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HDPE Barrier Laminating Films for Use in Flexible Packaging Structures

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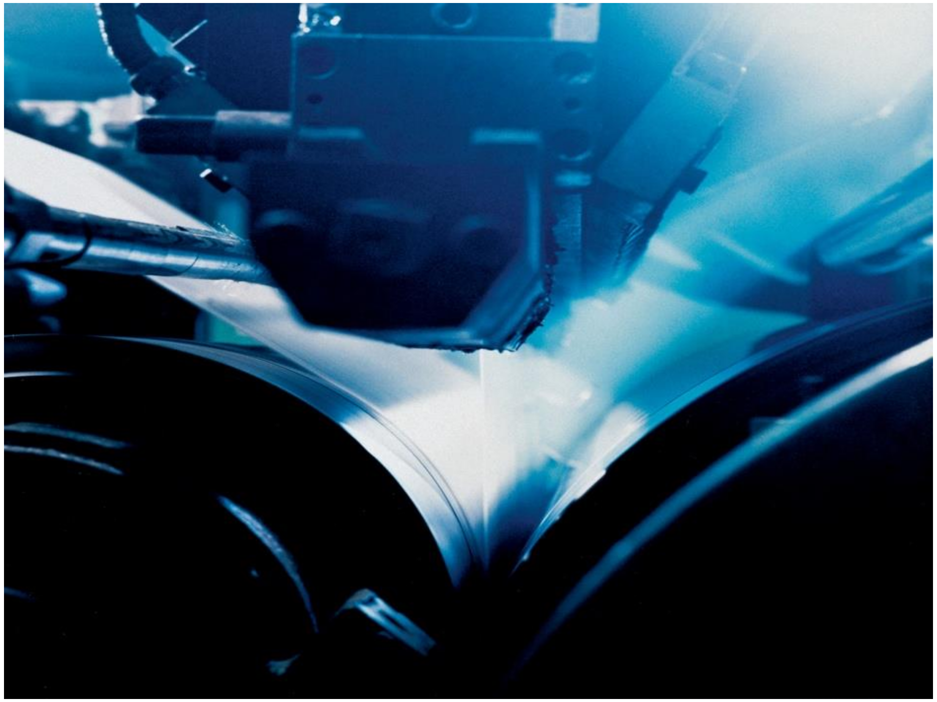
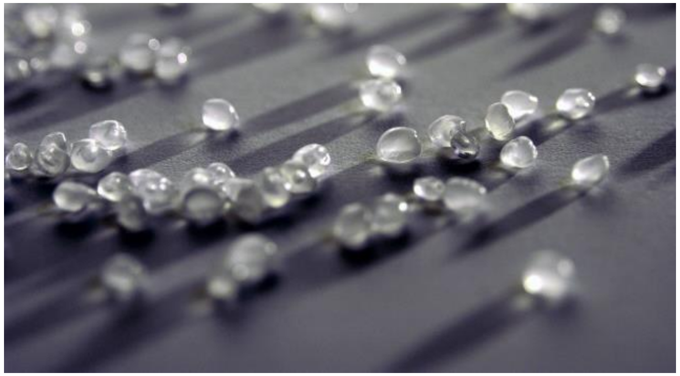
Presentation Outline

- Objective
- Market / Applications
- Experimental Procedures
- Results
- Benefits / Conclusions





HDPE Barrier Laminating Films

- Proposition: Extrusion lamination of high barrier HDPE-based films to replace:
  - Foils and metalized films
  - HDPE extrusion coatings

- Potential Benefits
  - Sustainability/Recyclability – Eliminating or reducing foils and metalized films
  - Weight and energy savings
  - Cost savings – Replacing over-engineered structures
  - Improved Water Vapor Transmission Rates (WVTR) compared to LDPE and HDPE extrusion coatings
  - Design flexibility to optimize WVTR and Oxygen Transmission Rate (OTR)

Extrusion Coating Markets / Applications

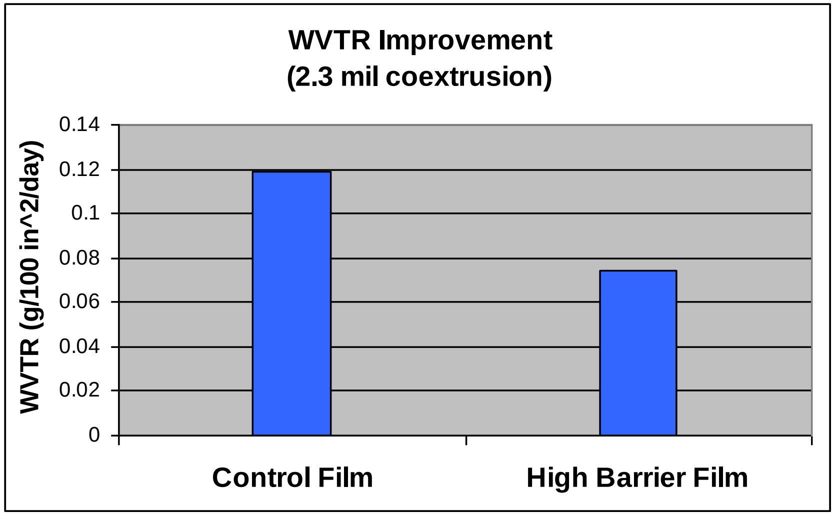
- Flexible Packaging
  - Snacks (chips, peanuts)
  - Dry-goods (instant potatoes, hot chocolate)

- Medical Flexible Packaging

- Paper / Paper Board Packaging
  - Folding cartons (frozen foods, bulk packaging)
  - Liquid cartons (orange juice)

Alathon M6010SB (1.1 g/10 min Melt Index, Homopolymer) Next-generation MMW HDPE for Barrier Films

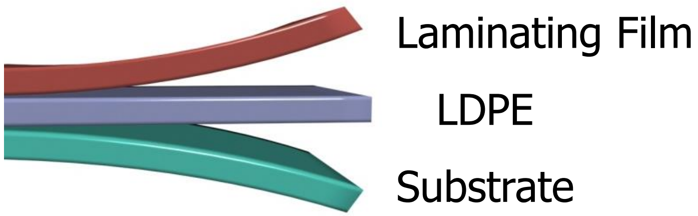
- Used in films having optimized moisture barrier improvement through resin structure design and nucleation
  - 30-40% WVTR improvement compared to incumbent barrier HDPE resins
  - Specifically formulated to retain important film properties
    - Tear
    - Puncture, dart
    - Stiffness
    - Low organoleptics
    - Low gels
  - Film processability – can be used in any film layer without processing issues
    - Low dusting
    - No melt fracture



Extrusion Coating Structures

- Incumbent Structures Using:
  - HDPE extrusion coating resins
  - High cost specialty resins or substrates
    - e.g. laminations using foils and metalized films

- Proposed Structures
  - Laminations Using HDPE-Based Barrier Films
    - Laminations designed for specific product requirements
    - Can incorporate monolayer and co-ex HDPE film structures



Potential Film Structures for Lamination

- Monolayer Structure
  - Supports WVTR Barrier improvements
  - WVTR controlled by film thickness

- 3 Layer Structures
  - Skins for heat seal / seal strength requirements
  - Core layer for WVTR requirements

- 5-Layer Structures
  - Skins: HDPE for WVTR needs
  - Core: Specialty resin for OTR requirements

Experimental Outline

- Performed laboratory studies to evaluate the performance of barrier HDPE film laminations compared to:
  - standard HDPE extrusion coatings
  - incumbent foil-based packaging structures

- Produced monolayer and 5-layer coextruded films at three thicknesses

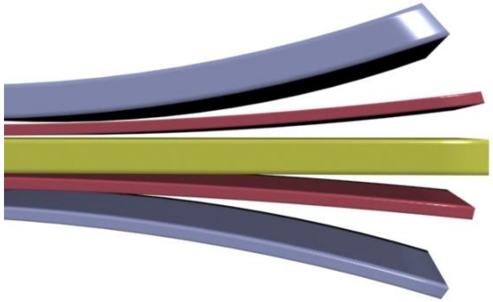
- Conducted extrusion coating / lamination trials

- Measured WVTR and OTR

HDPE Blown Film Lab Trials
Samples produced at 19, 32 & 51 microns (0.75, 1.25 and 2.0 mils)

- Monolayer 100% high barrier HDPE Film Structure
  - 152 mm die, 1520 micron gap, 2.8 BUR, 80 kg/hr (175 lbs/hr)

- 5-Layer Co-ex Film Structure
  - 203 mm die, 1400 micron gap, 2.5 BUR, 68 kg/hr (150 lbs/hr)
  - ABCBA film structure:



Extrusion Coating / Lamination Lab Trials

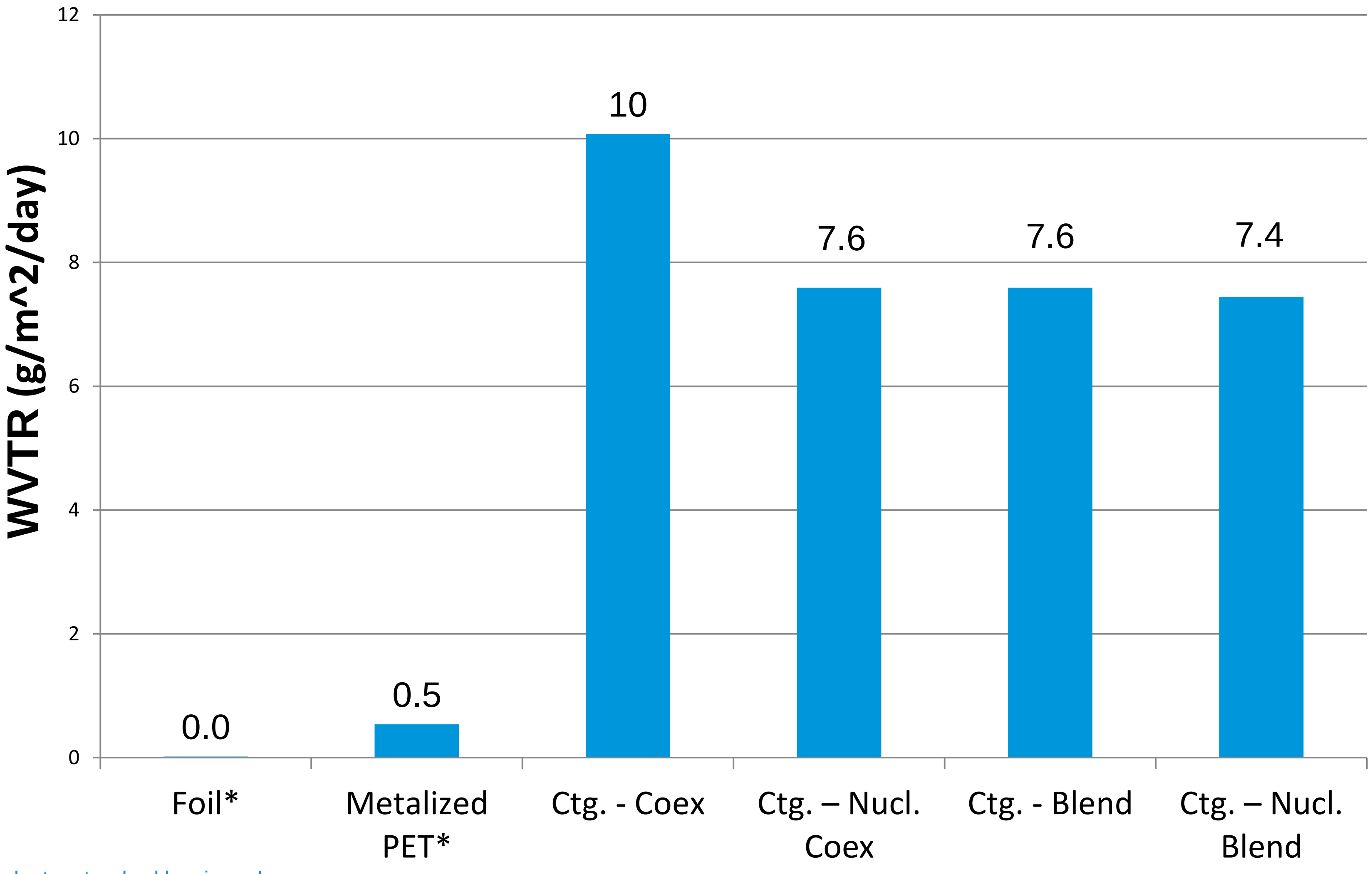
- Coating trials were designed to compare HDPE extrusion coatings to HDPE-based film laminations

- Extrusion coating processing conditions:
  - 320^{o}C melt temperature
  - 180 m/min line speed
  - 178 mm air gap
  - 68 micron Kraft paper

Extrusion Coated Lab Structures
Incorporating HDPE Extrusion Coating Resins

Sample ID	Substrate 68 micron	Inner Layer 21 micron (25%)	Core Layer 41 micron (50%)	Sealant Layer 21 micron (25%)
Ctg. - Coex	kraft	LDPE MI: 10 g/10 min Density: 0.918 g/cc	HDPE MI: 12 g/10 min Density: 0.960 g/cc	LDPE MI: 10 g/10 min Density: 0.918 g/cc
Ctg. – Nucl. Coex	kraft	LDPE	Nucleated HDPE	LDPE
Ctg. - Blend	kraft	Monolayer Blend of 50% LDPE / 50% HDPE		
Ctg. – Nucl. Blend	kraft	Monolayer Blend of 50% LDPE / 50% Nucleated HDPE		

WVTR Results
Comparing HDPE-Based Extrusion Coatings

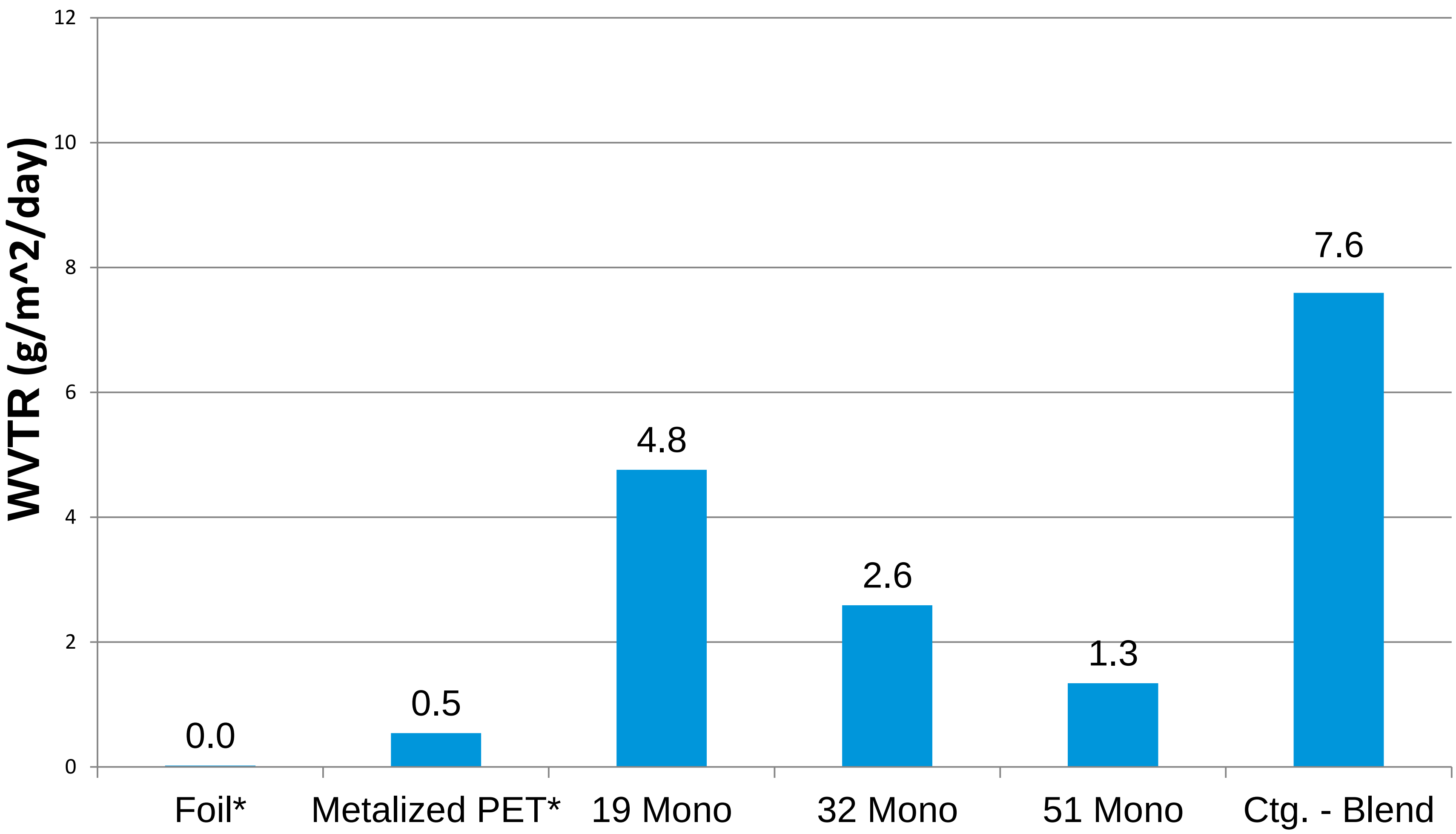


* Industry standard barrier values

Extrusion Lamination Lab Structures Incorporating HDPE-Based Lamination Films

Sample ID	Substrate 68 micron	Core Layer 12 micron	Laminating Film 19 – 51 micron
19 Mono	kraft	LDPE MI: 5.6 g/10 min Density: 0.923 g/cc	19 Micron Monolayer Film
32 Mono	kraft	LDPE	32 Micron Monolayer Film
51 Mono	kraft	LDPE	51 Micron Monolayer Film
19 Coex	kraft	LDPE	19 Micron 5-Layer Film
32 Coex	kraft	LDPE	32 Micron 5-Layer Film
51 Coex	kraft	LDPE	51 Micron 5-Layer Film

WVTR Results
Monolayer HDPE Film Laminations vs. Incumbents



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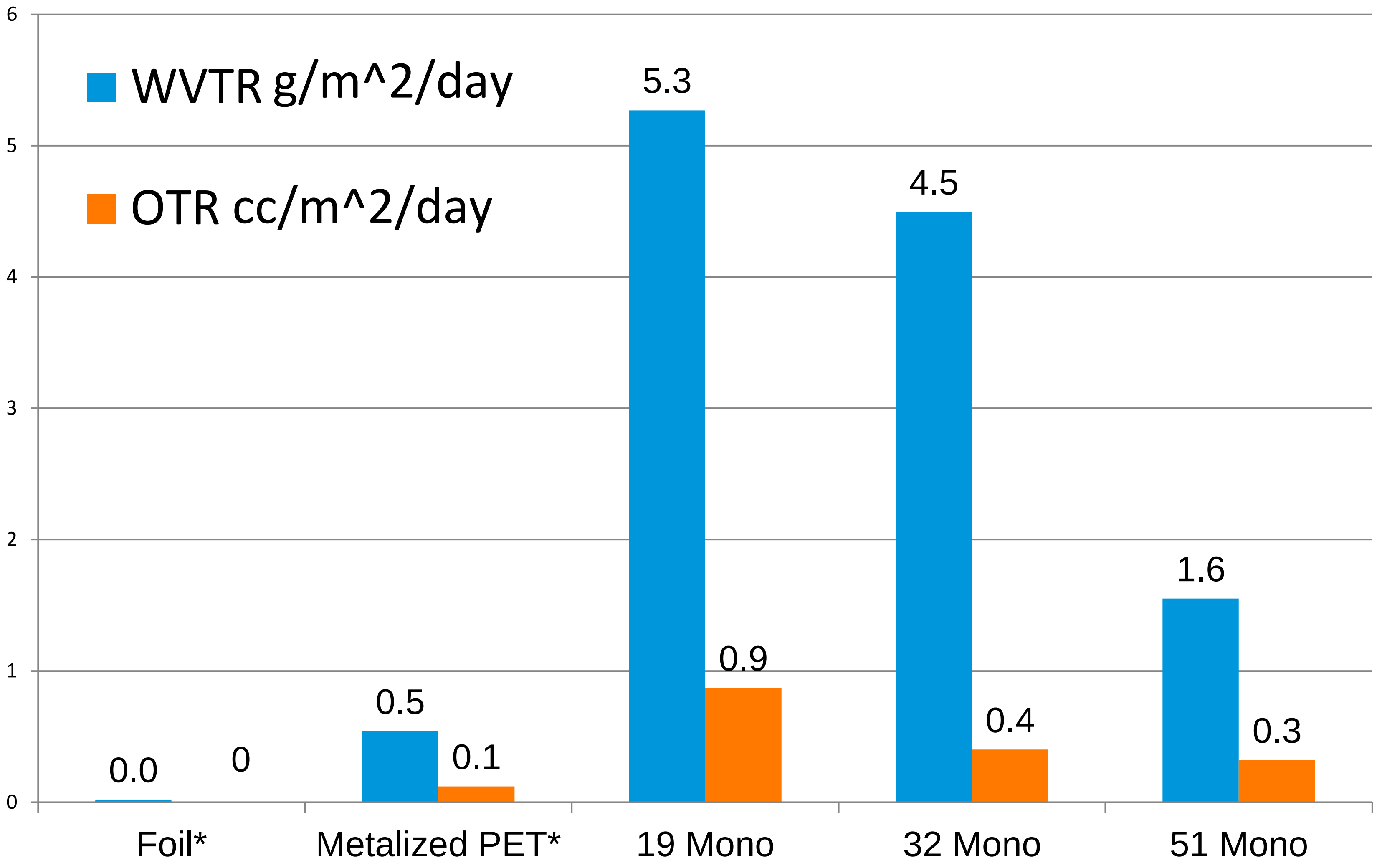
WVTR / OTR Results
Co-ex HDPE Film Laminations vs. Incumbents



* Industry standard barrier values

Conclusions / Demonstrated Benefits

- Primary Benefits
  - Sustainability/Recyclability – Eliminating or reducing foils and metalized films
  - Weight and energy saving
  - Cost savings – Replacing over-engineered structures
  - Improved Water Vapor Transmission Rates (WVTR) compared to LDPE and HDPE extrusion coatings
  - Design flexibility to optimize WVTR and Oxygen Transmission Rate (OTR)

- Additional Benefits vs. HDPE Coatings
  - Package physical property improvements (e.g. tear, puncture, modulus)
  - Design flexibility for package sealant layer
  - Improved processing
  - Organoleptics

Polyolefin Innovations from LyondellBasell

- Thank you for your attention. Questions?
- Special thanks to: Tom Schwab, Jeff Borke, Scott Clayton, Bob Holweger and Barb Harding
- Please contact scott.weber2@lyondellbasell.com for more information

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Thank you

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