

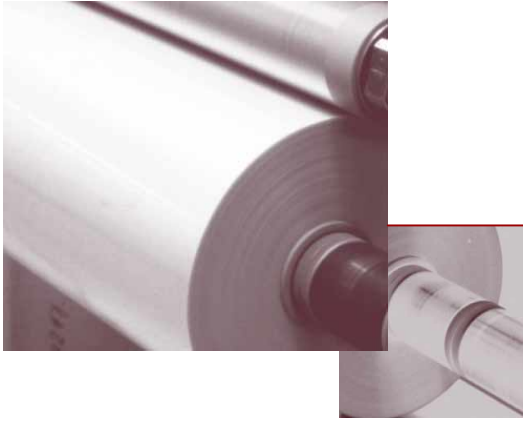


# Developments in Clear High Barrier Packaging

Dhuanne Dodrill

Flexible Packaging Conference 2004

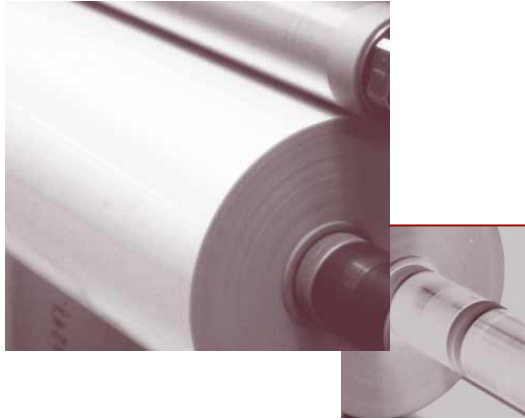
March 24 - 26, 2004



# Package Clarity

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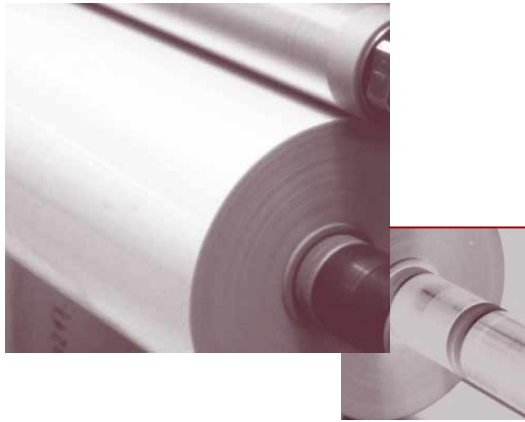
- Product Visibility
  - Consumer appeal
  - Product Identification
  - Product Inspection
    - Visual
    - Metal Detection
- Package Inspection



# The Standard

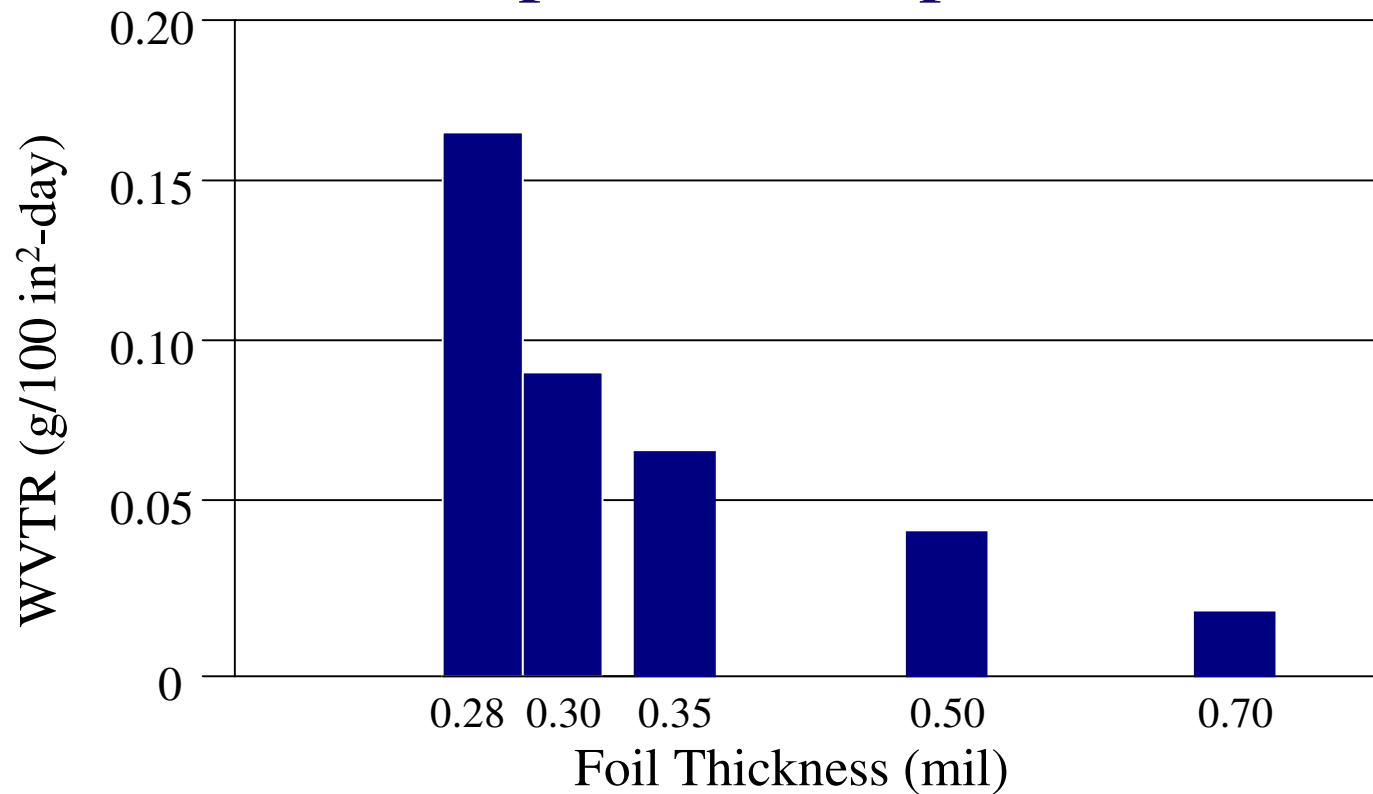
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- Aluminum Foil
  - 1 mil and above considered pinhole free
  - Virtually impervious to moisture and gas
  - Well understood with long history
  - Not clear
  - Limited formability



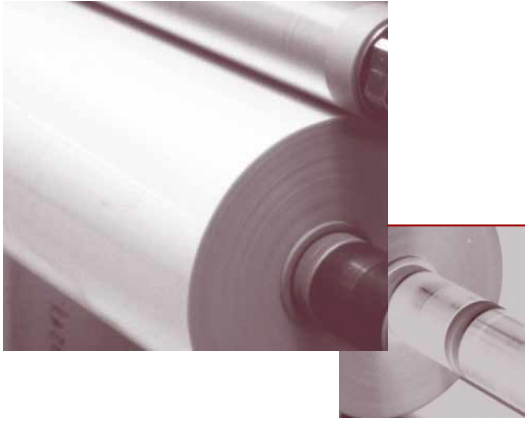
# The Standard

- Below 1 mil, pinholes impact barrier



Reference: ASTM B 479

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# Package Requirements

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- Barrier
  - Oxygen
  - Water Vapor
  - Aroma
  - Chemical
  - UV
  - Microbial



# Package Requirements

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- Product
  - Contain Water
  - Chemically Active
  - Sharp
- Sterilization Method (if applicable)
- Formability
- Environmental/Disposal Requirements
- Cost



# Barrier Choices

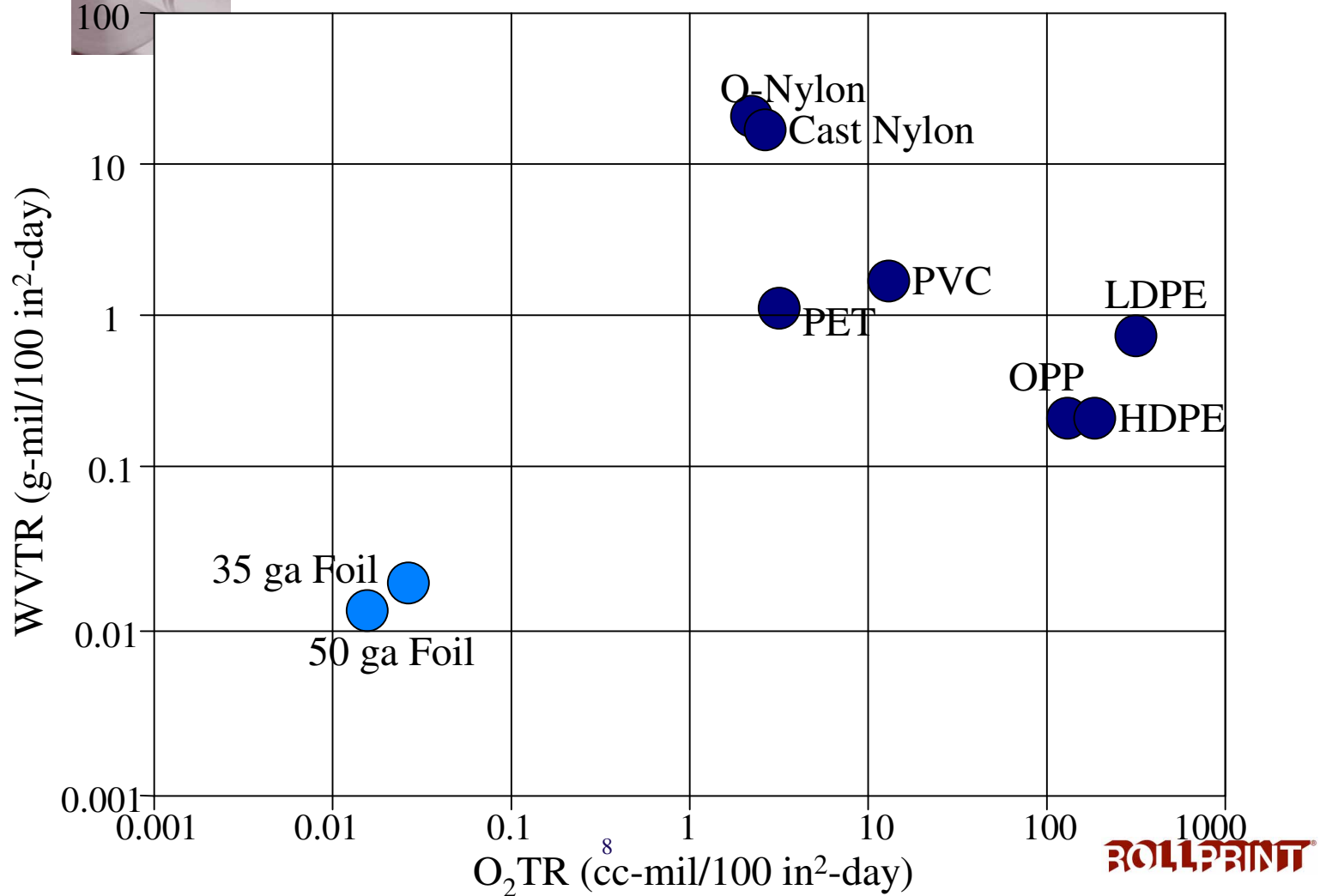
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- Barrier Films
  - Barrier proportional to the thickness.
- Barrier Coatings
- Combination of Films/Coatings



# Barrier Properties

## Common Films



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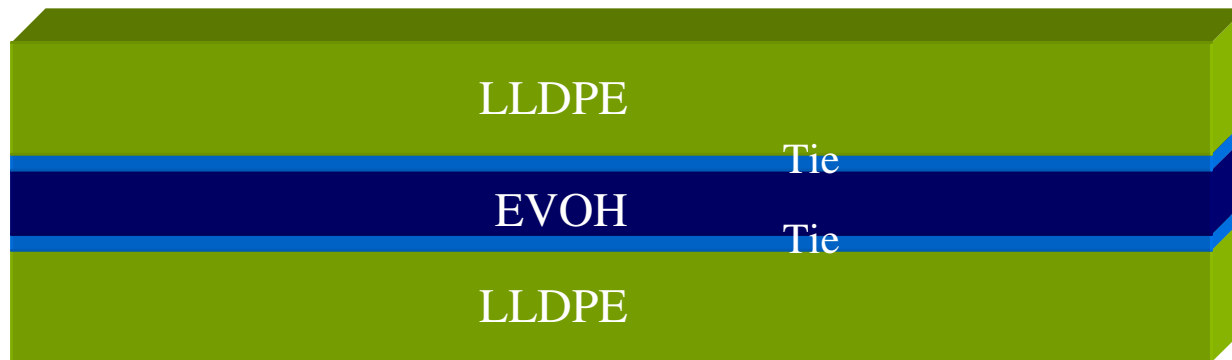


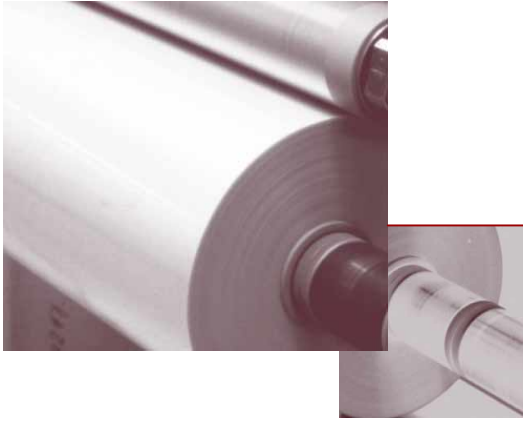


# Barrier Films – EVOH

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- Ethylene Vinyl Alcohol (EVOH)
  - Discrete layer in a coextrusion

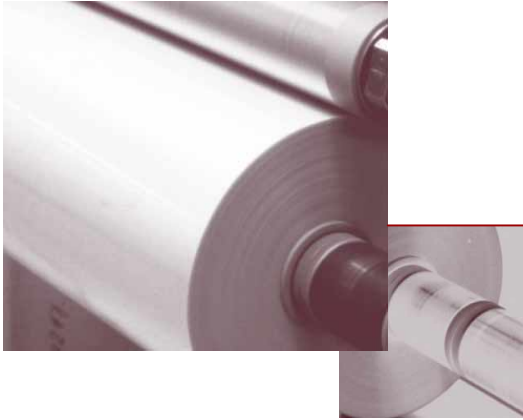




# Barrier Films – EVOH

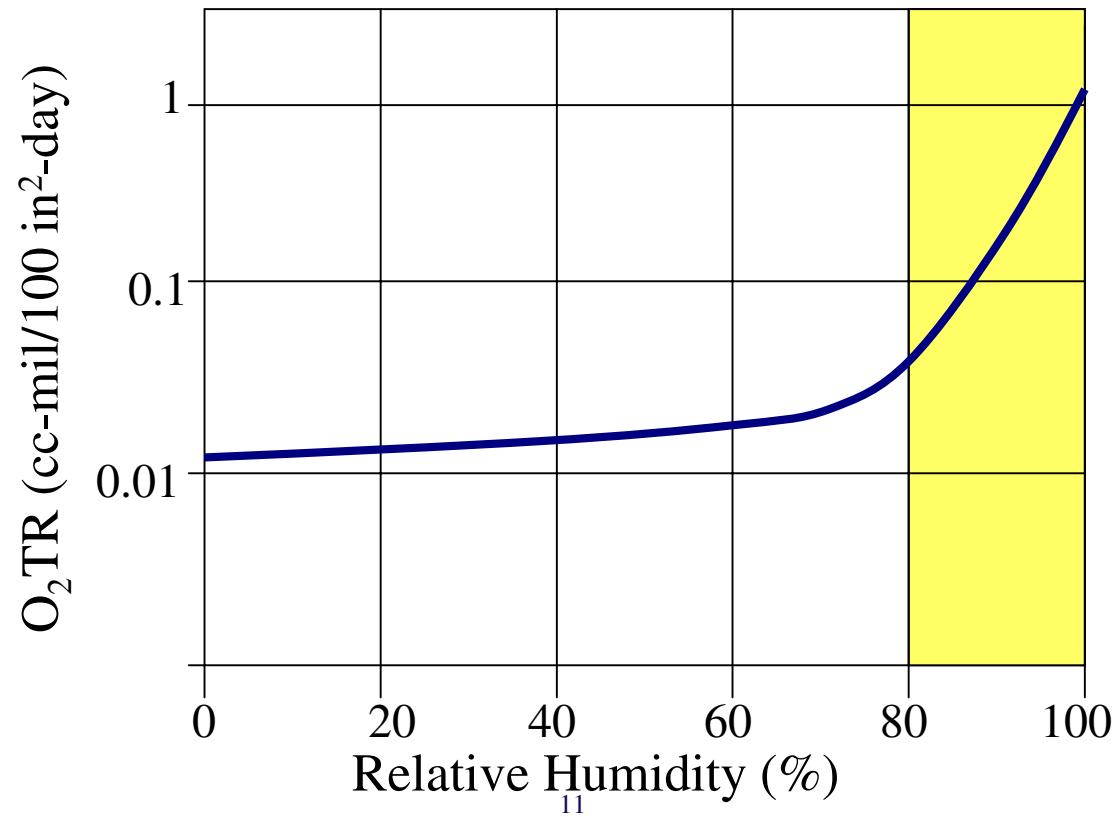
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- Excellent Oxygen Barrier
  - 0.006 - 0.12 cc-mil/100 in<sup>2</sup>-day
  - Barrier dependent upon:
    - Mole percent
    - Degree of crystallinity
    - Thickness
    - Humidity
    - Temperature



# Barrier Films – EVOH

- Effect of humidity on oxygen barrier



Tested at 20°C

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# Barrier Films – EVOH

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- Excellent Oxygen Barrier
- Excellent Odor/Aroma Barrier
- Thermoformable
- Widely used and well understood



## Barrier Films – Barex<sup>®</sup>

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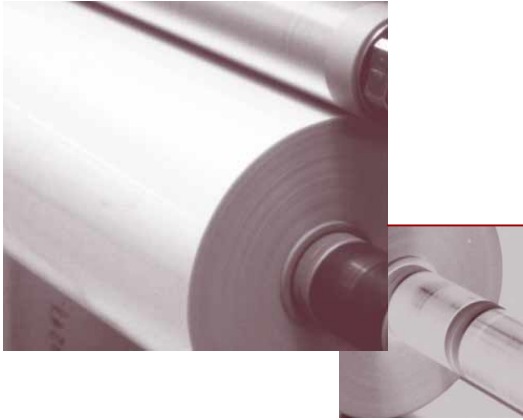
- Good Oxygen Barrier
  - 0.7 g-mil/100in<sup>2</sup>-day
- Thermoformable
- Can be used as a sealant



# Barrier Films – COC

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- Cyclic Olefin Copolymers (COC)
  - Excellent moisture barrier
    - Discrete layer in a coextrusion or laminate.
    - Topas<sup>®</sup> 8007: 0.071 g-mil/100 in<sup>2</sup>-day
    - Topas<sup>®</sup> 6015: 0.11 g-mil/100 in<sup>2</sup>-day
  - Enhance stiffness
  - Excellent clarity
  - Thermoformable
  - Heat Resistant Grades Available



# Barrier Films – LCP

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- Liquid Crystal Polymers (LCPs)
  - Typically used as a 0.08 - 0.2 mil layer in a coextrusion
  - Excellent barrier properties
    - Vectran V200P: O<sub>2</sub>TR: 0.04 cc-mil/100 in<sup>2</sup>-day  
WVTR: 0.015 g-mil/100 in<sup>2</sup>-day
  - Thermally stable
  - Inert
  - Chemical resistance
  - Thermoformable

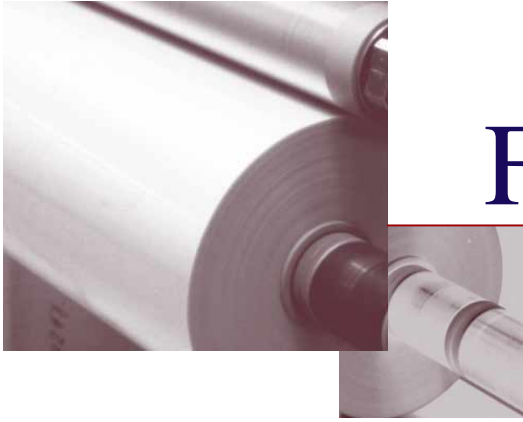


# Films – CTFE

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- Chlorotrifluoroethylene (CTFE)
  - Excellent Moisture Barrier
    - Aclar 22C: 0.026 g-mil/100 in<sup>2</sup>-day
    - Aclar UltRx, SupRx: 0.016 g-mil/100 in<sup>2</sup>-day
  - Inert
  - Excellent Clarity
  - Thermoformable





# Films – Nanocomposites

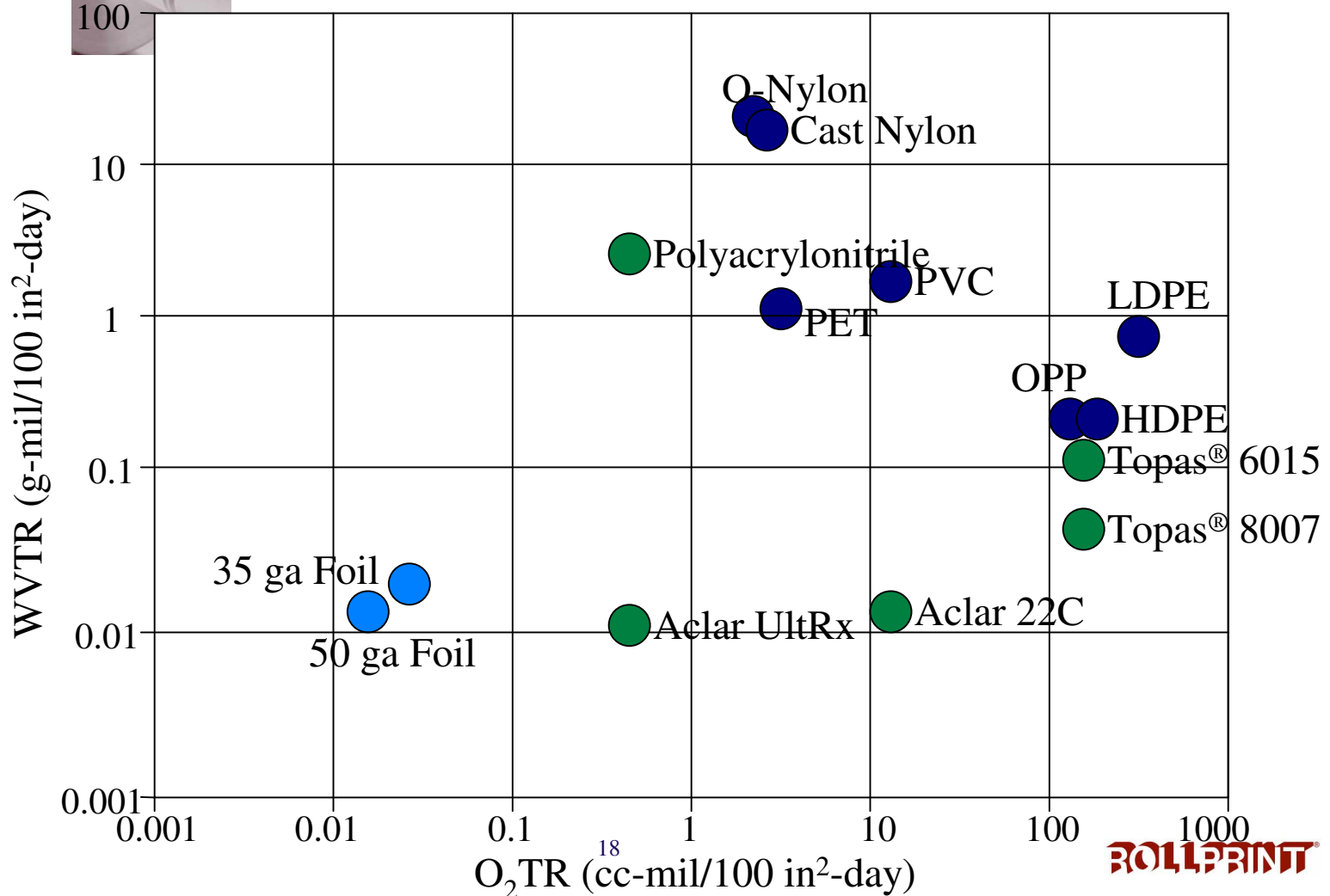
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- Nanocomposites
  - Polymer structures containing fillers in the nanometer range.
  - The fillers separate into tiny platelets that disperse into a matrix of layers
  - Increased oxygen and gas barrier
  - Increased strength and puncture resistance

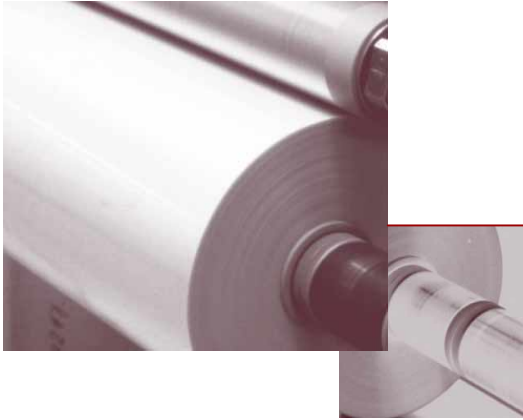


# Barrier Properties

## Barrier Films



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# Coatings – PVdC

- Polyvinylidene chloride (PVdC)
  - Good oxygen and moisture barrier

<b>Material</b>	<b>O<sub>2</sub>TR (cc/100 in<sup>2</sup>-day)</b>	<b>WVTR (g/100 in<sup>2</sup>-day)</b>
PVdC-coated PET	0.5	0.5
PVdC-coated OPP	1.3	0.3
PVdC-coated Nylon 6	0.7	0.65



# Coatings – PVdC

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- Good Barrier
  - Barrier dependent upon coating thickness
- Good aroma/flavor barrier
- Widely used and well understood
- Contains chlorine
  - Specialized equipment to apply
  - Incineration issues



# Coatings – PVOH

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- Polyvinyl alcohol (PVOH)
  - Excellent oxygen barrier
    - PVOH-coated PET: 0.2 cc/100 in<sup>2</sup>-day
    - PVOH-acrylic-coated OPP: 0.02 cc/100 in<sup>2</sup>-day
  - Barrier dependent upon coating thickness
  - Moisture sensitive

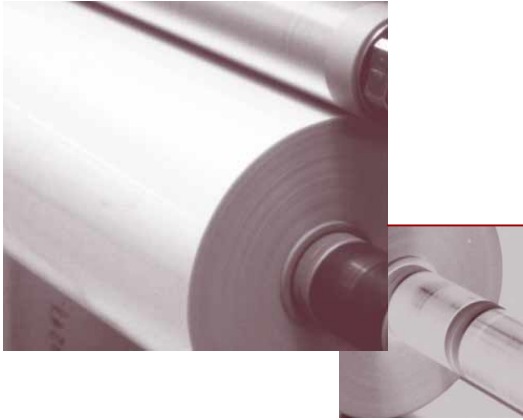


# Coatings – SiO<sub>x</sub>

- Silicon Oxide (SiO<sub>x</sub>)

Material	O <sub>2</sub> TR (cc/100 in <sup>2</sup> -day)	WVTR (g/100 in <sup>2</sup> -day)
ClearFoil <sup>®</sup> A	0.04	0.04
ClearFoil <sup>®</sup> F*	<0.003	0.02

\*Excellent flex-crack resistance



# Coatings – SiO<sub>x</sub>

- Flex/Pinhole Resistance

<b>Material</b>	<b>Flat O<sub>2</sub>TR (cc/100 in<sup>2</sup>-day)</b>	<b>Flexed O<sub>2</sub>TR (cc/100 in<sup>2</sup>-day)</b>
48 ga oPET/35 ga Foil/ 2mil LLDPE	0.03	3.2
48 ga oPET/Met/ 2mil LLDPE	0.1	0.7
48 ga oPET/ClearFoil <sup>®</sup> A/ 2mil LLDPE	0.04	0.5
48 ga oPET/ClearFoil <sup>®</sup> F/ 2mil LLDPE	<0.003	<0.003



# Coatings – $\text{Al}_2\text{O}_3$

- Aluminum Oxide ( $\text{Al}_2\text{O}_3$ )

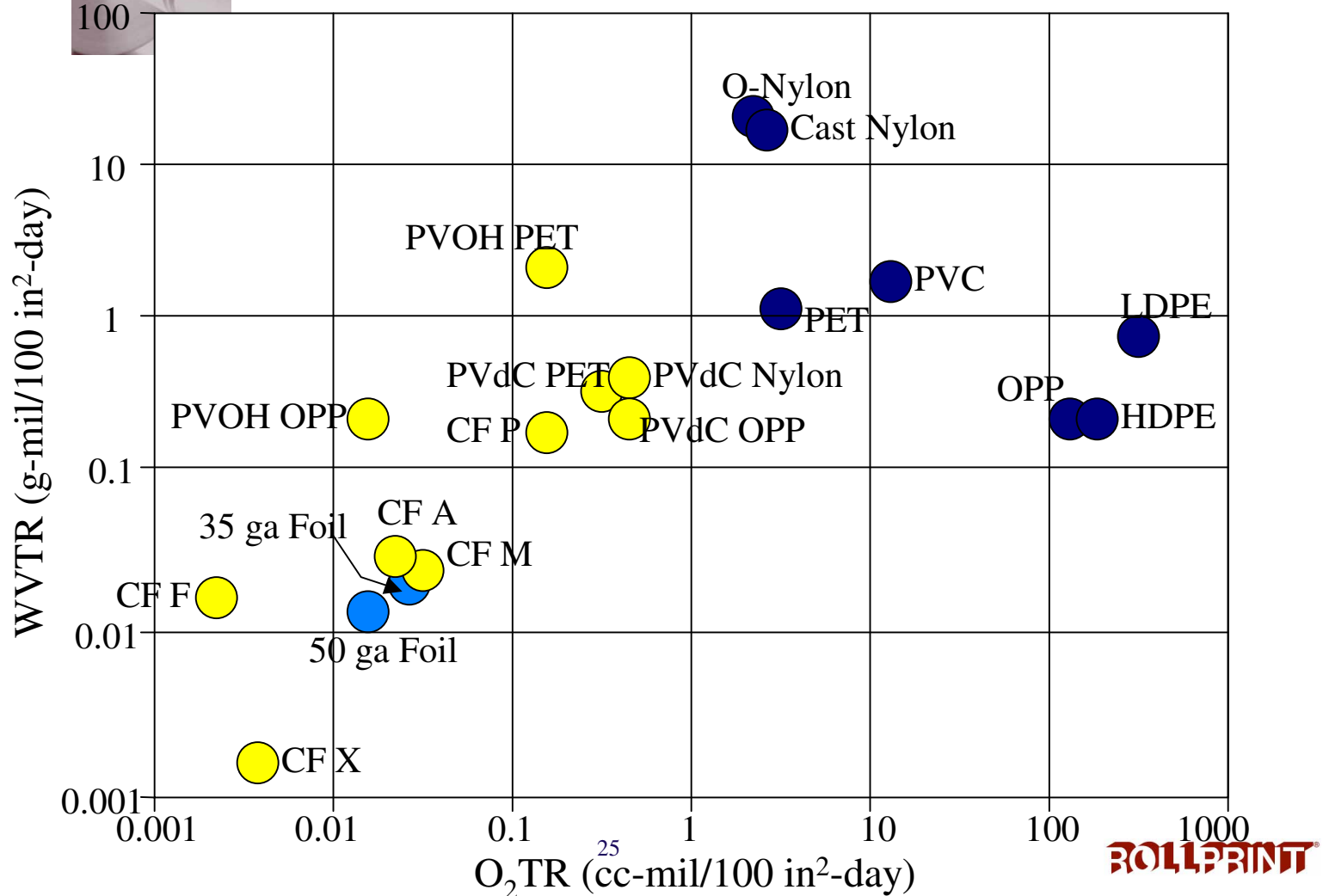
Material	$\text{O}_2\text{TR}$ (cc/100 in <sup>2</sup> -day)	WVTR (g/100 in <sup>2</sup> -day)
ClearFoil <sup>®</sup> P	0.2	0.2
ClearFoil <sup>®</sup> M	0.045	0.03
ClearFoil <sup>®</sup> M2	0.04	0.3
ClearFoil <sup>®</sup> X	0.005	0.002





# Barrier Properties

## Barrier Coatings

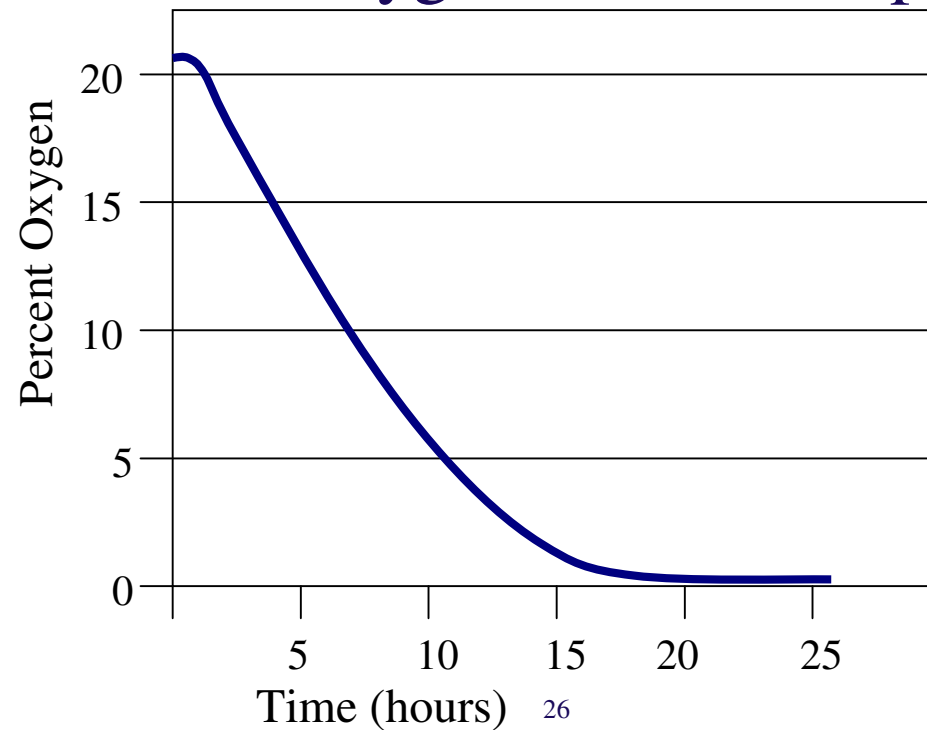




# Active Packaging

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- Oxygen Scavengers
  - Reduce oxygen level in the package



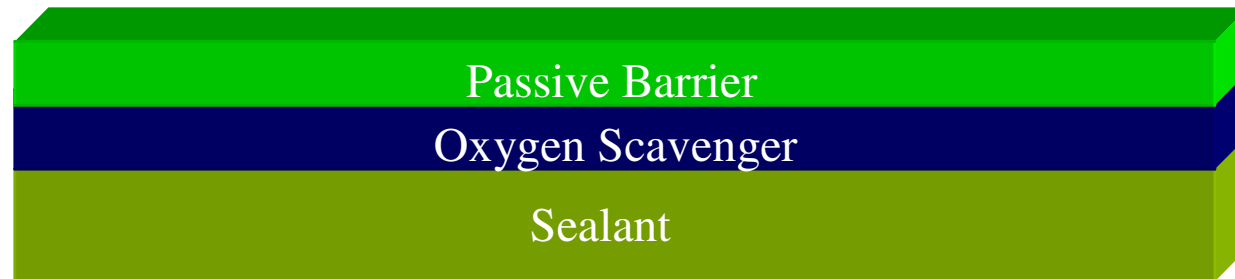
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# Active Packaging

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- Oxygen Scavengers
  - Use with a passive barrier
  - Separated from the product with a functional barrier





# Active Packaging

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- Oxygen Scavengers
  - Ferric compositions
    - Moisture activated (>40% RH)
    - Must store at low RH
  - OSP
    - Oxidizable polymer / transition metal catalyst / photoinitiator
    - UV to trigger oxidation mechanism
    - No degradation products



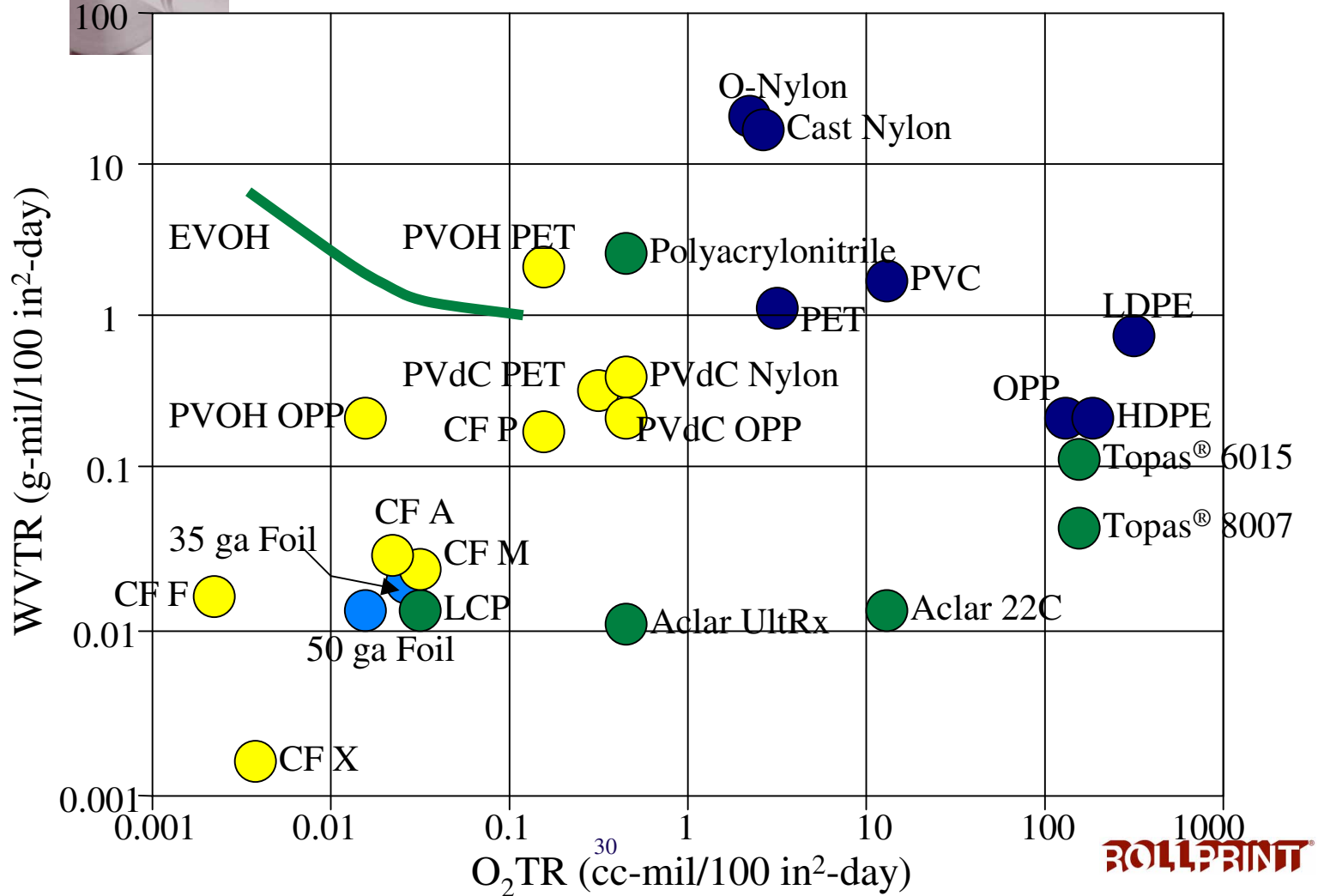
# Active Packaging

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- Antimicrobial
  - Inhibit or retard growth of microorganisms
  - Many options
    - Organic acids & anhydrides
    - Inorganic gases
    - Silver salts
    - Fungicides
    - Bacteriocins
    - Enzymes
    - Chelating agents
    - Spices
    - Essential oils
    - Parabens



# Barrier Properties





# Barrier Properties

## Summary

Category	Material	Trade Name	Thickness (mil)	MVTR (g/100in <sup>2</sup> -day)	O <sub>2</sub> TR (cc/100in <sup>2</sup> -day)	Thermoformable	Autoclaveable/Retortable
Films	oPET		1	1.5	4.5	No	Yes
	Oriented Nylon		1	26.5	3	No	Yes**
	Cast Nylon		1	19	3.5	Yes	Yes
	OPP		1	0.33	150	No	No
	LDPE		1	0.9	NA	Yes	No
	HDPE		1	0.37	NA	Yes	Marginal
	PVC		1	2.3	11	Yes	No
Barrier Films	Polyacrylonitrile	Barex	1	4.5	0.7	Yes	No
	EVOH		1	1.4 - 8.0	0.0006 - 0.12	Yes	Yes**
	COC	Topas 8007	1	0.071	NA	Yes	No
	COC	Topas 6015	1	0.11	NA	Yes	Yes
	LCP	Vectran V200P	1	0.015	0.04	Yes	Yes
	CTFE	Aclar 22C	1	0.026	15	Yes	Yes
	CTFE	Aclar UltRx/SupRx	1	0.016	7	Yes	Yes
Barrier Coatings	PVdC-coated PET		*	0.5	0.5	No	No
	PVdC-coated OPP		*	0.3	1.3	No	No
	PVdC-coated Nylon		*	0.65	0.7	No	No
	PVOH-coated PET		*	4	0.2	No	No
	PVOH-acrylic-coated PET		*	0.37	0.02	No	No
	SiO <sub>x</sub> -coated PET	ClearFoil A	*	0.04	0.04	No	Yes
	SiO <sub>x</sub> -coated PET	ClearFoil F	*	0.02	<0.003	No	No
	Al <sub>2</sub> O <sub>3</sub> -coated PET	ClearFoil P	*	0.2	0.2	No	No
	Al <sub>2</sub> O <sub>3</sub> -coated PET	ClearFoil M	*	0.03	0.045	No	No
	Al <sub>2</sub> O <sub>3</sub> -coated PET	ClearFoil M2	*	0.3	0.04	No	Yes
	Al <sub>2</sub> O <sub>3</sub> -coated PET	ClearFoil X	*	0.002	0.005	No	No
Opaque Barrier	Metallized PET		*	0.05	0.1	No	No
	Aluminum Foil (flat)		0.35	0.02	0.03	No	Yes
	Aluminum Foil (flat)		0.5	0.01	0.02	No	Yes
	Aluminum Foil (flat)		1	<0.00	<0.000	Yes	Yes

\* The barrier for these materials is due to the coating and is not dependent upon substrate thickness.

\*\*Dependent upon the composite construction.