



Dr. Pal Arjunan
PO/Chemical Catalysts Division

Advantage™ - Ziegler Natta PE Catalyst *for Solution LLDPE Process Platform*

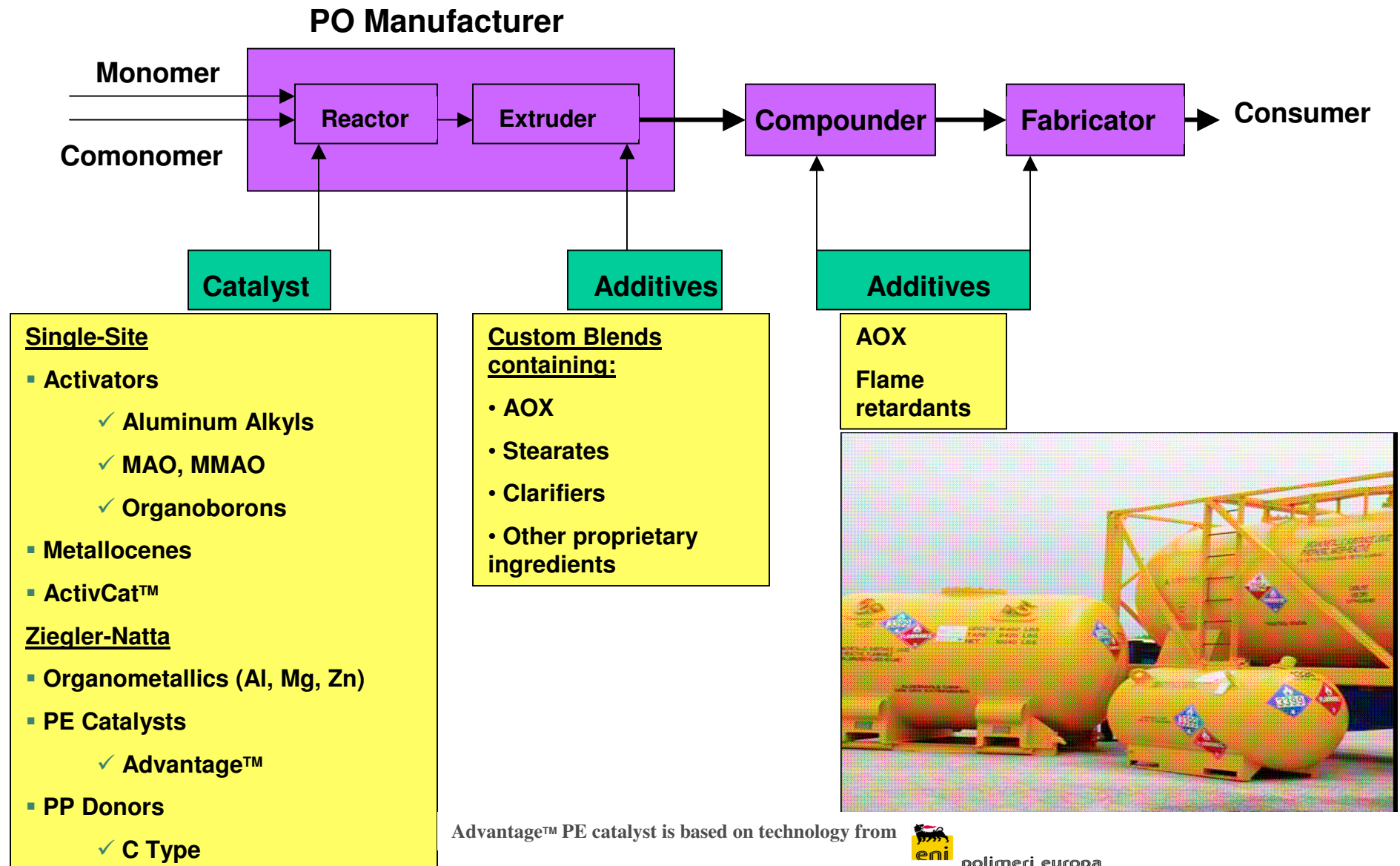


***ACS Poly Div Workshop Conference: “Advances in PO 2011”
Sep 25-28/2011, Hilton-Santa Rosa, Sonoma Valley, CA, USA***

Presentation Overview

- Albemarle Overview
- Advantage™ Ziegler-Natta PE Catalysts
- Advantage™ LL77 for Solution Process
- Conclusion

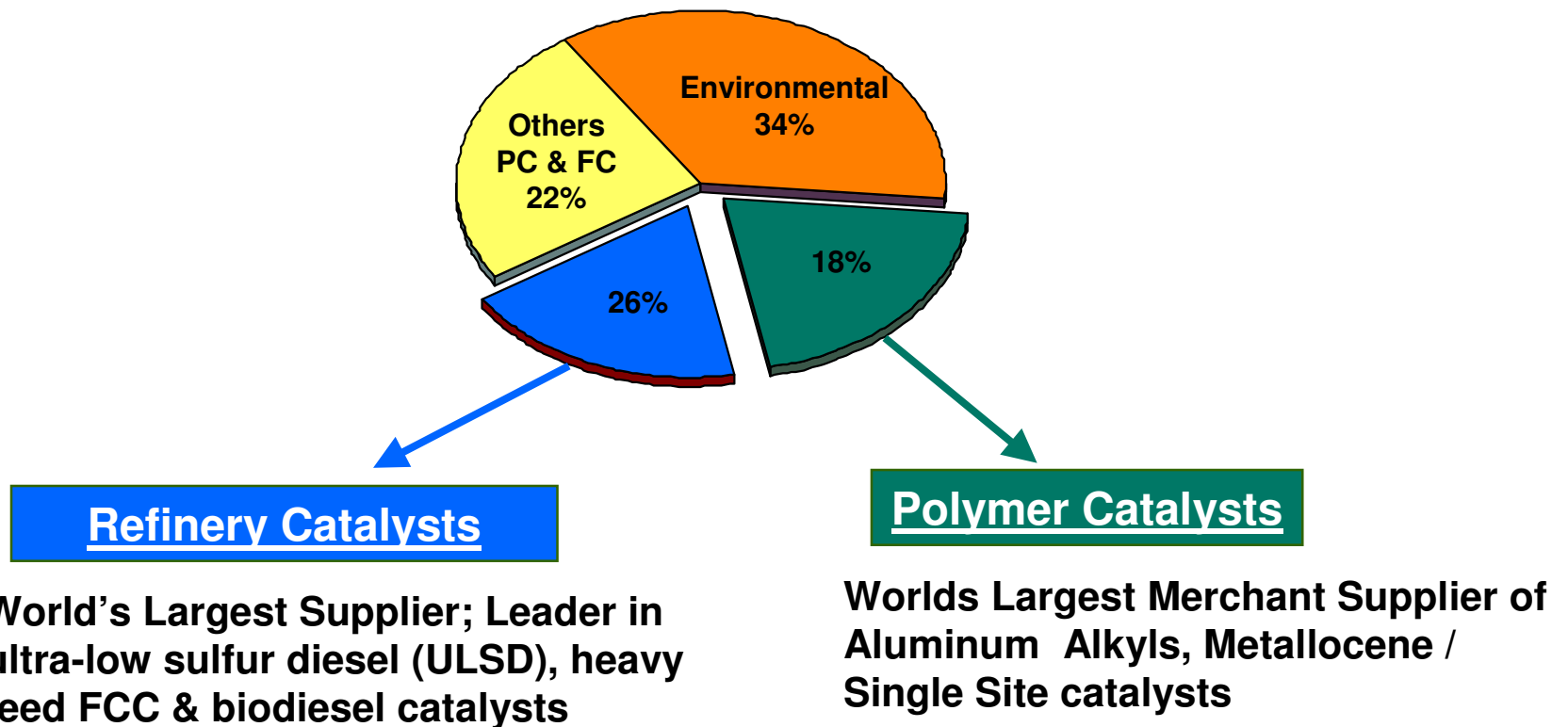
Albemarle's Offerings Support Customers' PO Value Chain



Albemarle: a World-Leading Catalyst Company

- **Global Catalysts Industry: \$18/2009 > 25/2015 Billion, (AAGR = 7%)**

- (Ref: Catalyst Group Resources/2010)



Become the Global Leading Catalysts Solution Provider - Step-Out Growth Mandate

Albemarle PO/Chemical Catalysts Business

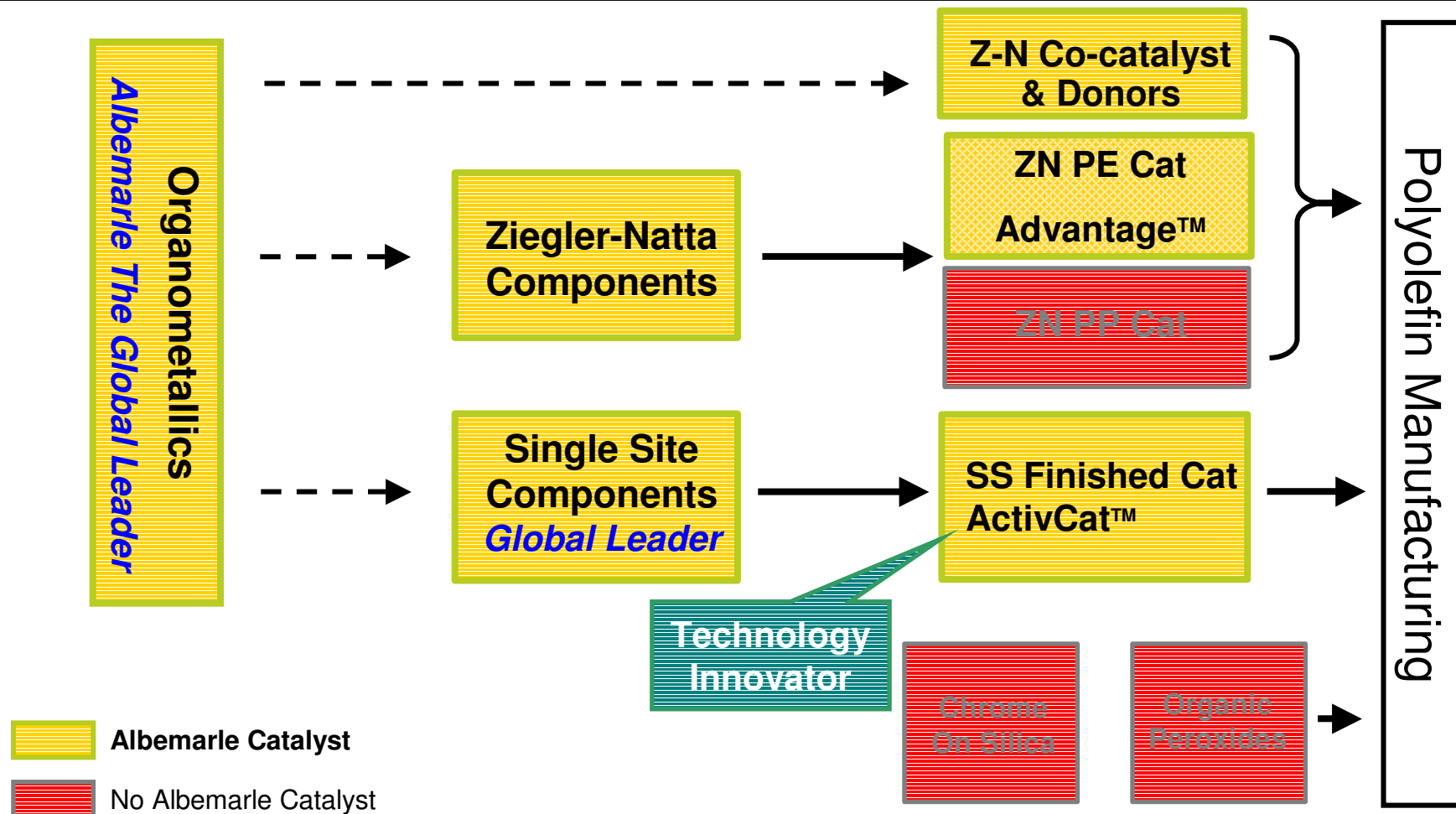
Setting Higher Goals and Clear Strategies



Strategic thrusts and commitment will propel our PO/Chemical Catalyst Business to the next level

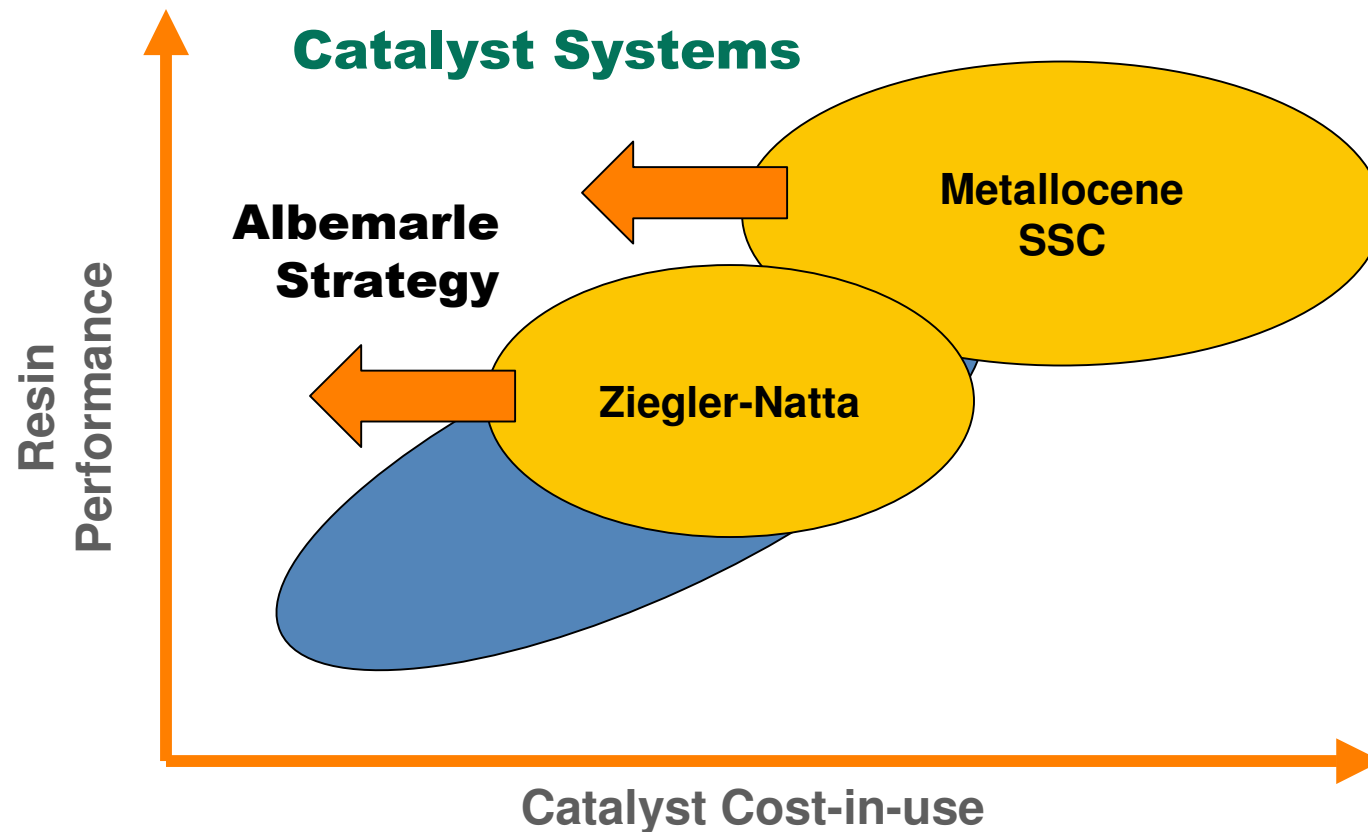
Albemarle PO Catalysts Landscape: Essential to the Global PO Industry

“Back Integration + Wide Range of Products + Global Manufacturing”



Advantage™ PE catalyst is based on technology from 

Albemarle “Value creation” strategy to PO Resin Producers



Improve value to customer without compromise to resin performance / properties

Advantage™ Polyethylene Catalysts

(Licensed from Polimeri-Europa)



- $MgCl_2$ supported, Ti based Ziegler cats to produce HDPE / LLDPE resins
- Advantage™ HD26 and HD46 for HDPE:
 - Suitable for Slurry CSTR and Slurry Loop Process Platform
 - Hostalen CSTR
 - Mitsui CX CSTR
 - CPCChem slurry loop
 - Innovene S slurry loop
 - Related applications – UHMWPE, amorphous PP etc.
- Advantage™ LL26 for LLDPE:
 - Suitable for High Pressure Processes – Autoclave, Tubular
 - Unique LLDPE products
- Advantage™ LL77 for LLDPE
 - Bimetallic catalyst for improved balance of resin properties
 - Suitable for Solution Process Platforms:
 - Sclairtech
 - Dupont, DSM (Sabtech by Sabic)

Advantage™ LL77 Catalyst

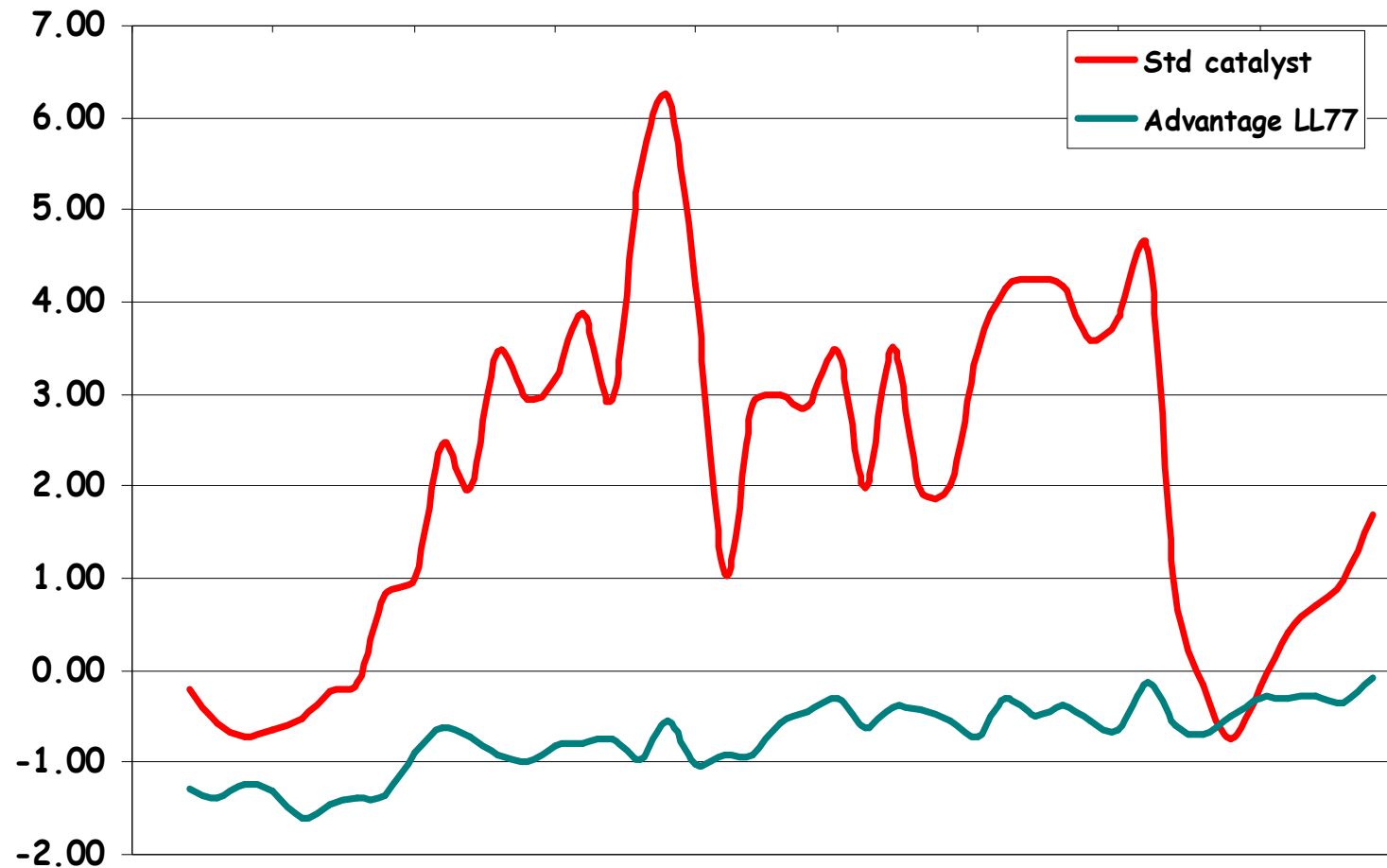
- Traditionally, Vanadium/Titanium halides are used to produce LLDPE grades in solution process.
- A proprietary modified Ziegler-Natta bimetallic catalyst system has been developed that is suitable for use in high temperature Solution processes offering key process/product advantages:
 - ✓ Improved onstream time – more stable reaction
 - ✓ Lower variable cost – comonomer, alkyls, purifiers
 - ✓ Improved comonomer distribution
 - ✓ Improved balance of resin properties for film applications
 - ✓ High yield catalyst - low transition metals residue in LLDPE resins, improved color

Advantage™ LL77 Produced LLDPE Resin

- Balanced MD and TD properties - for biorientation purposes.
- Ideal for flexible food packaging applications - stiffness and high thermal stability properties
- Compares favourably to standard C8 countertype. In addition to breathable film application, it can be successfully used in stretch cast film formulations where high mechanical performances and ease of processing are required.
- Competitive with market leaders in super power stretch cast film.

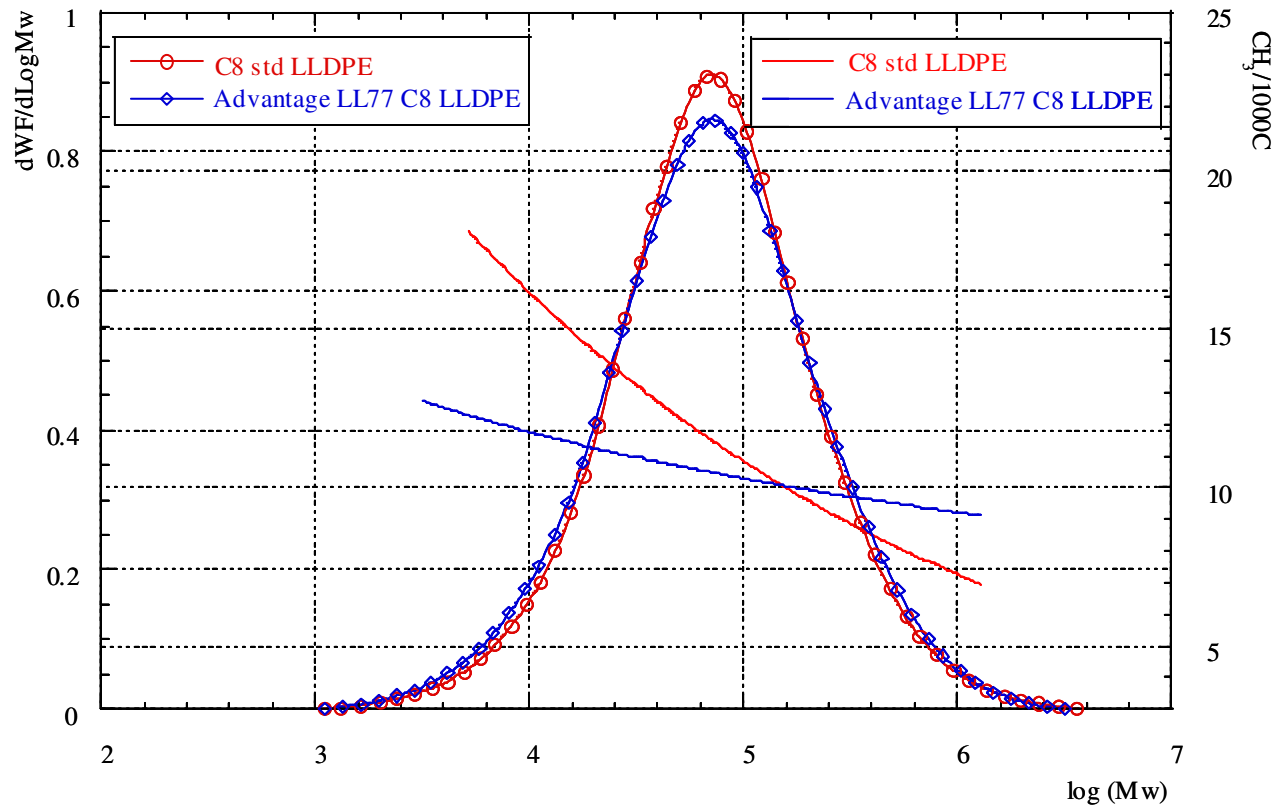
C₈=-LLDPEs Exhibit Improved YI and Color

Yellow index chart over a ten days production campaign



C_8 -LLDPE has Narrow CD, like metallocene-LLDPEs - better than the competitive ZN LLDPE resins

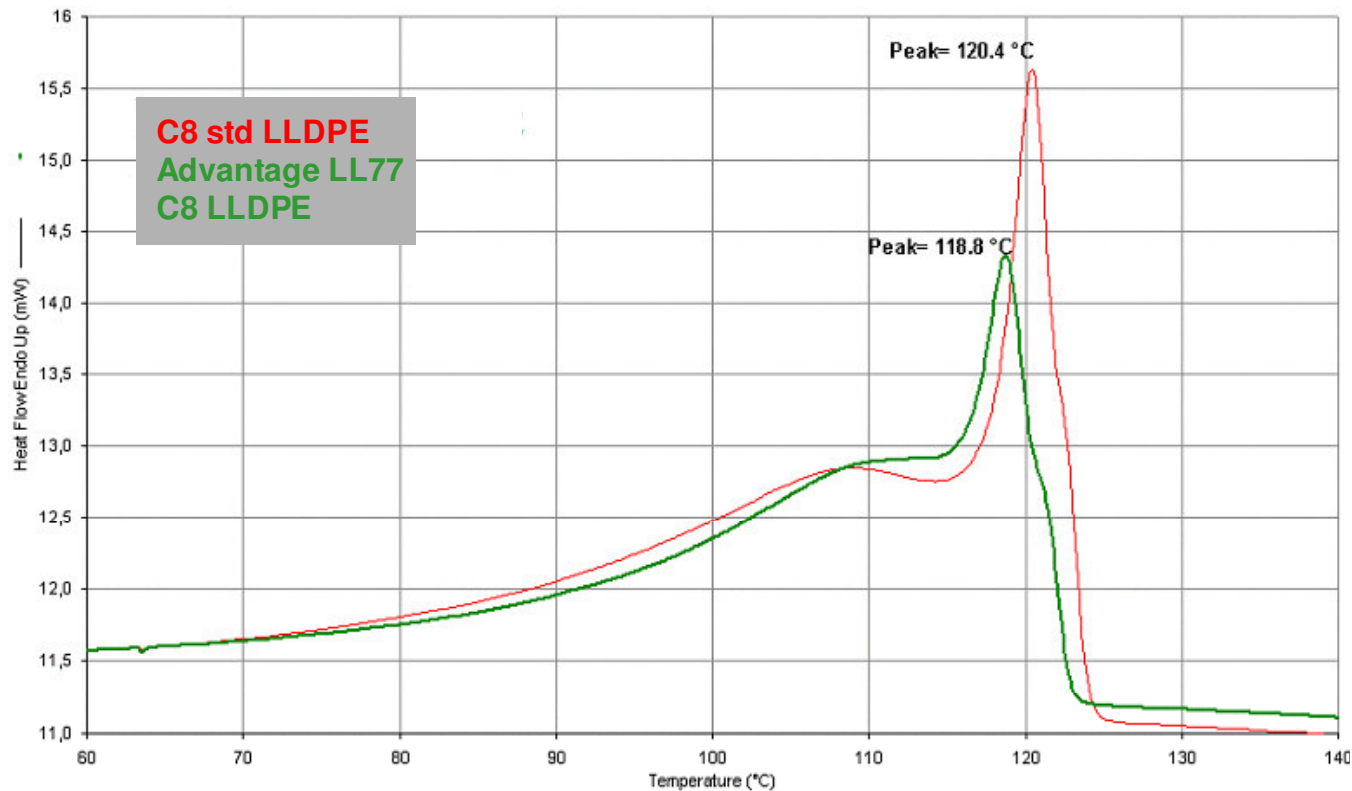
MW and Comonomer Distribution



- AdvantageTM LL77 catalyst avoids wax formation by incorporating homogeneously C_8 comonomer in the PE backbone

C₈-LLDPE's has attractive melt attribute- Suitable for heat sealing applications

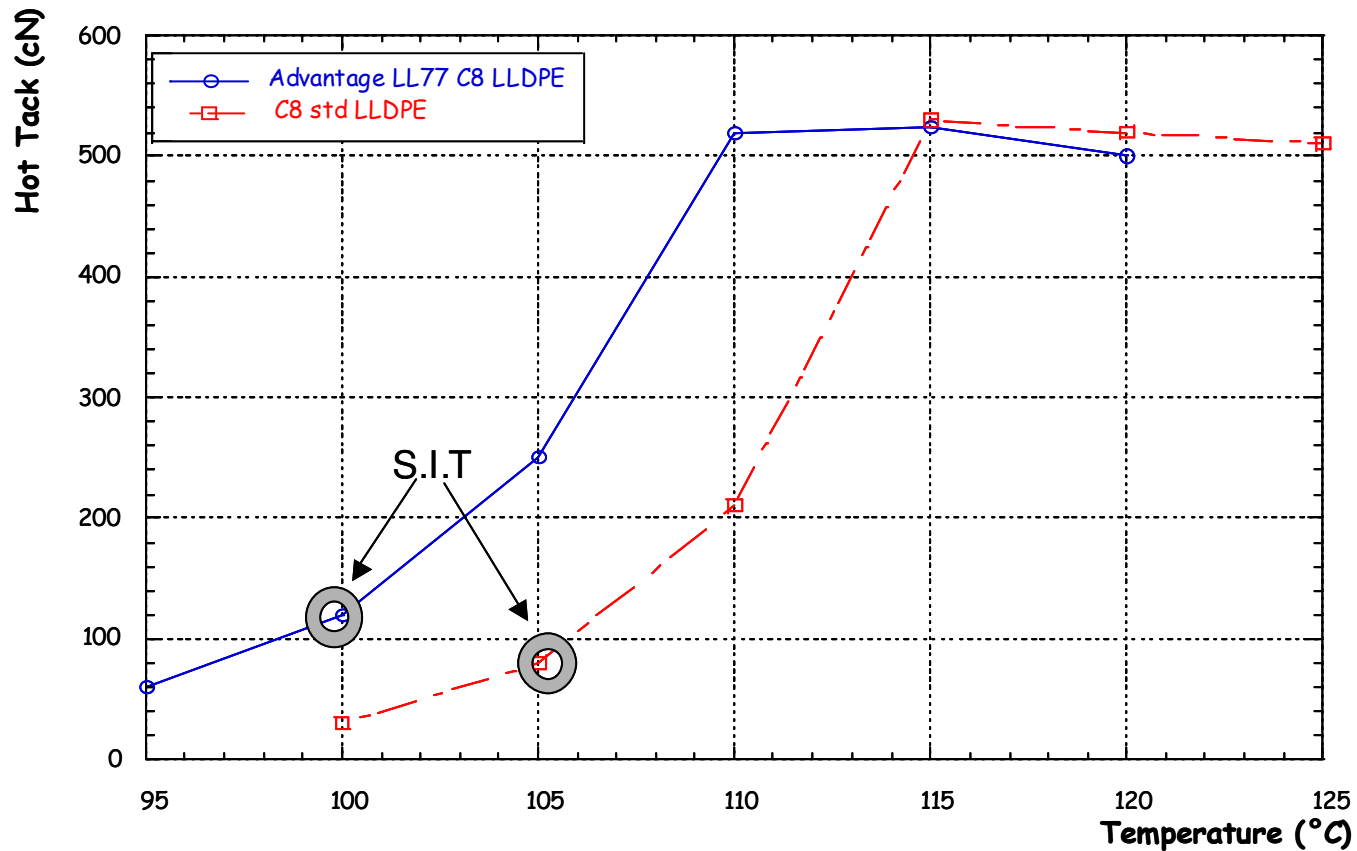
DSC Melting Temperature



- *Advantage™ LL77 C8 product melting temp is significantly reduced vs. its std C8 counterpart - this results in excellent low temperature sealing characteristics*

C₈=-LLDPE Film has Superior Sealability

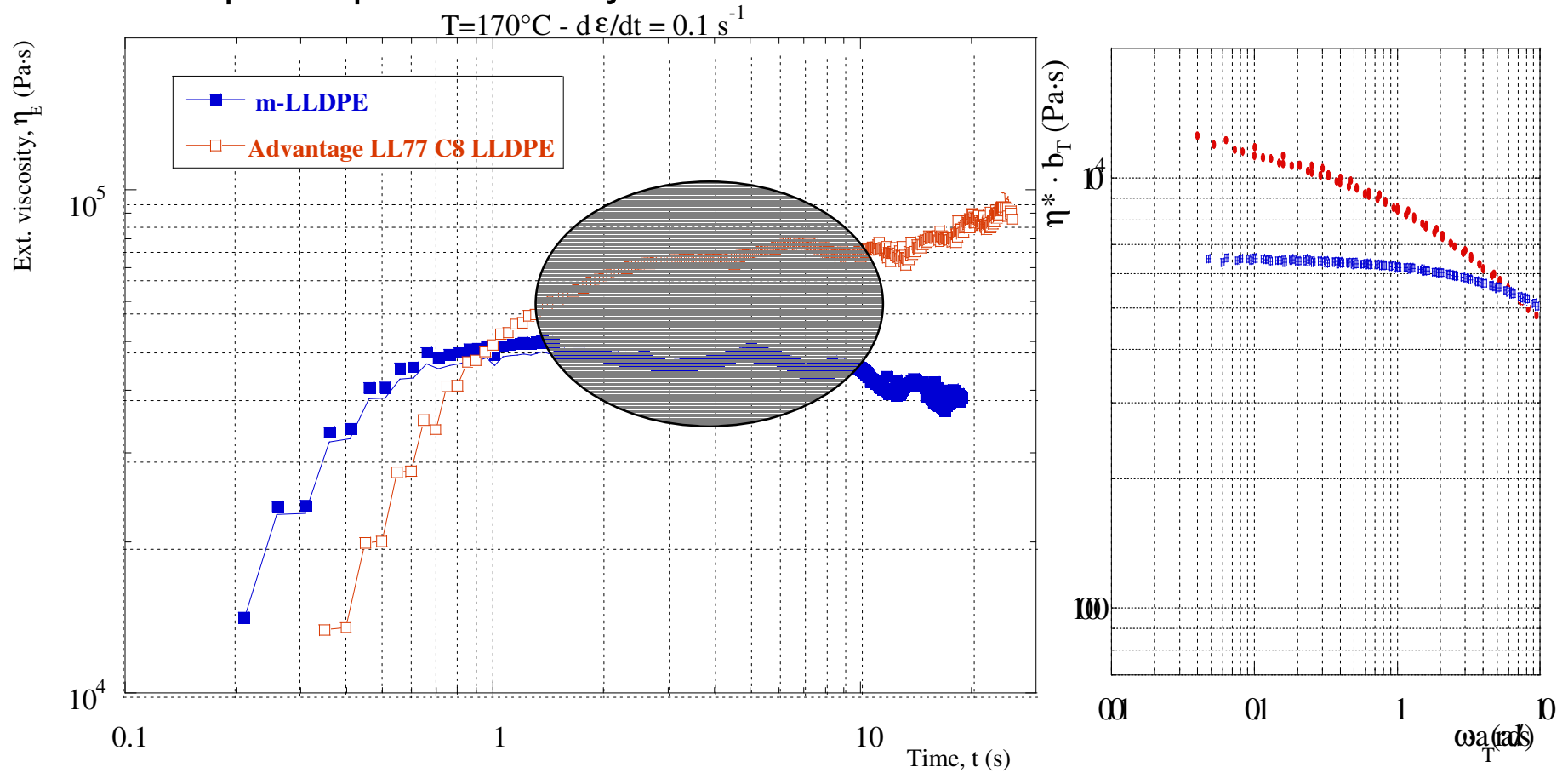
Advantage™ LL77 product, C₈=-LLDPE shows the lowest seal initiation temperature, as expected from its attractive melt characteristics



Note: monolayer film 100% LLDPE obtained on lab scale extruder
thickness 25 microns; output 60kg/h, T=220°C

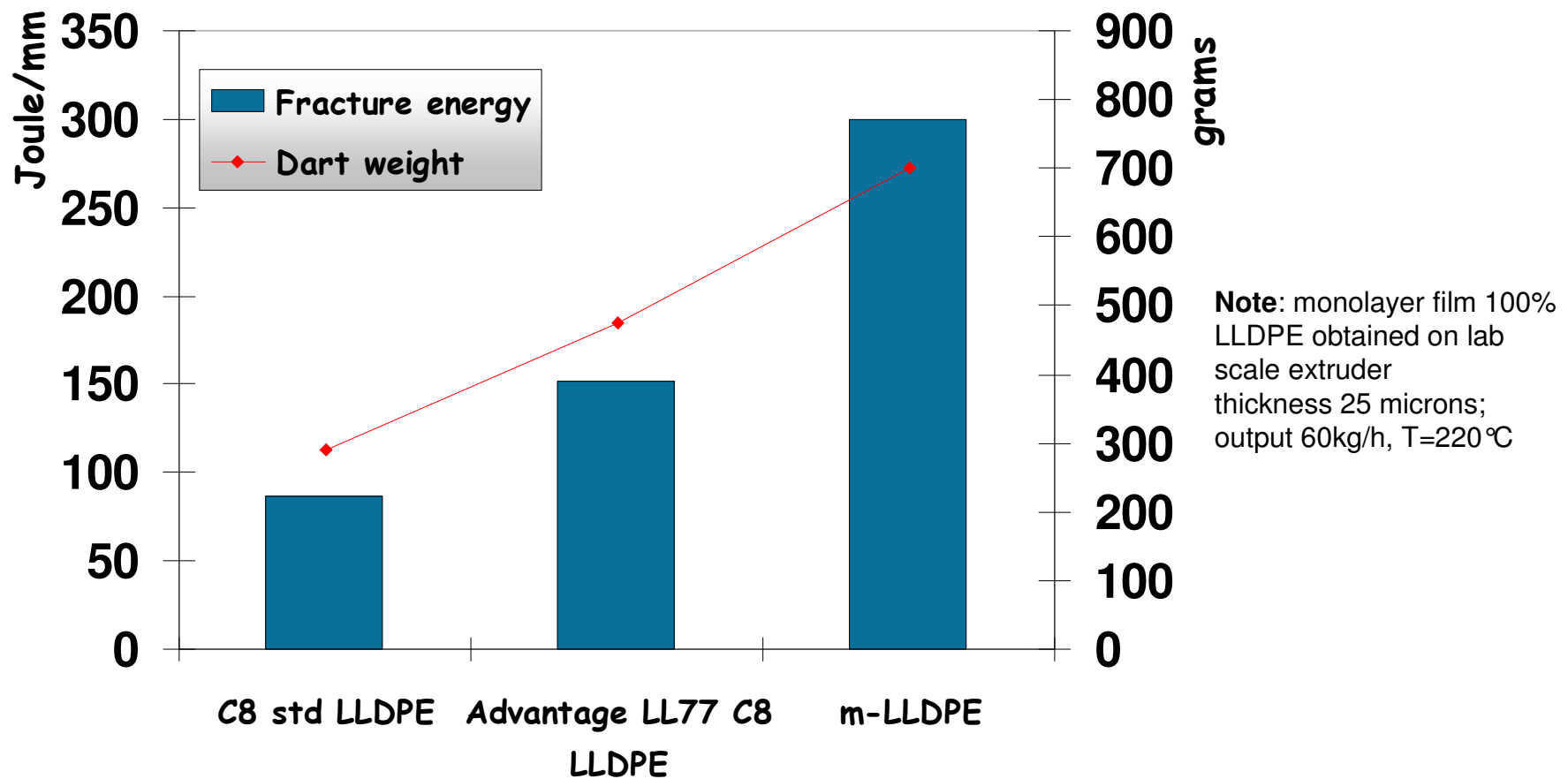
C₈-LLDPE has better processability Vs m-LLDPEs

C₈-LLDPE exhibit better “shear thinning” and “melt strength” - Superior processability Vs the m-LLDPEs



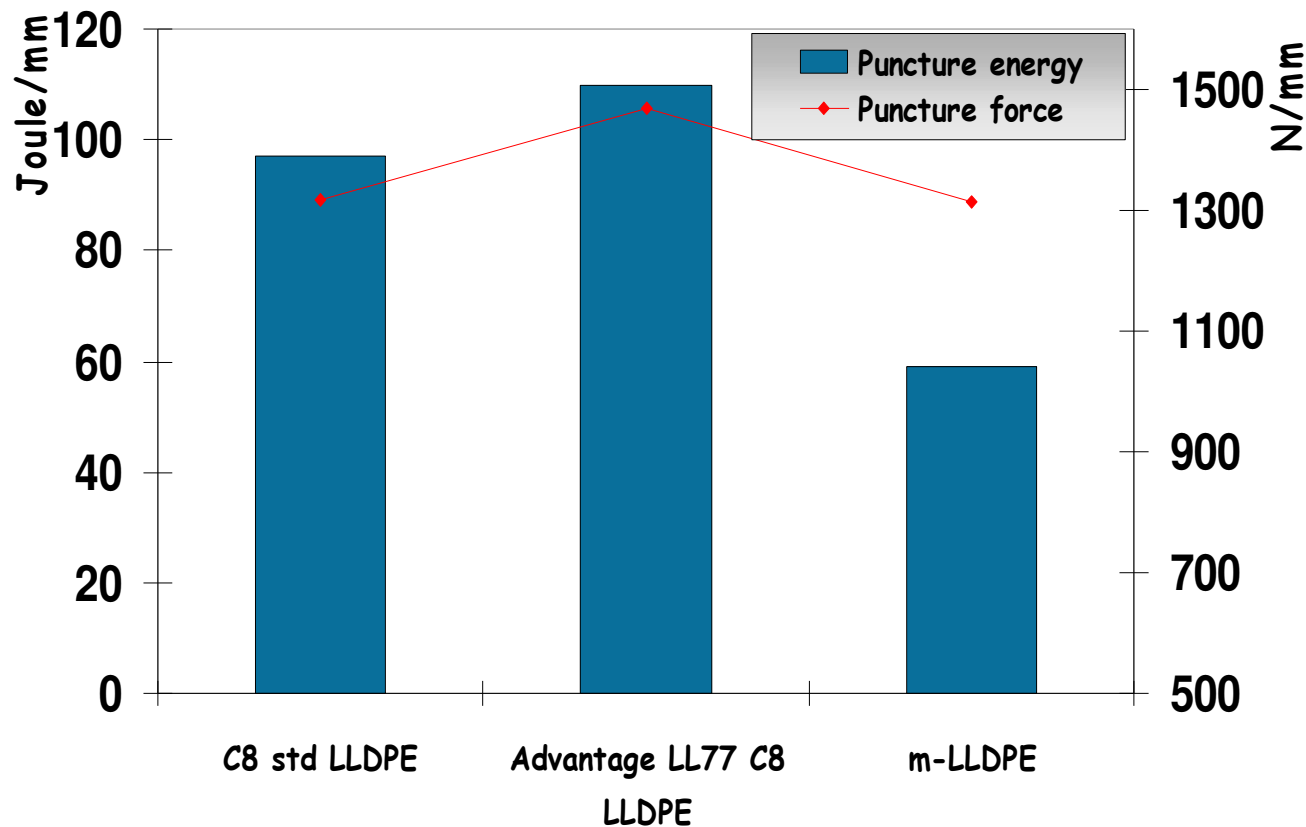
C₈-LLDPE Film: Improved Toughness

Advantage™ LL77 C8 LLDPE has higher toughness compared to new std C8 grade, but it's still far from m-LLDPE



C₈-LLDPE Film has Higher Flexibility – Superior Puncture Resistance

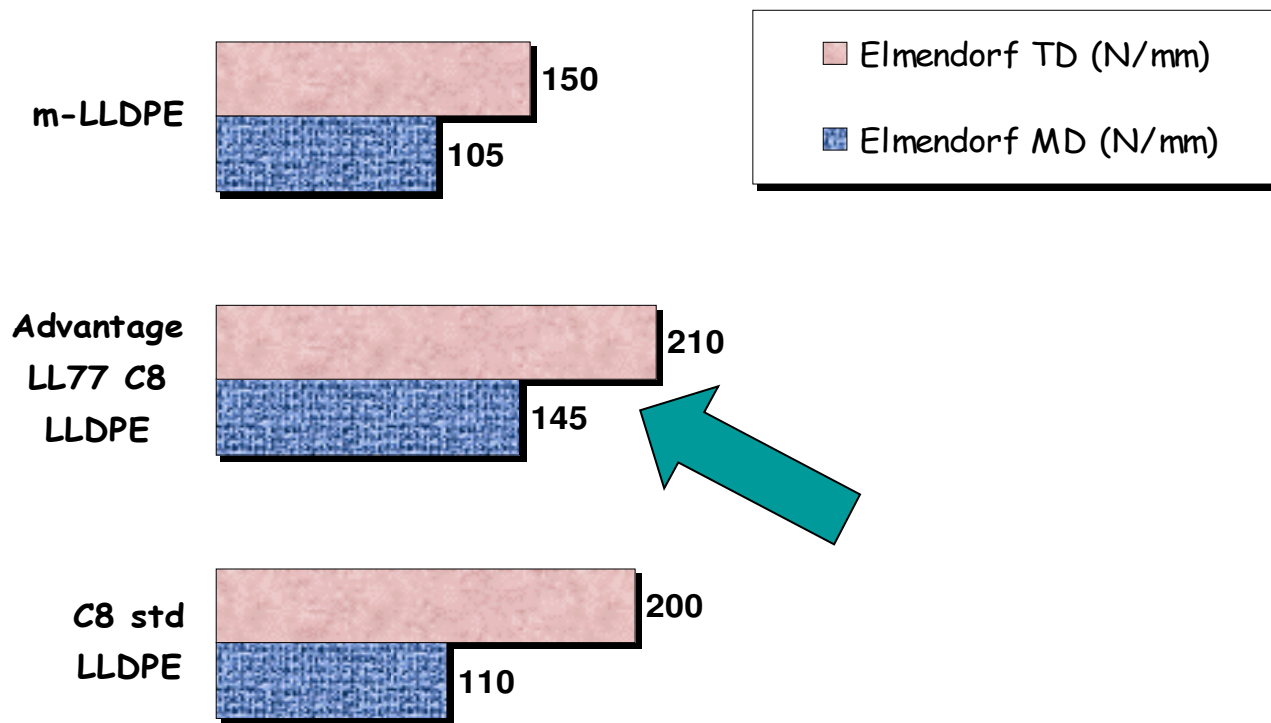
Owing to its high flexibility, Advantage™ LL77 C8 LLDPE has superior puncture resistance Vs Competitive Z-N & m-LLDPEs



Note: monolayer film 100% LLDPE obtained on lab scale extruder thickness 25 microns; output 60kg/h, T=220 °C

C₈-LLDPE Film has Superior Tear Resistance

Advantage™ LL77 C8 LLDPE's tear strength is superior Vs m-LLDPE

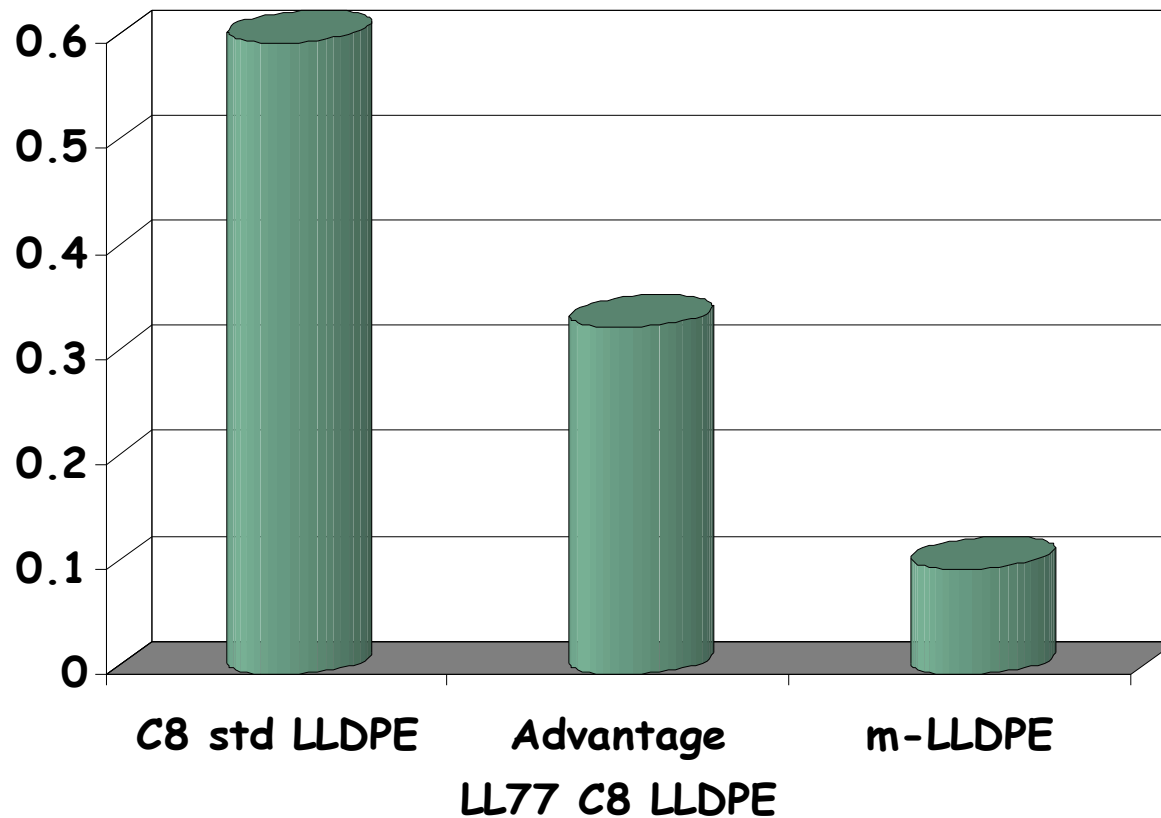


Note: monolayer film 100% LLDPE obtained on lab scale extruder thickness 25 microns; output 60kg/h, T=220 °C

Excellent balance between MD and TD properties

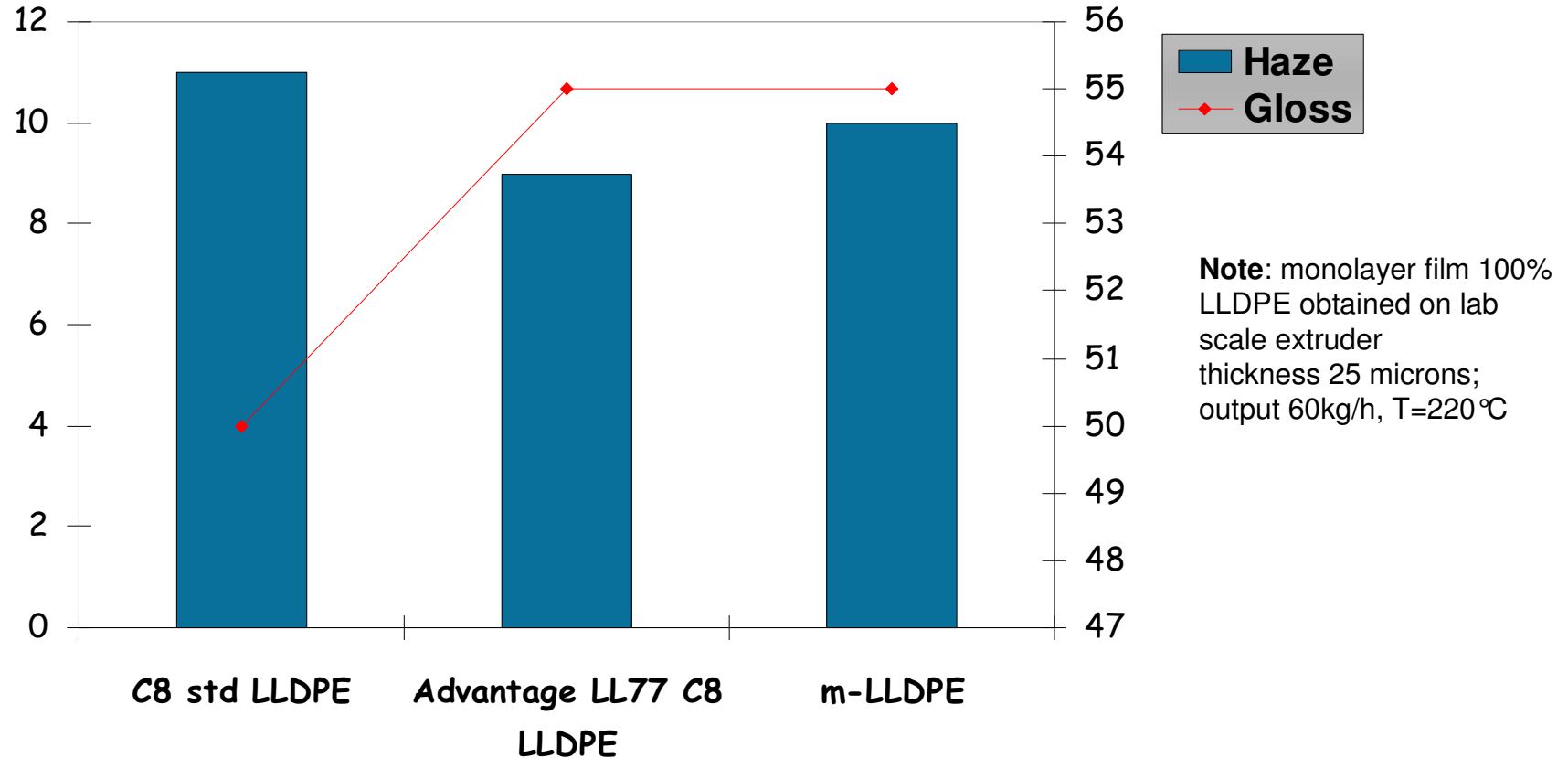
C₈-LLDPE blown-film shows lower stickiness

Lower n-hexane extractables (i.e. more homogeneous CD) leads to less blown film stickiness



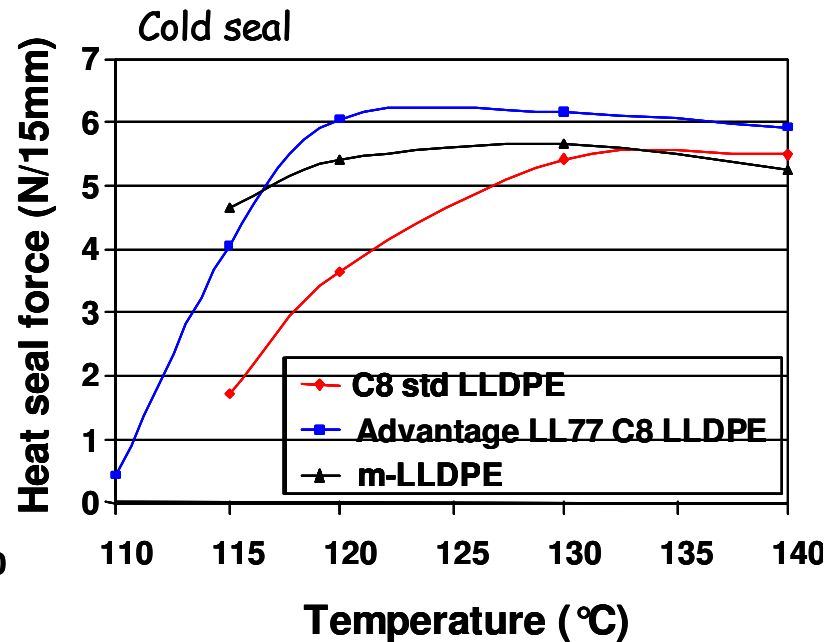
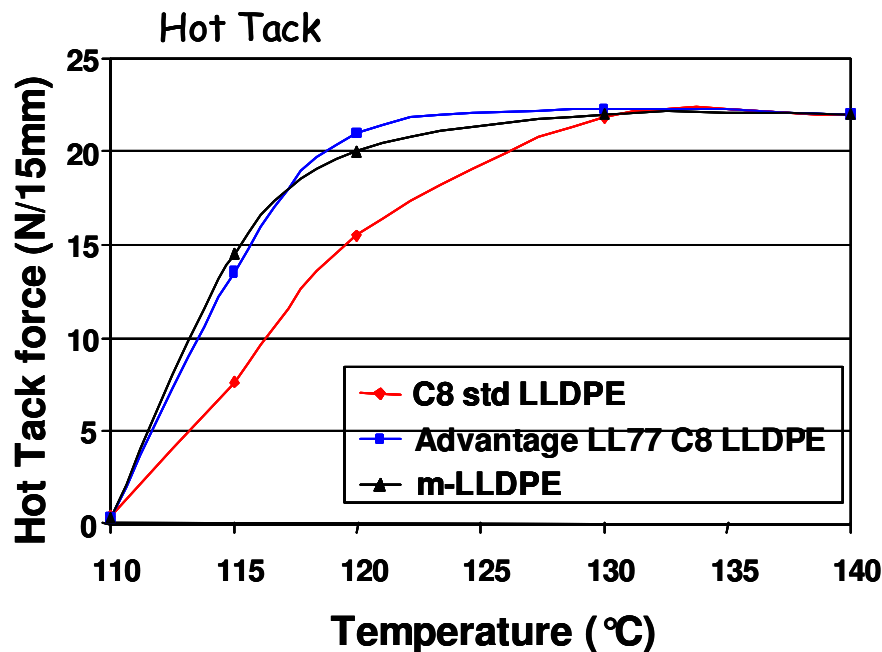
C₈-LLDPE Film has Improved Optical Properties

Advantage™ LL77 C8 exhibit enhanced opticals vs C8 std LLDPE
Balance of properties Compares well with m-LLDPE



C₈-LLDPE Resin has better compatibility with LDPE - Useful in Coextrusion applications

- Sealing layer in mono and coex lamination film
 - Flexible food packaging

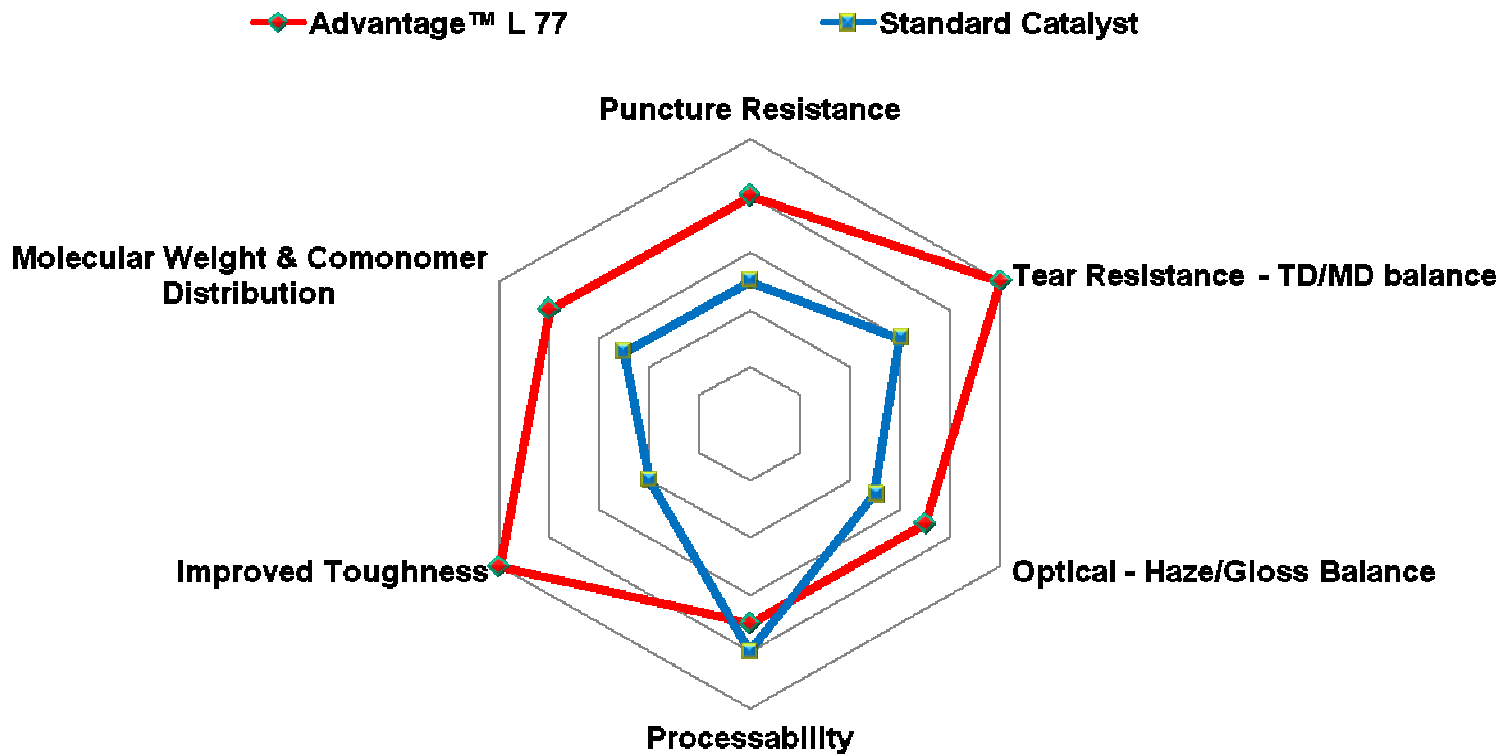


Note: monolayer film blend LLDPE/LDPE 60/40; thickness 60 microns; output 160kg/h, T=185°C

ADVANTAGE™ VERSUS STANDARD CATALYST

C₈ LLDPE Film Performance

- Superior Comonomer Distribution, Toughness, & Puncture Resistance.
- Better balance in Tear Resistance & Optical Properties



Advantage™ LL77 offers a better C8-LLDPE resin for Film Applications

Advantage™ LL77: Cost-in-Use Benefits

- Same reactor operating temperature
- Higher reactor stability – improved onstream time
- 70% comonomer reactor concentration - about 10% reduction of comonomer consumption
- High yield catalyst, 8-10 MT PE/Kg catalyst
- 50% of the Alkyls demand
- Four times longer solution adsorber bed life
- Purifier beds 20% more efficient
- 2% off spec reduction; colour and alumina fines
- Better comonomer distribution and resin color

Summary: Advantage™ LL 77

- better catalyst to solution-LLDPE Production!

- The Advantage™ LL77 catalyst system delivers significant benefits to High Temperature Solution Processes:
 - ✓ Improved resin color consistency
 - ✓ Reduced variable cost
 - *octene, co-cat etc*
 - ✓ Reduced environmental impact (*Solution absorber life x 4*)
 - ✓ Lower co-catalyst costs
 - ✓ Improved Reactor Control
 - ✓ Higher value resin
 - *Better CD, Lower m.pt, Better melt flow/strength behavior*
 - ✓ Improved product mix:
 - *octene, octene/butene and butene films, rotomolding.*

Conclusion

Albemarle Partnership and Value creation to Customers

- **Albemarle is well suited and committed to meet our customers - Global PO Industries**
 - **Fully integrated catalyst supplier**
 - **Control and manage supply chain**
 - **Expanding manufacturing capacity globally**
 - **World class product and safety stewardship**
 - **Supporting our customers through process development and innovation**
 - **Offering partnership in Value Creation to our customers**



Thank You for your Attention!
Any Questions.....?



- Albemarle Corporation
- Polimeri-Europe
- ACS Poly Workshop Organizers