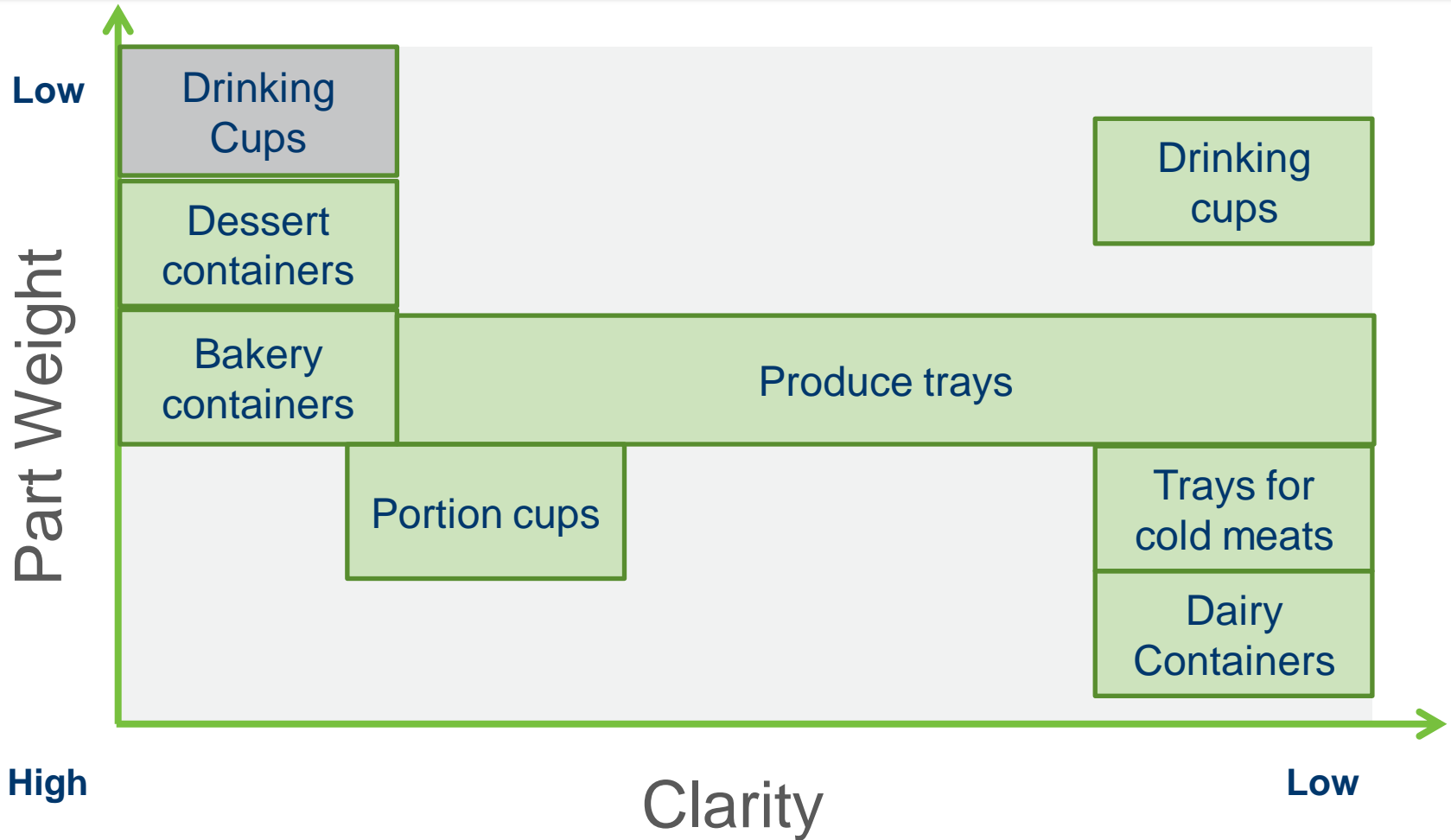
**Sheet applications represent a large segment of the PP market**

# Showcase 1: Ultra-clear thermoformed articles

GRACE



## High clarity market is served by RCP



**High clarity market is served by RCP**

## Inter-polymer substitutions

- PS: brittle if clear, tough non clear
- PET: Tough and clear – high density, difficult processing

## Inter fabrication process substitutions

- Replacing IM containers with high volume simple symmetrical designs

## Equipment advances

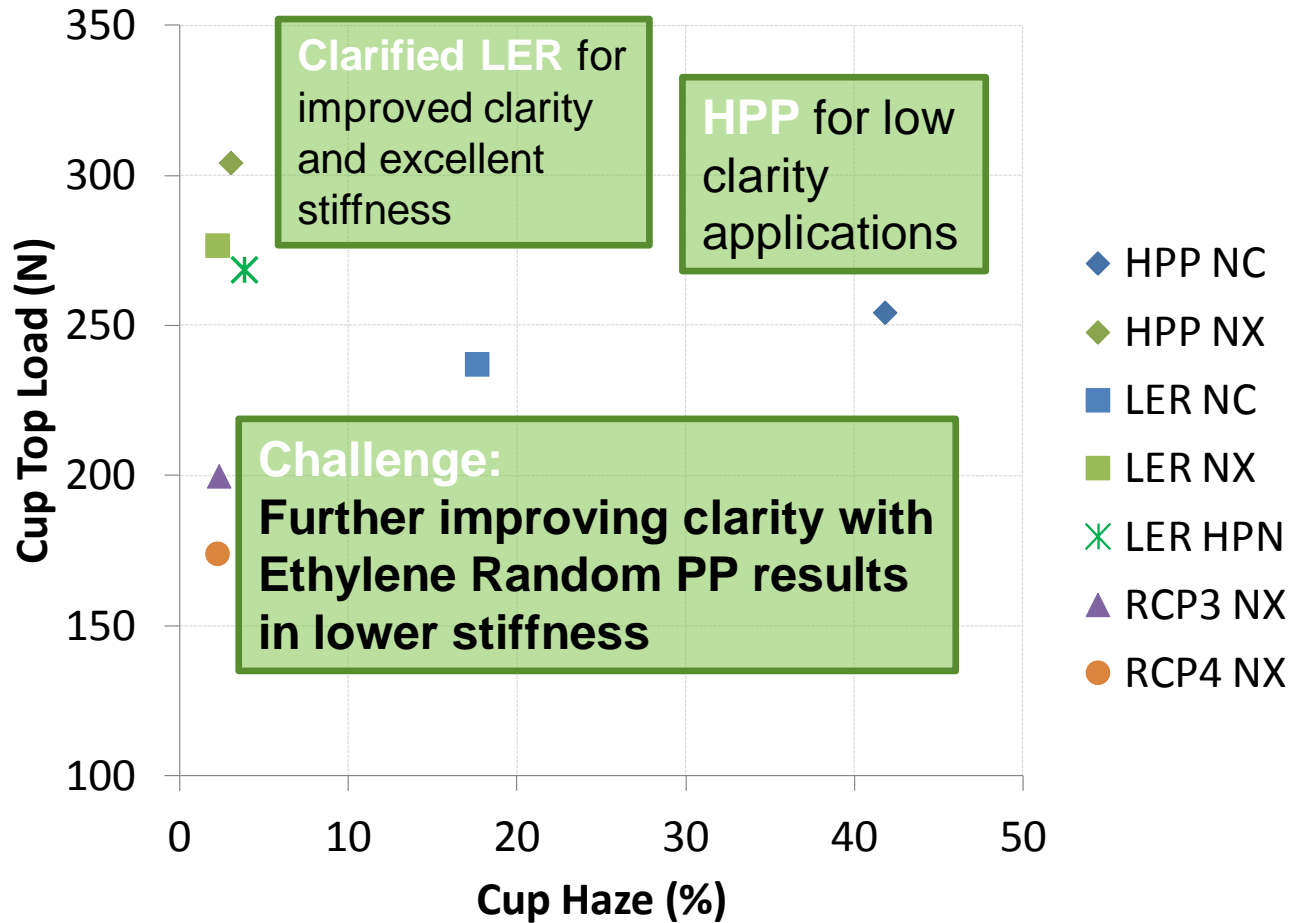
- On purpose PP lines, no longer fabrication on PS lines
- Excellent temperature control of the web

## Material advances

- Materials with better transparency in non drawn zones
- RCP made with CONSISTA® catalysts and Millad® NX8000 clarifiers

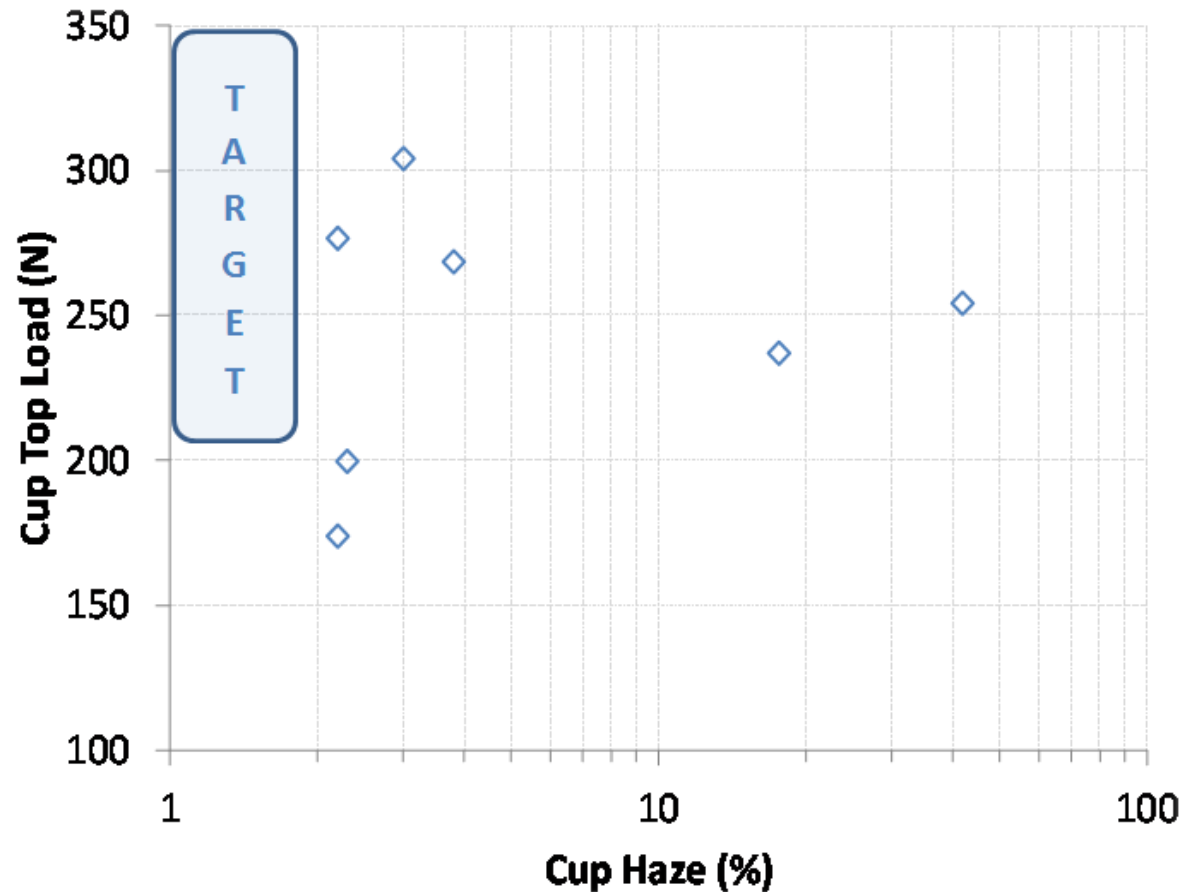


# Clarity drives innovation



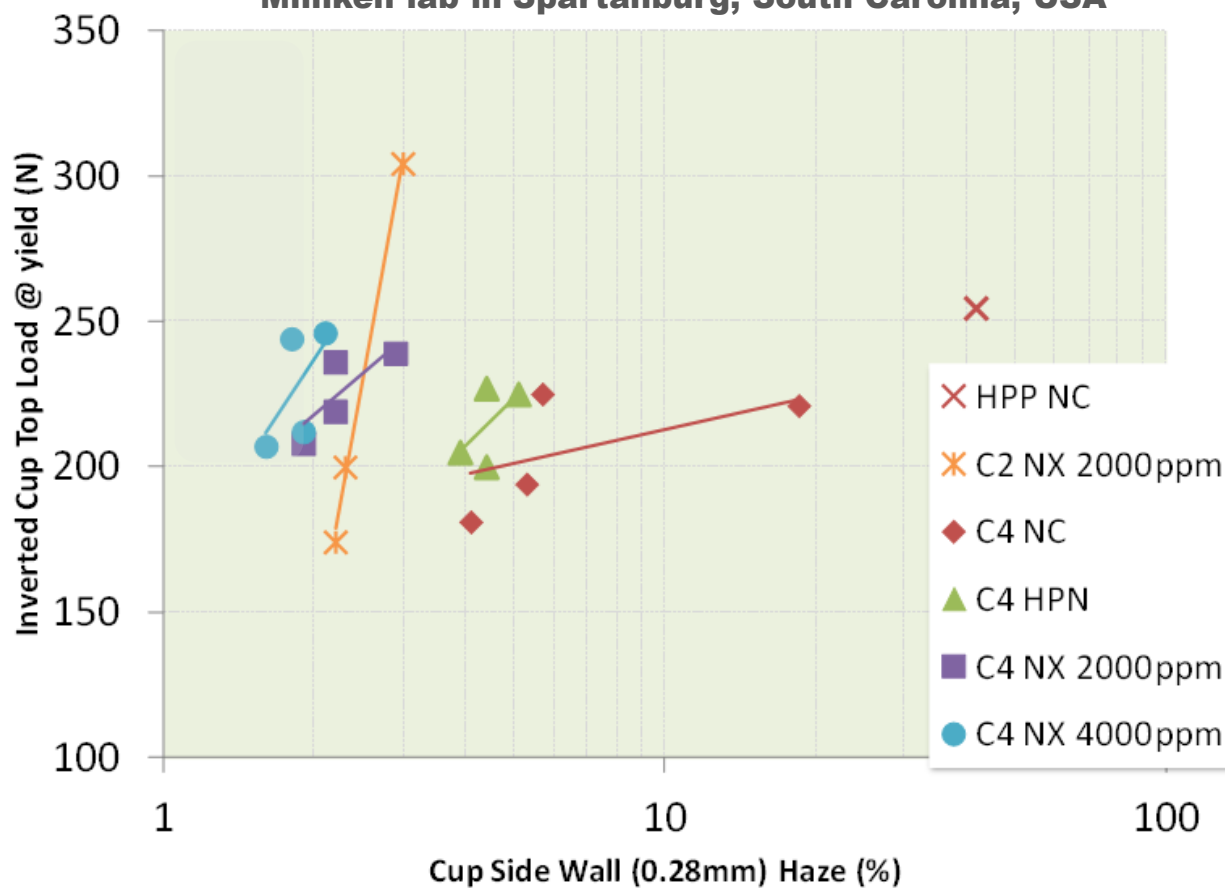
Deep draw part

## Traditional top load – clarity space



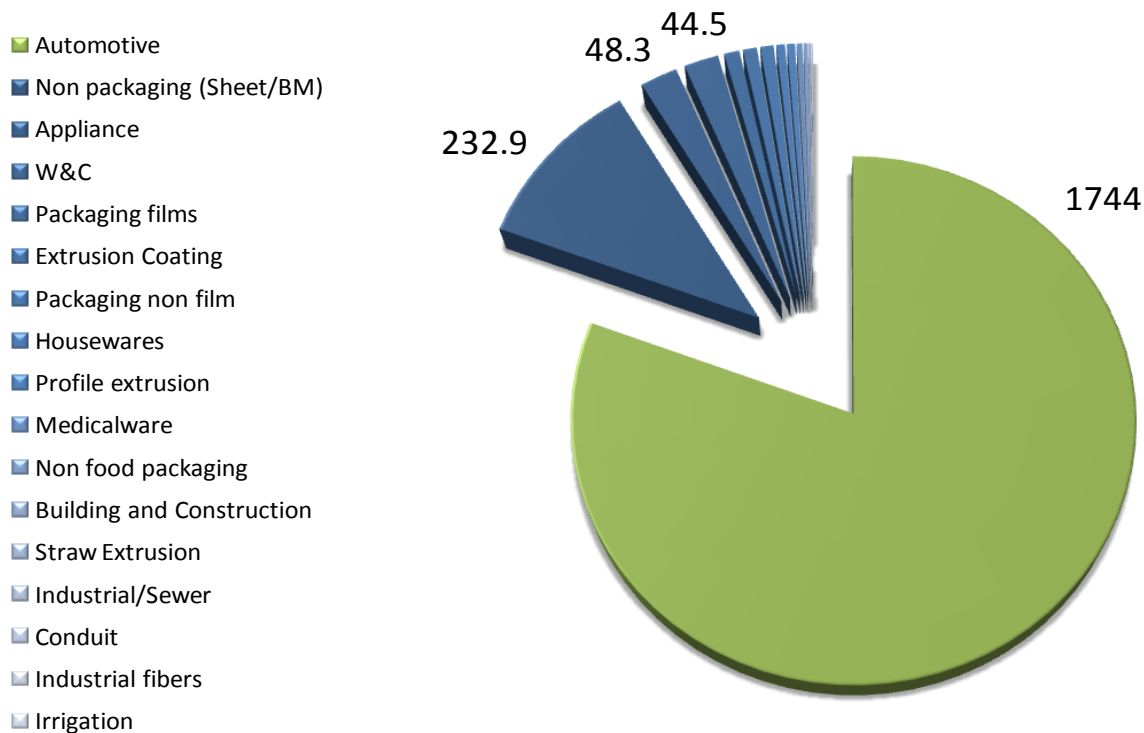
**Challenge:**  
**design product to meet low haze and high stiffness**  
**for high- and low-draw ratio applications**

Thermoforming work was conducted at the Milliken lab in Spartanburg, South Carolina, USA



**Solution: clarified butene-RCP**  
**Catalyst: CONSISTA® Platform**

**TPO Consumption Volume by Application 2015, kt**

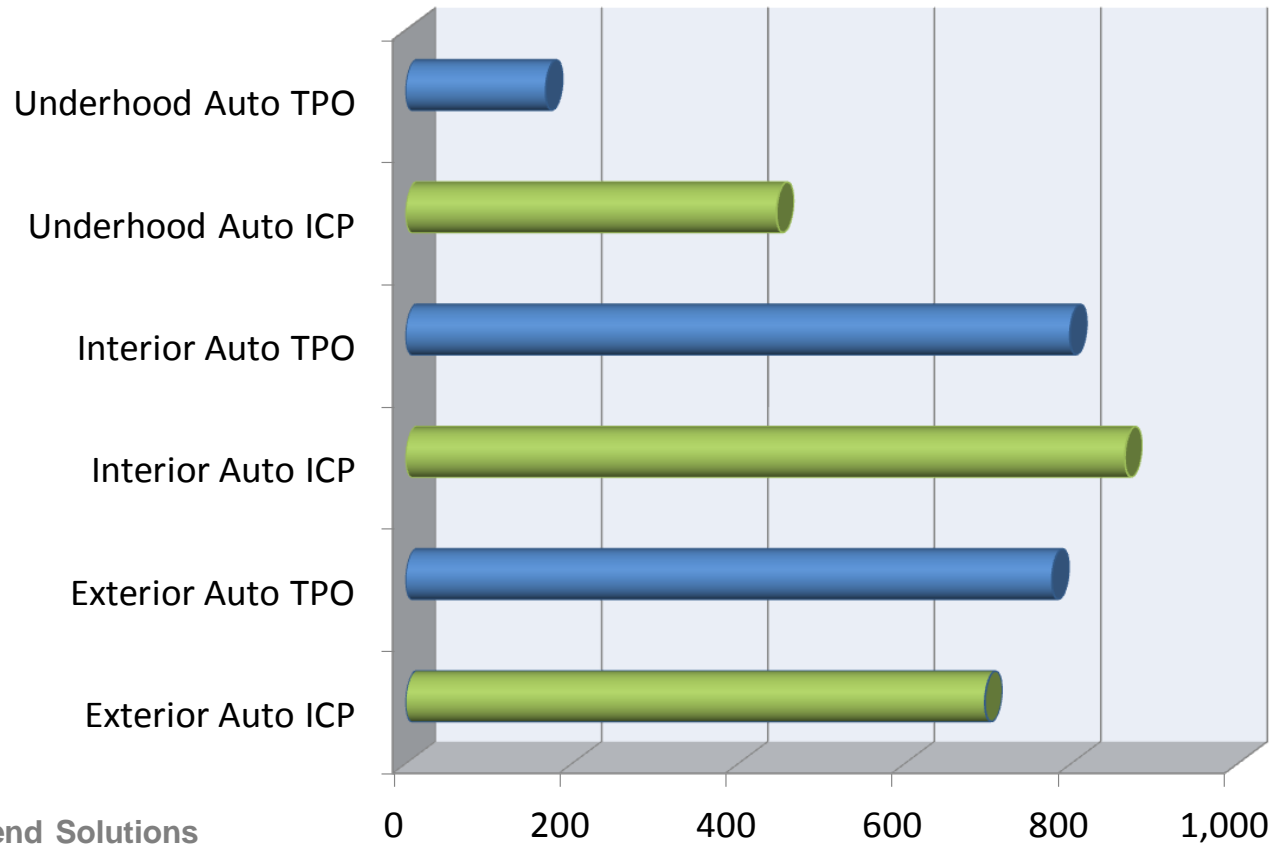


Source: Townsend Solutions

**80% of TPO used in automotive applications**  
**Growth rate of TPO in automotive of 5.2%**

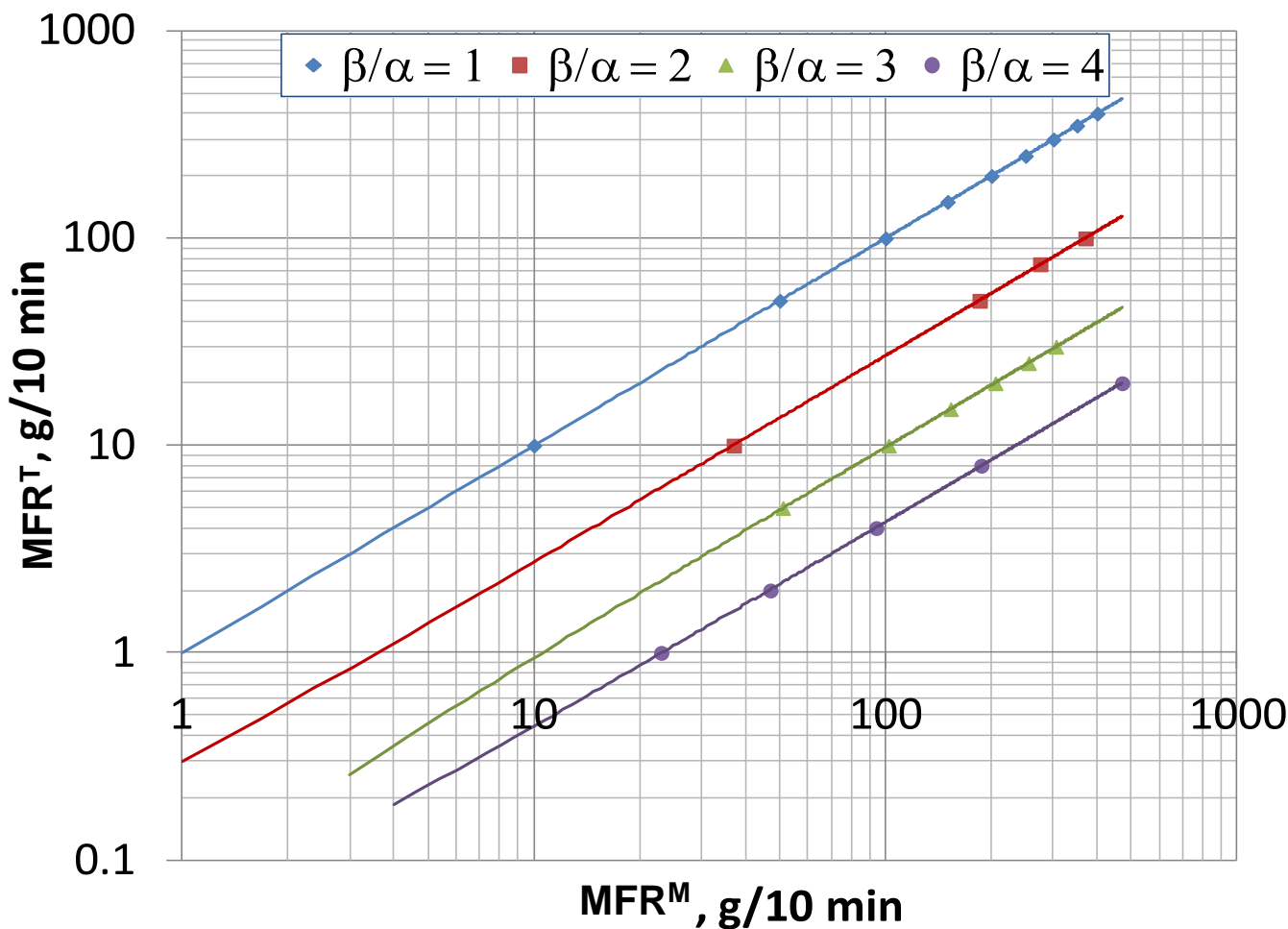


Global Automotive Applications Volume 2015, kt



Source: Townsend Solutions

**Very large TPO usage in interior applications**  
**Low temperature impact is less of a concern**



Domain Break-up  
Taylor Theory  
(Empirical Relation)

$$d \propto \frac{G}{\gamma} \frac{\eta_R}{\eta_M}$$

$\beta/\alpha$  ratio

d EPR particle size  
G PP/EPR Interfacial Tension  
 $\gamma$  Shear rate  
 $\eta$  Viscosity

**Challenge: highest MFR possible with no-break behavior at room temperature**

## Showcase 2: High MFR r-TPO

GRACE

### Hypothesis

Low rubber viscosity can help achieve optimum impact resistance at high MFR

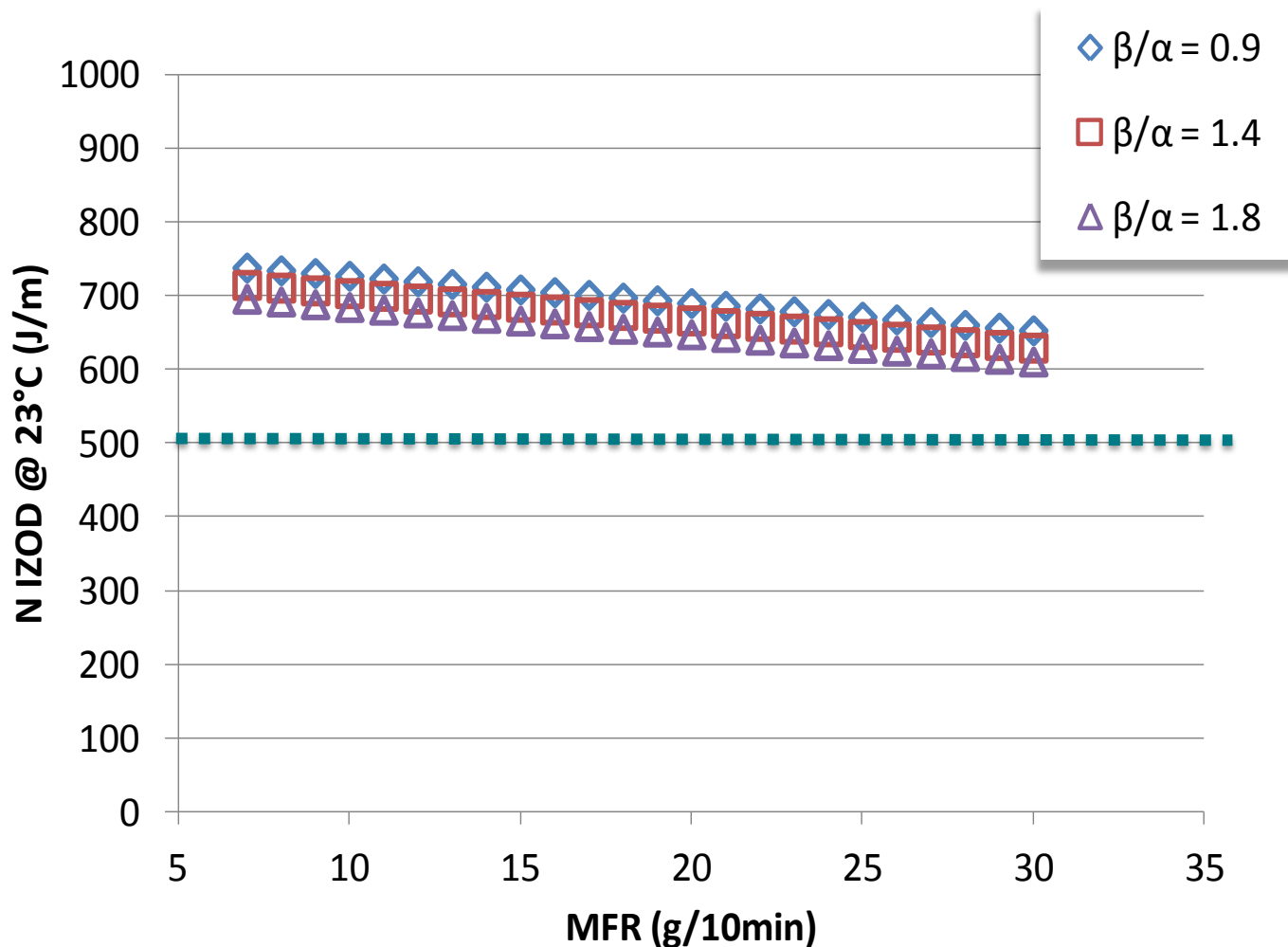
### Boundary condition

Maximum EPR concentration allowed was 33 w%

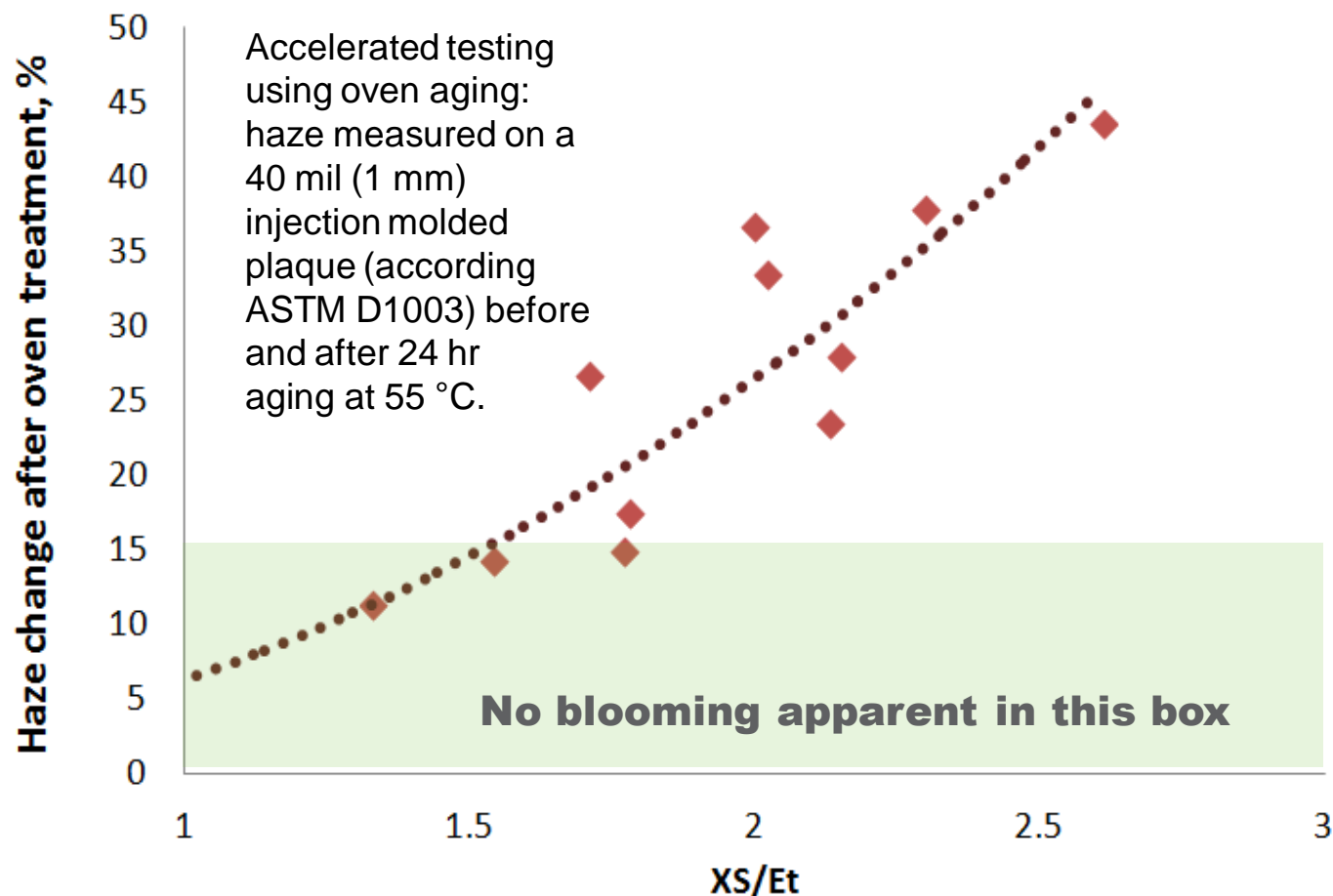
### Notes

Multivariate models developed from experimental data points

Graph shows modeled data



**30 g/10min MFR r-TPO possible**  
**Catalyst: CONSISTA® Platform**



**Catalyst sensitive to external donor enables low Xs/Et ratios**  
**Catalyst: CONSISTA® Platform**

# Summary

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- Grace has developed advanced internal donor, external donor, support and process aids technologies with value propositions for PP producers, converters, brand owners, and ultimately consumers.
- Grace ZN catalyst technology enables innovative product features such as ultra-high clarity thermoformed parts, high MFR in-reactor TPO injection molding grades for automotive and low blooming injection molded articles for packaging applications.



## **Manu Rego** | Specialty Catalysts R&D

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[grace.com](http://grace.com)

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