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# Next Generation UNIPOL™ PE Metallocene Developments

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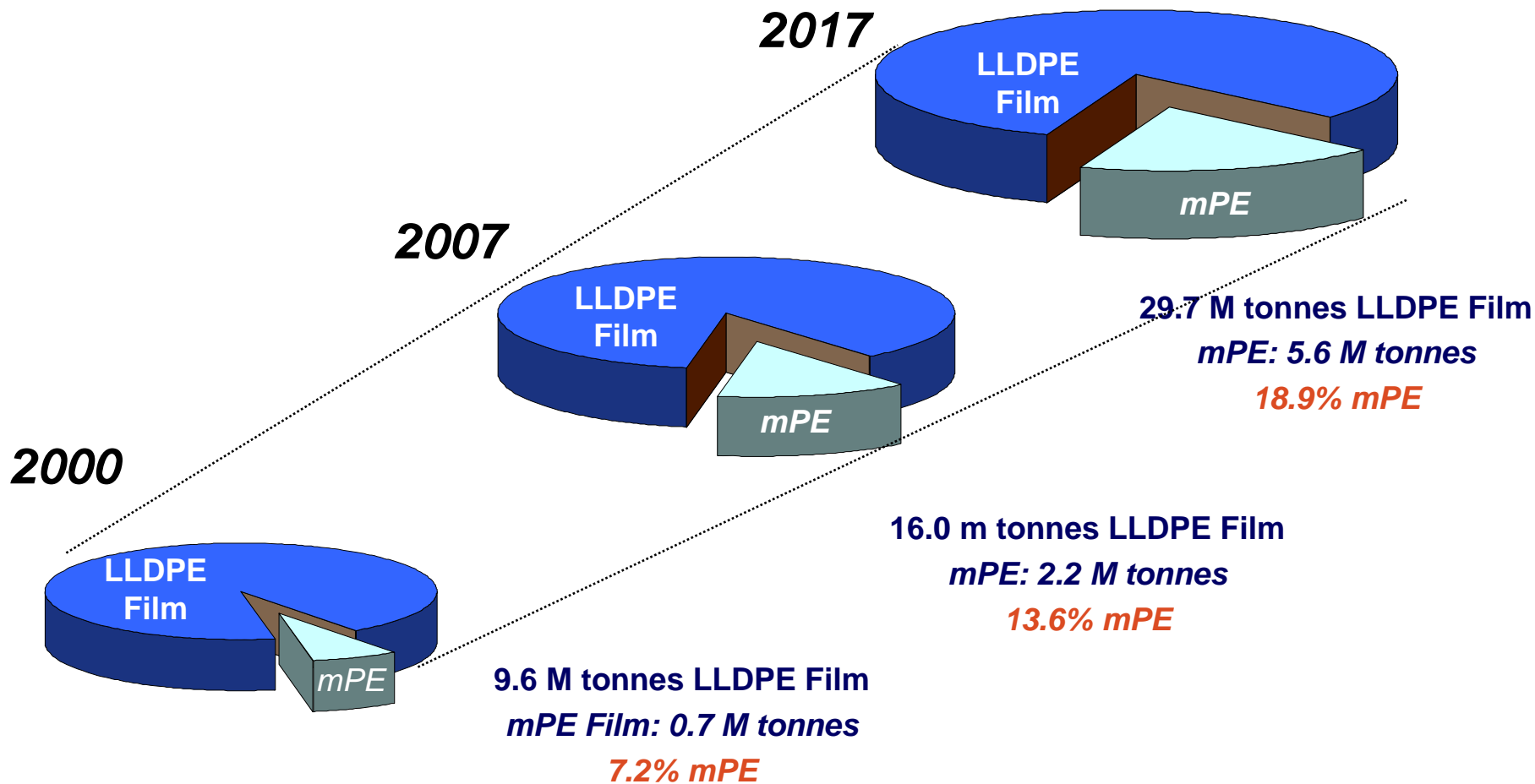
# Topics

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- **PE Metallocene Demand Trends**
- **Three Generations of advances in Univation's PE Metallocene Products**
  - XCAT™ High Performance (HPR) mLLDPE Resin
  - XCAT™ Easy Processing (EZP) mLLDPE Resin
  - XCAT™ Versatile Performance (VPR) mLLDPE Resin
- **Summary**

# mPE Portion of LLDPE Film – Global

*mLLDPE Film Growth 9.8% AAGR 07-17*

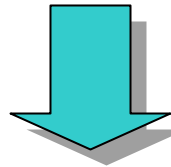


Source: Nexant Chem Systems, POPS 2007  
Millions of metric tonnes

# Univation's XCAT™ Metallocene Technology

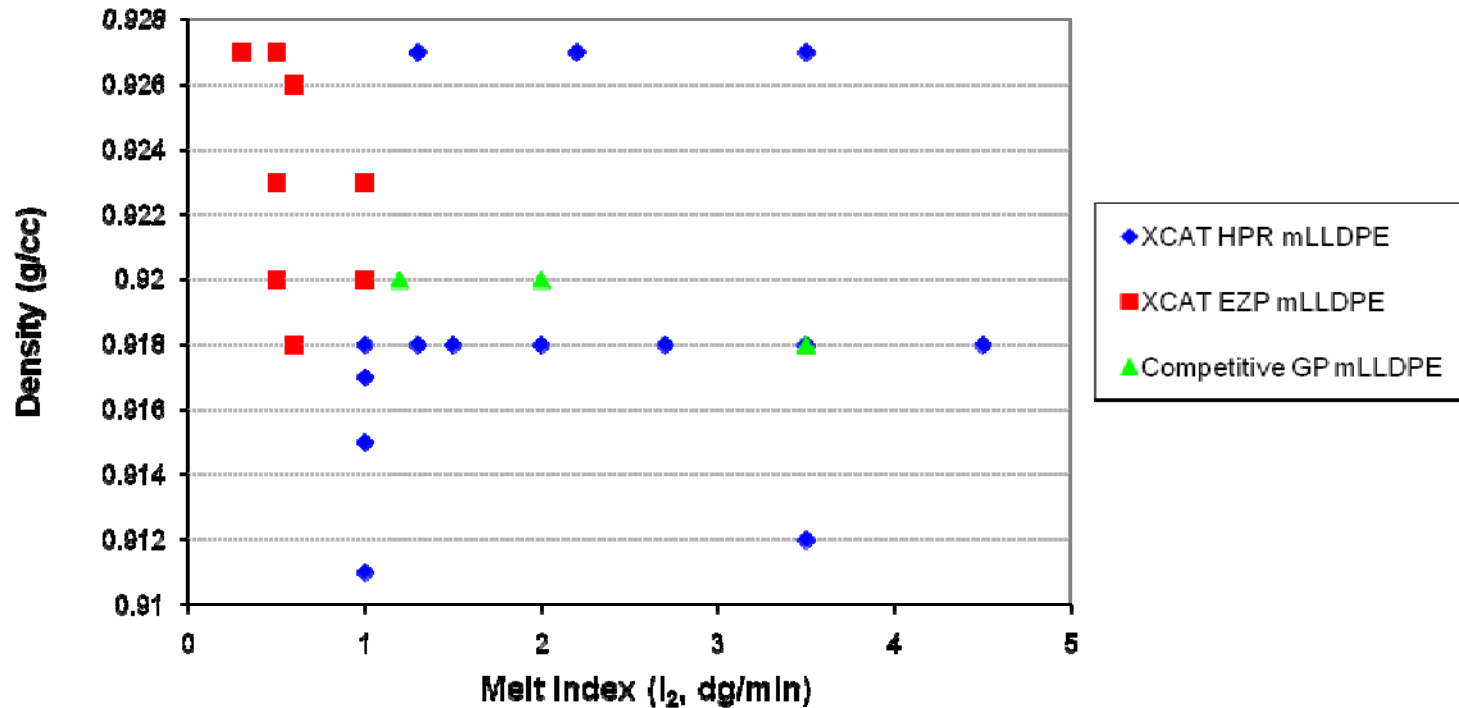
*Leading global supplier of proven MCN PE technology*

*Nearly 4.0 million tonnes of MCN PE produced with UNIPOL PE Process and XCAT catalyst technology over the last 15 years*



- **XCAT HPR mLLDPE** – the largest commercial volume MCN
- **XCAT EZP mLLDPE** – the newest commercial family with improved processability
- **XCAT VPR mLLDPE** – developmental products to expand the market accessibility of MCN's

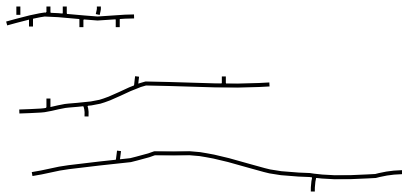
# XCAT HPR and XCAT EZP mLLDPE Commercial Resins



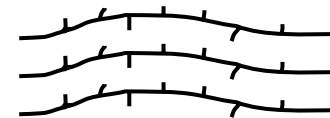
- **Commercial grade slate includes 20+ reactor grades and 40+ finished products**
  - Broad product mix covers major blown and cast film applications
  - Stretch, agricultural, heavy duty sacks, lamination, shrink, packaging, liners

# Advances in Product Technology

- **XCAT HP-100 Metallocene Catalysts** deliver the ability to control polymer molecular architecture, allowing independent manipulation of key parameters
  - Molecular weight distribution (MWD)
  - Comonomer distribution (CD)



**Broad Comonomer and  
Moderate MWD**  
(ZN LLDPE)



**Narrow Comonomer  
and MWD**  
(XCAT HPR mLLDPE)

# XCAT High Performance (HPR) mLLDPE Resins

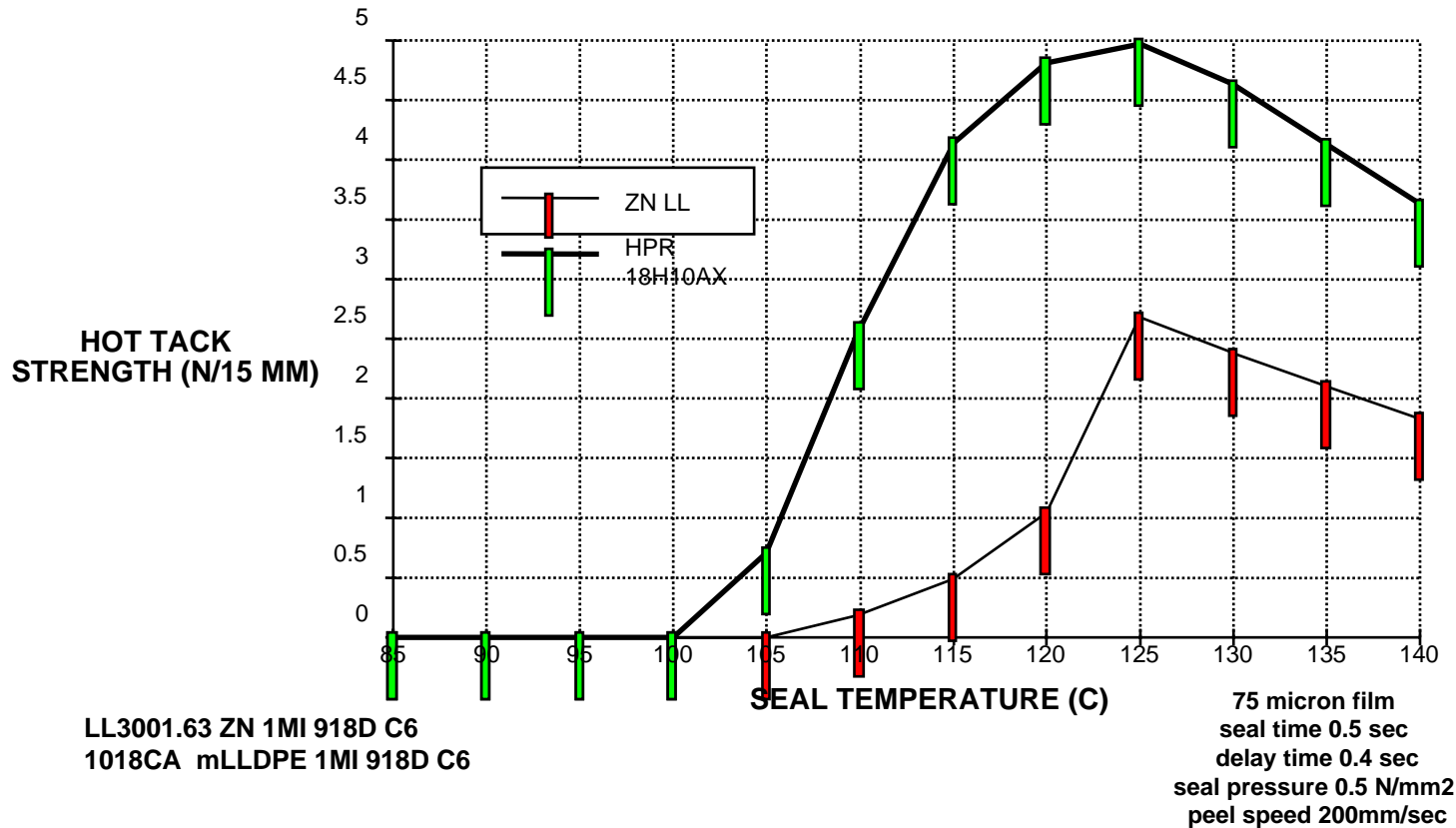
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- **XCAT HPR mLLDPE offer a unique balance of strength and toughness properties (tensile, puncture and dart impact), coupled with outstanding heat sealing and good optical properties**
- **Delivers exceptional product performance compared to conventional LLDPE**
- **Suitable for a wide range of flexible film applications including mVLDPE**

## **Application Versatility**

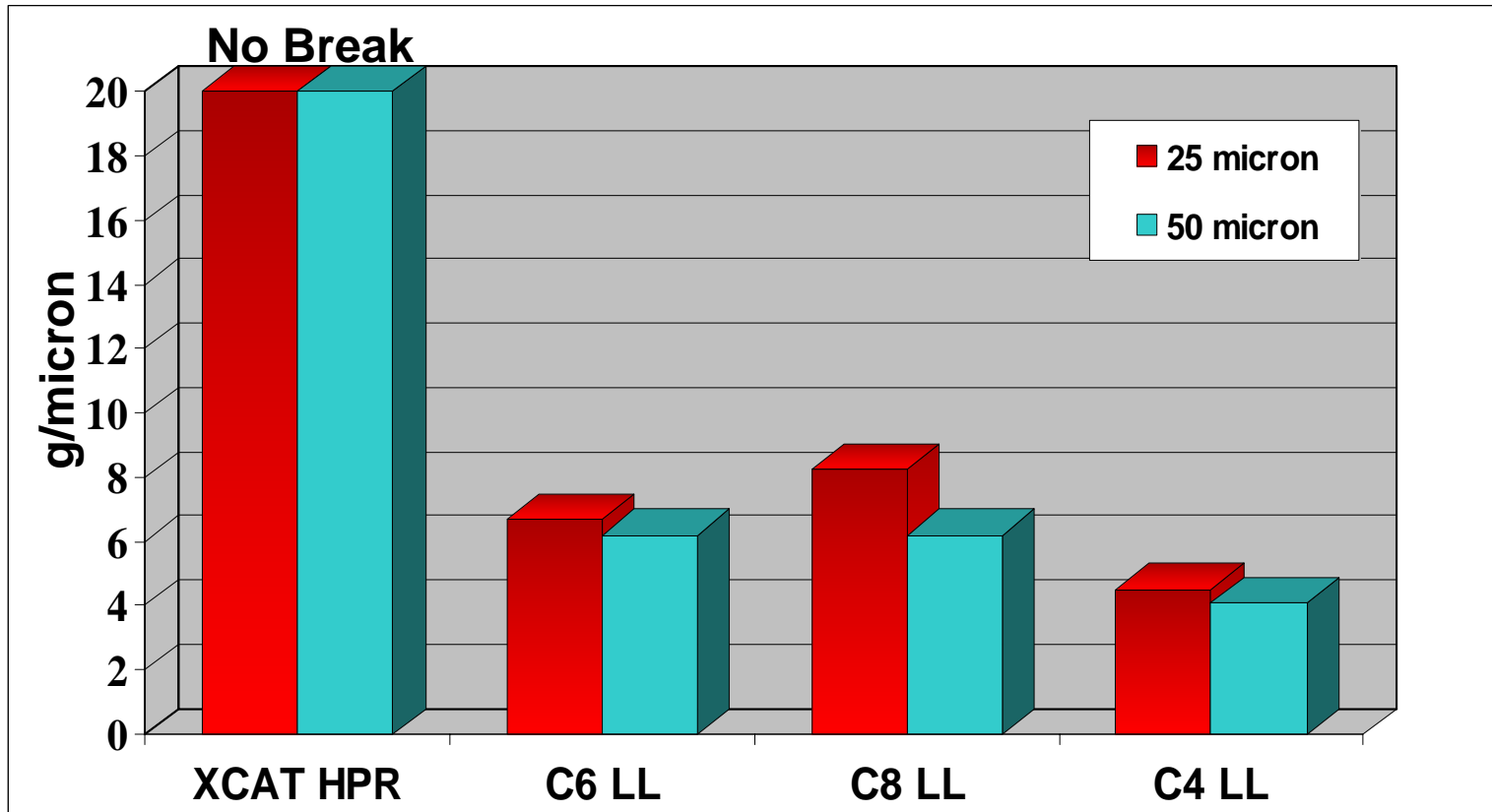
CAST stretch  
Blown stretch  
Can liners  
Heavy-duty shipping sacks  
Flexible food bags  
Frozen food bags  
Laminations  
Processed meats & cheese  
Ice bags  
Courier pouches  
Diaper back sheet  
Industrial packaging  
Pallet wrap

# XCAT HPR mLLDPE Hot Tack Strength vs ZN LL



 XCAT HPR mLLDPE resins offer higher hot tack strength and broader sealing latitude than ZN copolymers of similar density and comonomer type.

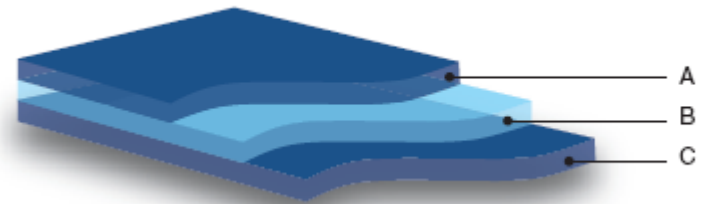
# Impact Strength for XCAT HPR mLLDPE vs ZN LLDPE



# XCAT HPR mLLDPE

## High Throughput/High Clarity (HTC)

- **Latest innovation combines mLLDPE toughness with high throughput rates and excellent optical properties**
- **Based on multi-layer, coextruded films using blend of HPR with LDPE or HDPE in the core**
- **Addition of LDPE in core layer improves bubble stability, allows for very high output rates**
  - Up to 2 kg/h/mm die diameter
- **Outstanding optical properties**
  - Haze as low as 1% for 25 micron film
  - <3% haze for 45 micron film
- **Maintain excellent toughness and heat sealing performance of HPR mLLDPE**



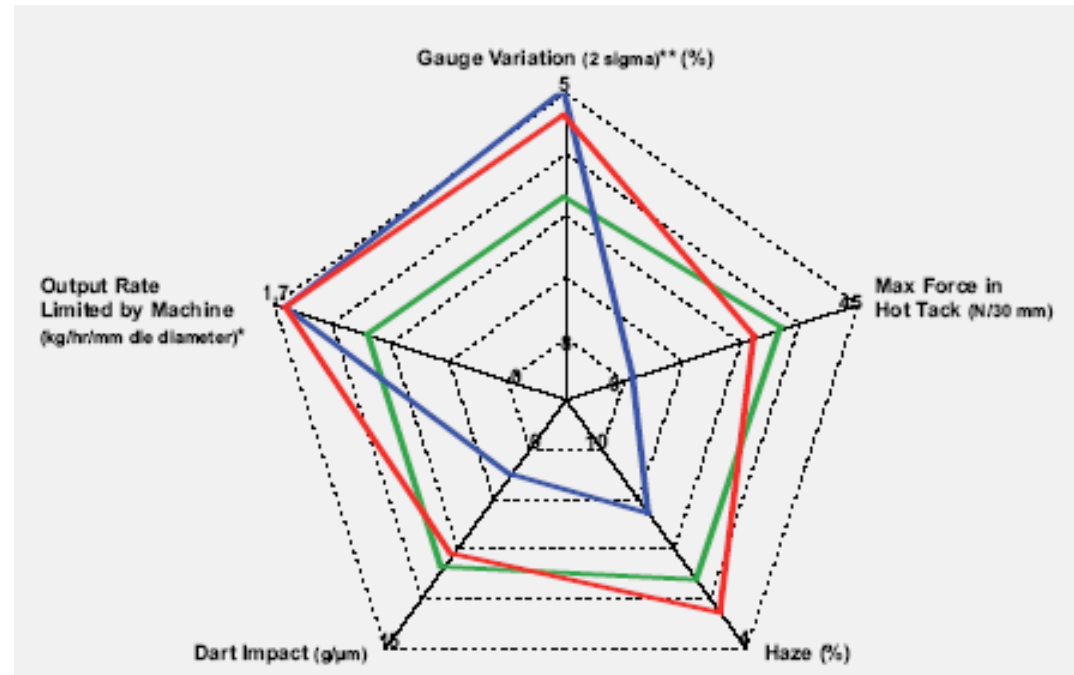
A = 100% XCAT HPR mLLDPE  
B = XCAT HPR mLLDPE rich plus LDPE  
C = 100% XCAT HPR mLLDPE

# XCAT HPR mLLDPE

## High Throughput/High Clarity (HTC)

### Ideal for flexible packaging films

- **Food Packaging**
  - significant down-gauging opportunity
  - improved optical & mechanical properties
  - higher stiffness structure ensuring good machine-ability
- **Lamination**
  - Higher output compared with traditional HPR mPE-based film
  - Retains the low seal initiation and high hot tack benefits of XCAT HPR mPE



Green = 50 micron monolayer film (90% XCAT HPR + 10% LDPE)

Blue = 50 micron monolayer LDPE

Red = 50 micron coex HPR based HTC film

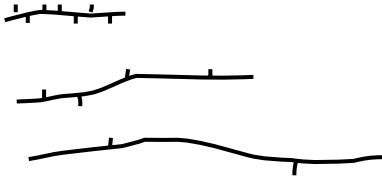
# Summary – XCAT HPR mLLDPE Technology

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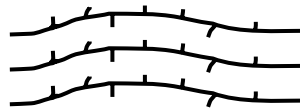
- **Leading Metallocene resins in the market today**
  - XCAT HPR mLLDPE Products have been commercial since 1995
  - Industry leading applications have been developed using this technology
- **Enhanced properties over standard ZN resins have been achieved**
- **HPR mLLDPE-type products are becoming a standard part of the LLDPE film resin portfolio**

# Advances in Product Technology

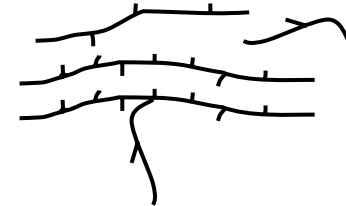
- **XCAT EZ-100** Metallocene Catalysts deliver the ability to control polymer molecular architecture, allowing independent manipulation of key parameters
  - Molecular weight distribution (MWD)
  - Comonomer distribution (CD)
  - Long chain branching (LCB)



**Broad Comonomer and  
Moderate MWD  
(ZN LLDPE)**

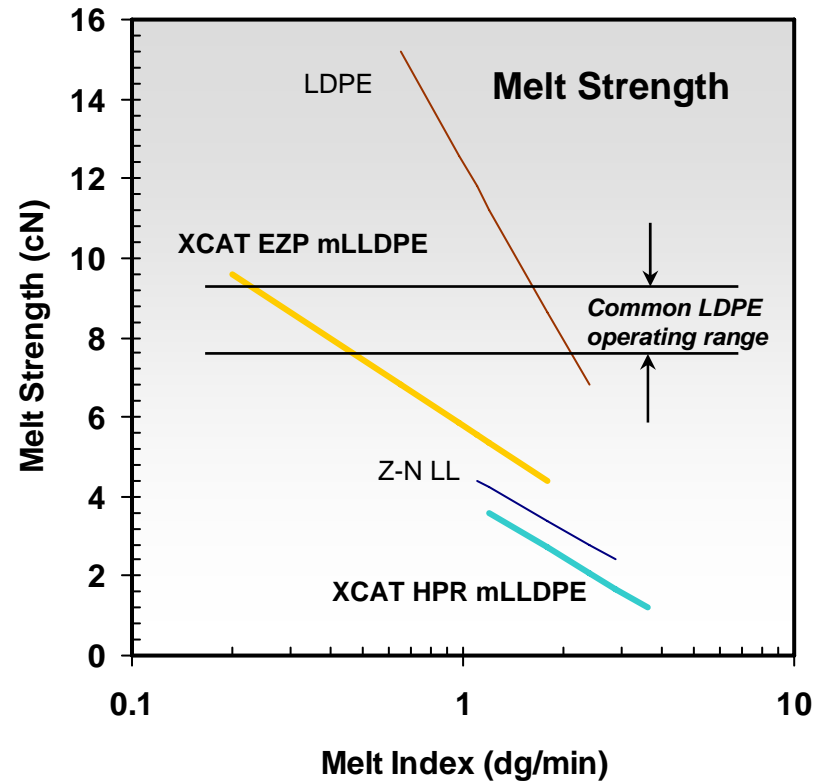
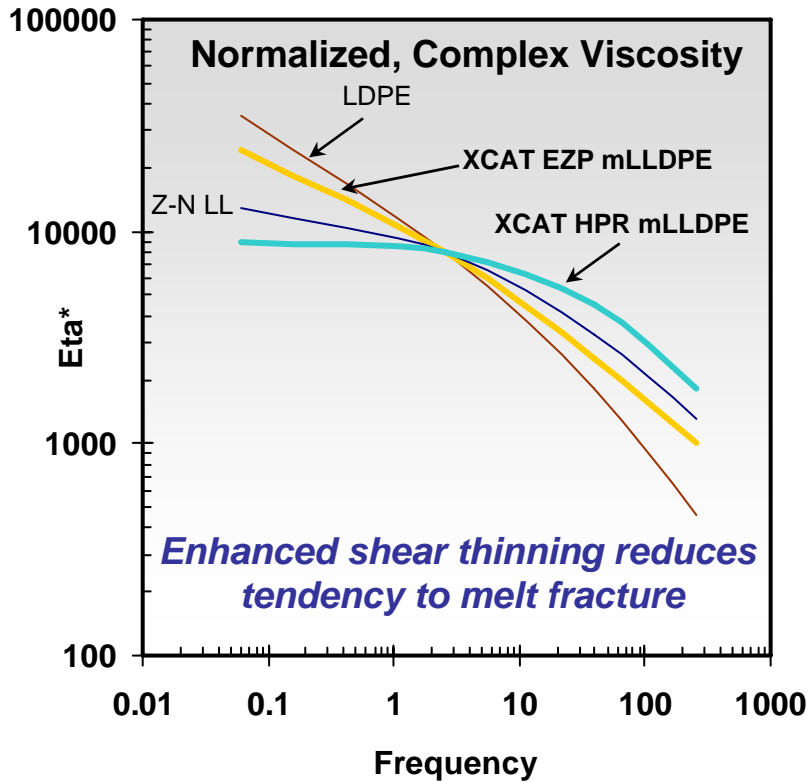


**Narrow Comonomer  
and MWD  
(XCAT HPR mLLDPE)**



**Narrow CD, low level  
LCB and moderate MWD  
(XCAT EZP mLLDPE)**

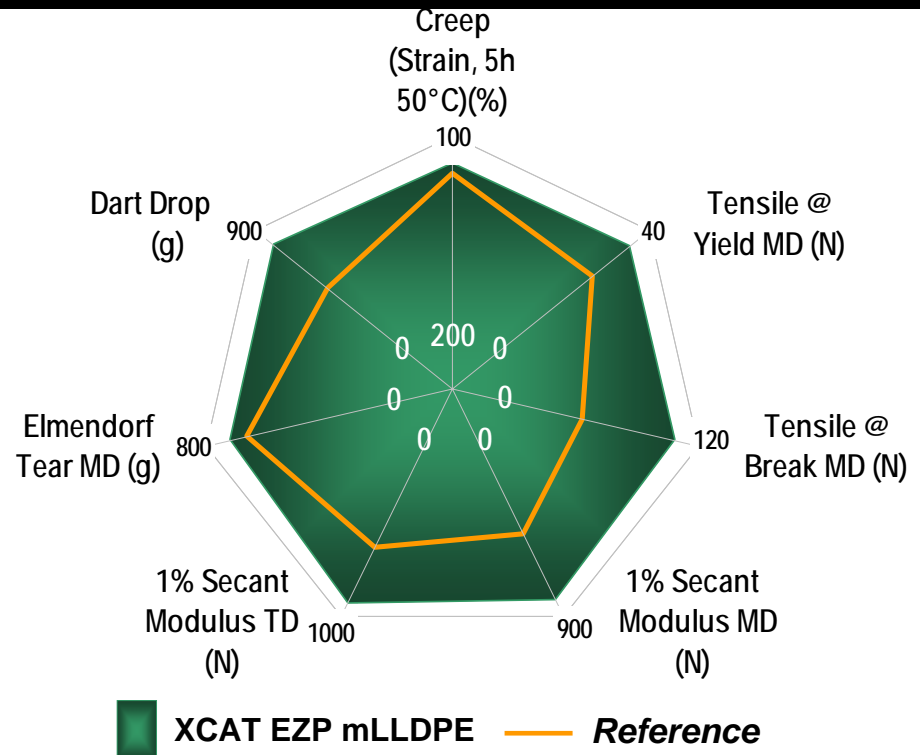
# XCAT EZP mLLDPE Processability



At 1.0 MI	HPR mLLDPE	Z-N LL	EZP mLLDPE	LDPE
$I_{21}/I_2$ Ratio (MWD - for extrudability)	15 - 17	27 - 29	40 - 50	50 - 70

# XCAT EZP mLLDPE Monolayer Heavy Duty Bags

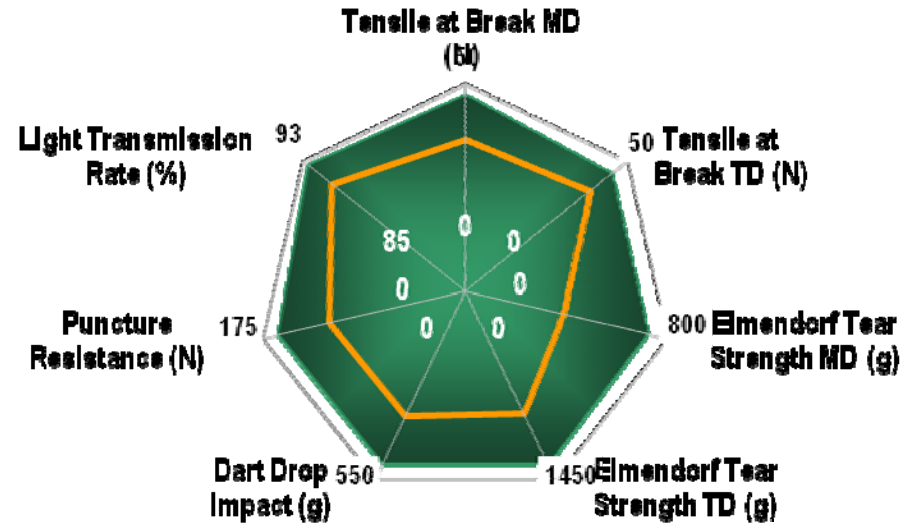
- XCAT EZP mLLDPE based Heavy Duty Bags offer:
  - Unit cost reduction achieved through 27% downgauging
  - Total film weight reduction of 25% - lower logistics cost
  - Improved tensile, modulus, tear and dart impact
  - Similar creep at significantly reduced gauge
  - No loss in output



	MI (dg/min)	Density (g/cm <sup>3</sup> )	EZP mLLDPE Formulation	Reference
Layer Thickness (μm)			160	220
LDPE	0.33	0.922		80
C4LLDPE	0.5	0.922		20
EZP mLLDPE	0.5	0.927	100	

# XCAT EZP mLLDPE Spring Greenhouse Film

- Unit cost reduction achieved through 20% down-gauging
- Overall performance improved at thinner gauge
- Improvement in physical properties
  - Tensile, puncture
  - Dart and tear
- Improves light transmission Rate
  - Allows for faster temperature rise in greenhouse



■ XCAT EZP mLLDPE (70 μm) — Reference (88 μm)

	MI (g/10 min)	Density (g/cm <sup>3</sup> )	EZP mLLDPE Coextruded 3 layer 70 μm film			Reference Coextruded 3 layer 88 μm film
Layer Ratio			1	1	1	
C4LLDPE	0.9	0.920				54
LDPE	0.3	0.922				46
EZP mLLDPE	1.0	0.920	100		100	
EZP mLLDPE	0.5	0.920		100		

# XCAT EZP mLLDPE Technology

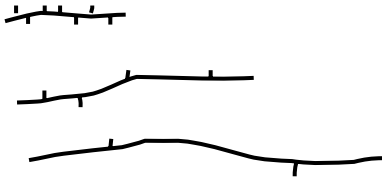
## Summary

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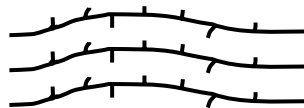
- **XCAT EZP mLLDPE is a second generation single site catalyzed product**
  - Commercialized in both North and South America
- **XCAT EZP mLLDPE resins have processing characteristics similar to commonly used LD/LL-rich blends**
  - Can be processed by a variety of blown film lines
    - LLDPE, Combi/Universal and LDPE screws
  - Reduced sensitivity to melt fracture
  - Allows film manufacturers more extrusion flexibility
- **XCAT EZP mLLDPE can be used in many applications that typically are served by HP-LDPE**
  - Heavy duty bags, greenhouse
  - Shrink Film applications

# Advances in Product Technology

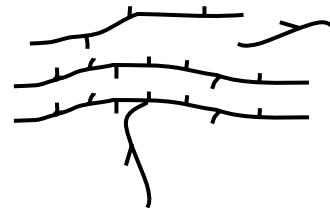
- **XCAT VP-100** Metallocene Catalysts deliver the ability to control polymer molecular architecture, allowing independent manipulation of key parameters
  - Molecular weight distribution (MWD)
  - Comonomer distribution (CD)
  - Long chain branching (LCB)
  - Distribution of comonomer with respect to molecular weight



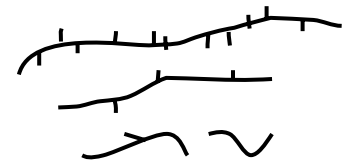
**Broad Comonomer and Moderate MWD**  
(ZN LLDPE)



**Narrow Comonomer and MWD**  
(XCAT HPR mLLDPE)



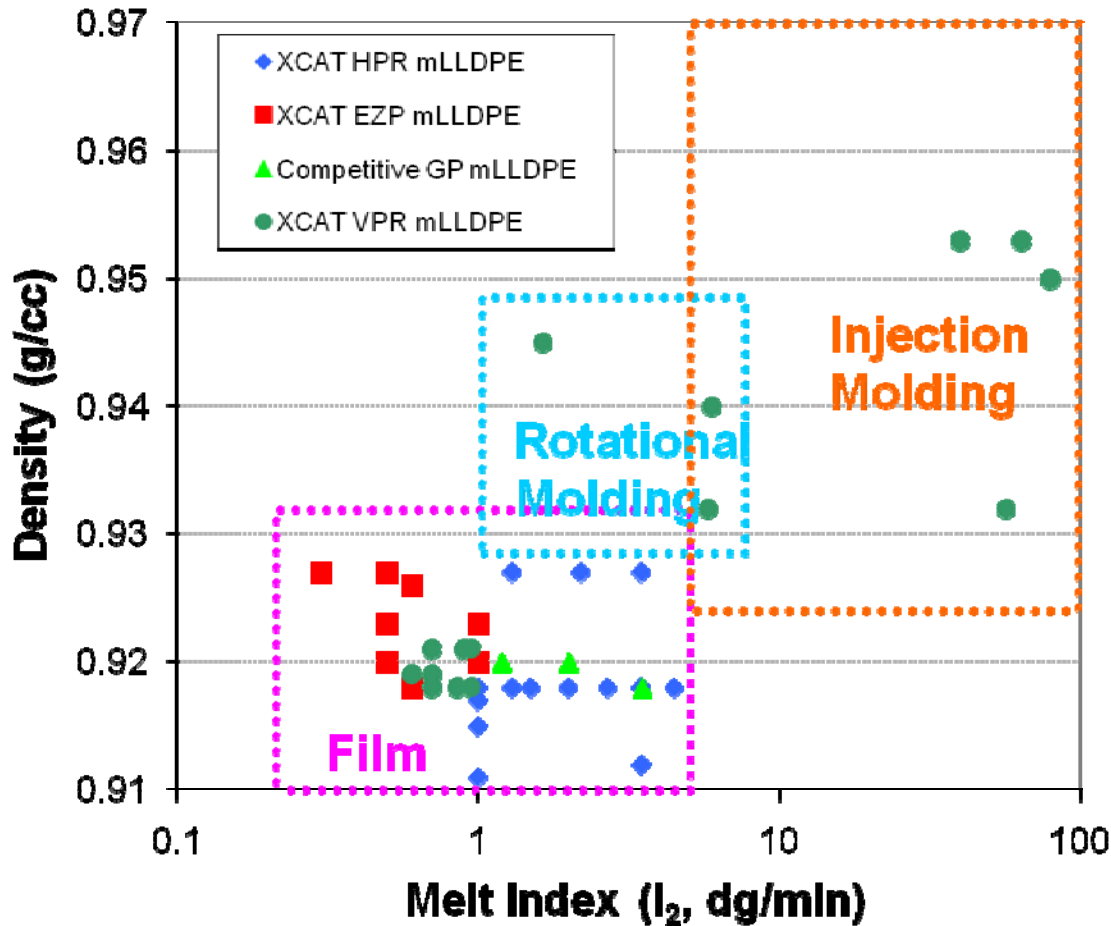
**Narrow CD, low level LCB and moderate MWD**  
(XCAT EZP mLLDPE)



**Tailored Comonomer Distribution or "BOCD"**  
(XCAT VPR mLLDPE)

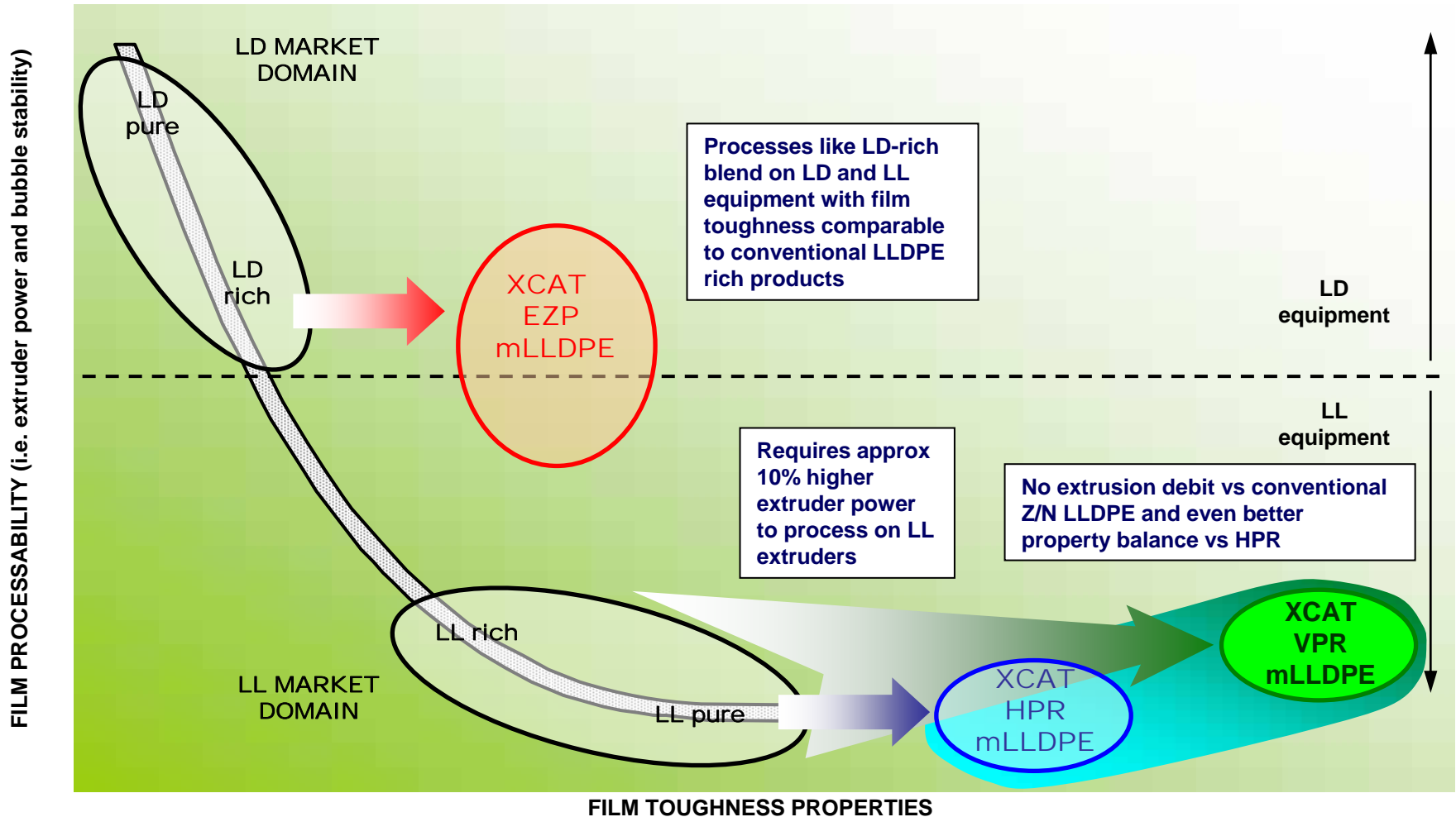
# XCAT Versatile Performance (VPR)

## mLLDPE Resins Open Large Application Spaces



Univation's third generation XCAT VP-100 technology can be used to produce film, injection molding and rotational molding grades

# Polyethylene - Processability vs Properties Map



# Univation's PE Metallocene Products

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- **Market trends indicate very high MCN growth in established markets (NA and WE)**
- **These growth trends are expected to carry over into emerging markets**
- **Products using XCAT Metallocene Catalysts provide outstanding property balance**
  - Enhanced toughness while maintaining optical properties
  - Low heat seal initiation and high hot tack strength
  - LDPE-like extrusion characteristics
  - Down-gauging opportunities in multi layer film constructions
- **Univation Technologies has a proven track record with Metallocene implementation**
  - >15 years of metallocene experience
  - ~ 4.0 Million tons of Metallocene produced to date using the UNIPOL PE Process
  - Two commercial metallocene technologies (XCAT HP-100 & XCAT EZ-100)
  - Third generation metallocene system (XCAT VP-100) in development that broadens application space



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