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PLACE
The Flexible Packaging & Converting Industry's Leading Resource
POLYMERS • LAMINATIONS • ADHESIVES • COATINGS • EXTRUSIONS

Expanding the Temperature Range of Polyolefin Films

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Statement of Problem

- PP and PE each offer advantages over the other
- PP
  - Heat resistance
  - Modulus / Optics balance
  - Abrasion / Grease Resistance
- PE
  - Impact resistance, especially at low temperatures
  - Tear resistance

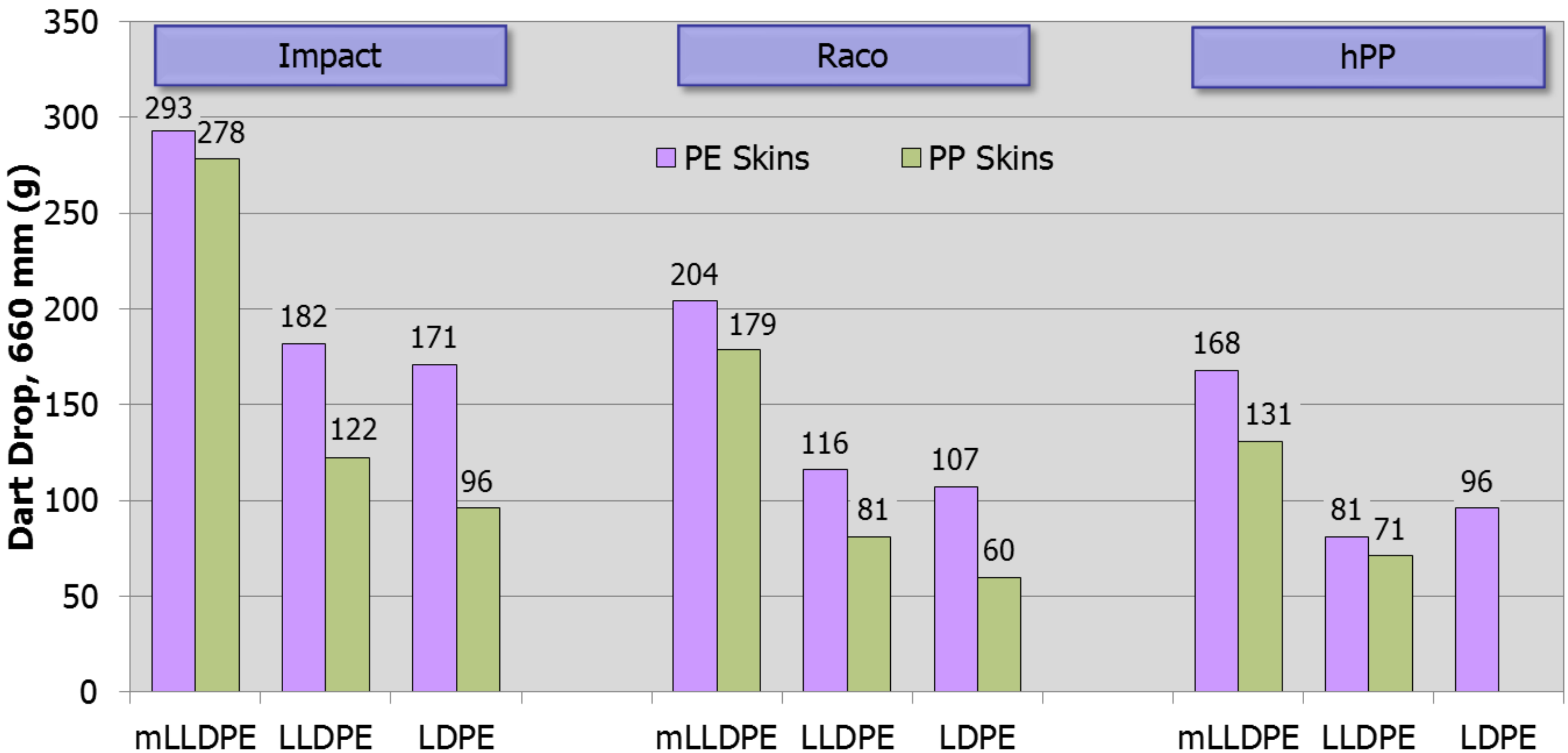
Can we use multilayer films to leverage the advantages of each material to create differential performance?

Experiment

- Combined 3 key types of PP with 3 key types of PE
- Coextrusion: 25 / 50 / 25 ABA layer distribution
  - Allows structure inversion with constant composition
  - No hPP skin / LDPE core sample due to lack of material
- 51 micron films, 2.54 mm die gap, 152.4 mm die, 2.5:1 BUR, 68 kg/hr

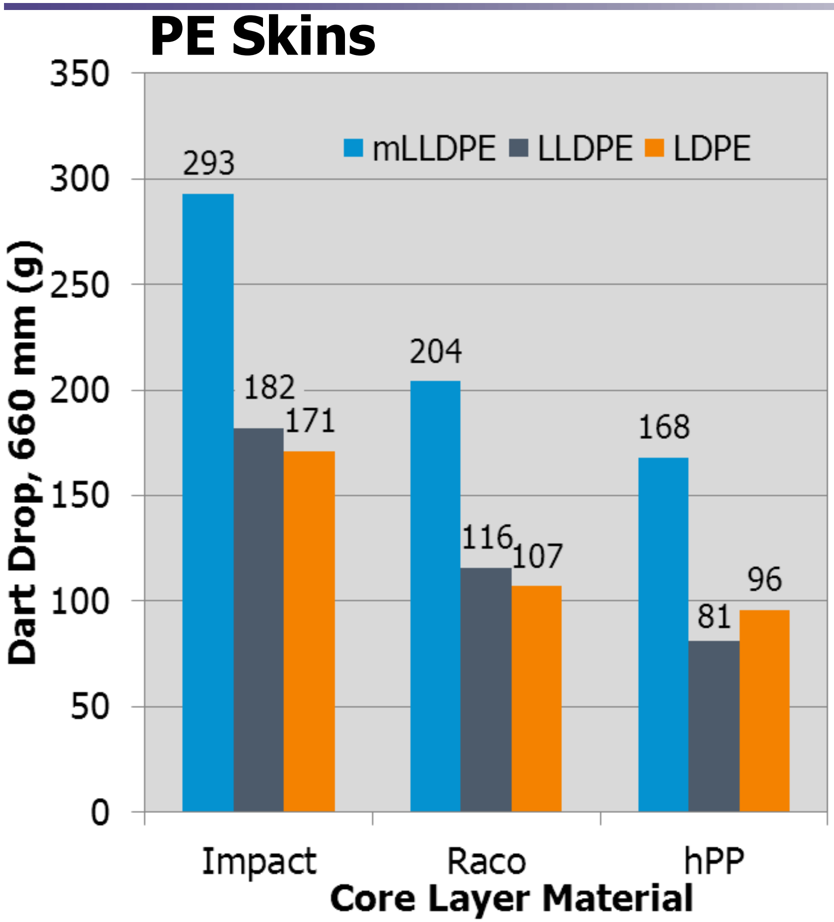
PP Type	Product Code	MFR (g/10 min)	% Ethylene	Key Additives
Homopolymer	hPP	1.5	-	-
Random Copolymer	Raco	2.0	3.5	Clarified
Impact Copolymer	Impact	1.8	10	-
PE Type	**Product Code**	**MI (g/10 min)**	**Density (g/cc)**	**Key Additives (ppm)**
Butene-LLDPE	LLDPE	1.0	0.918	900 slip / 5500 AB
mLLDPE	mLLDPE	1.0	0.918	1000 slip / 5000 AB
LDPE	LDPE	2.0	0.918	500 slip / 4000 AB

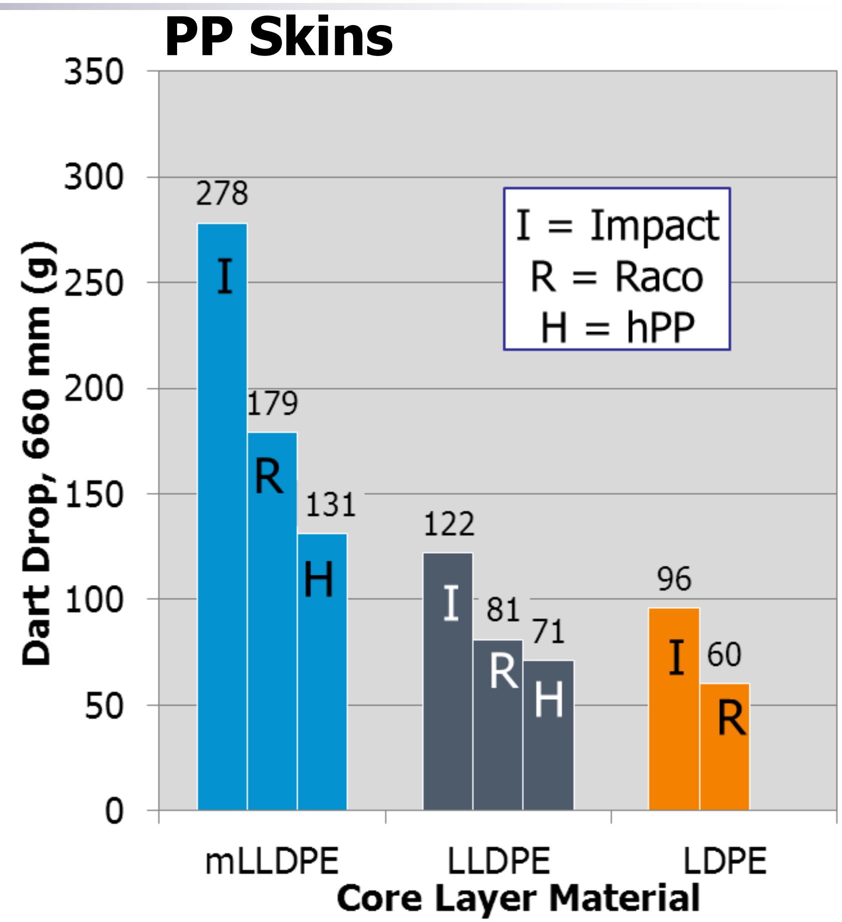
Dart Drop – ASTM D1709 Method A



Improves with PE Skins, mLLDPE or Impact Copolymer content

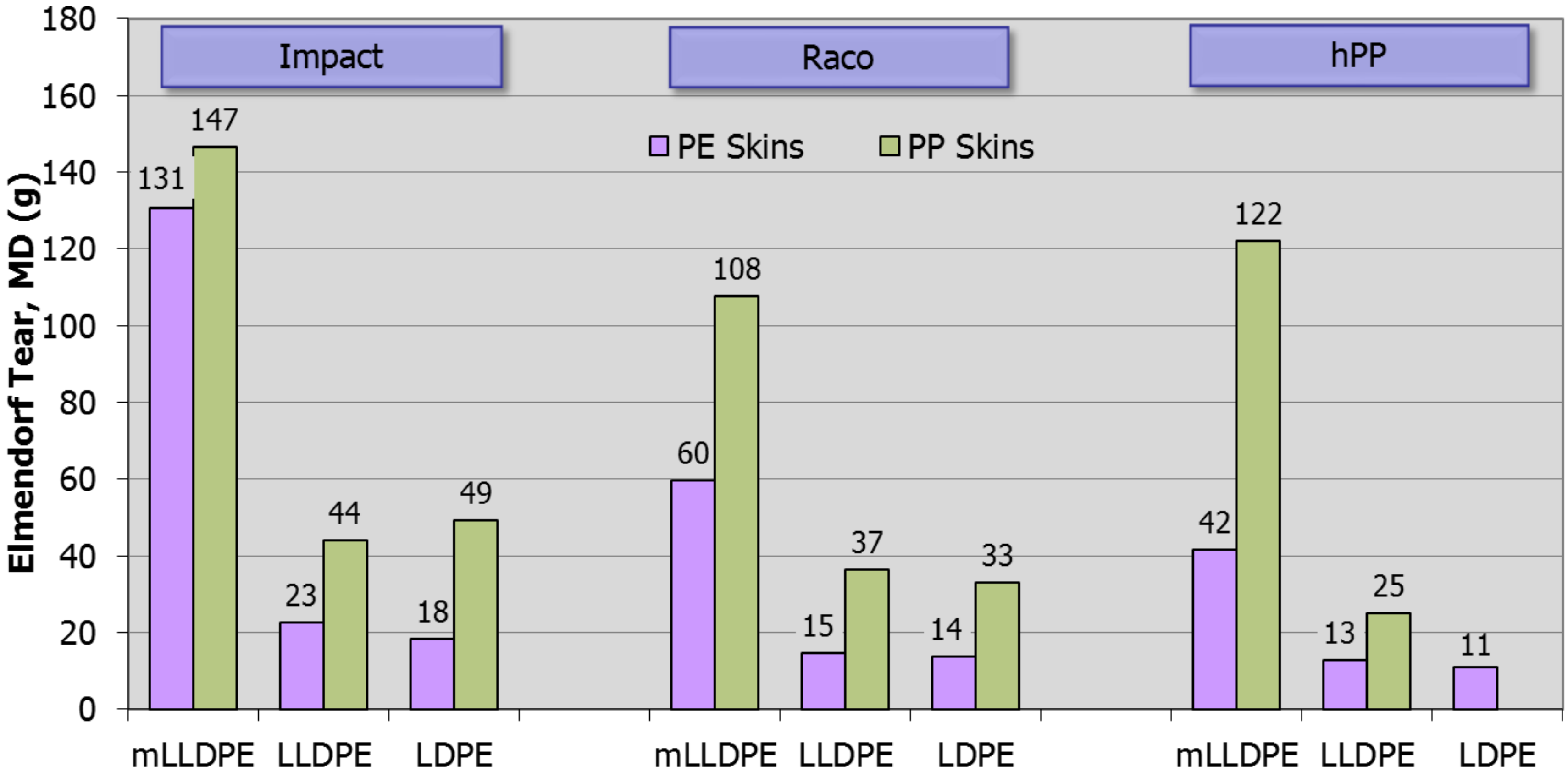
Dart Drop – Alternate Views of Results





Improves with PE Skins, mLLDPE or Impact Copolymer content

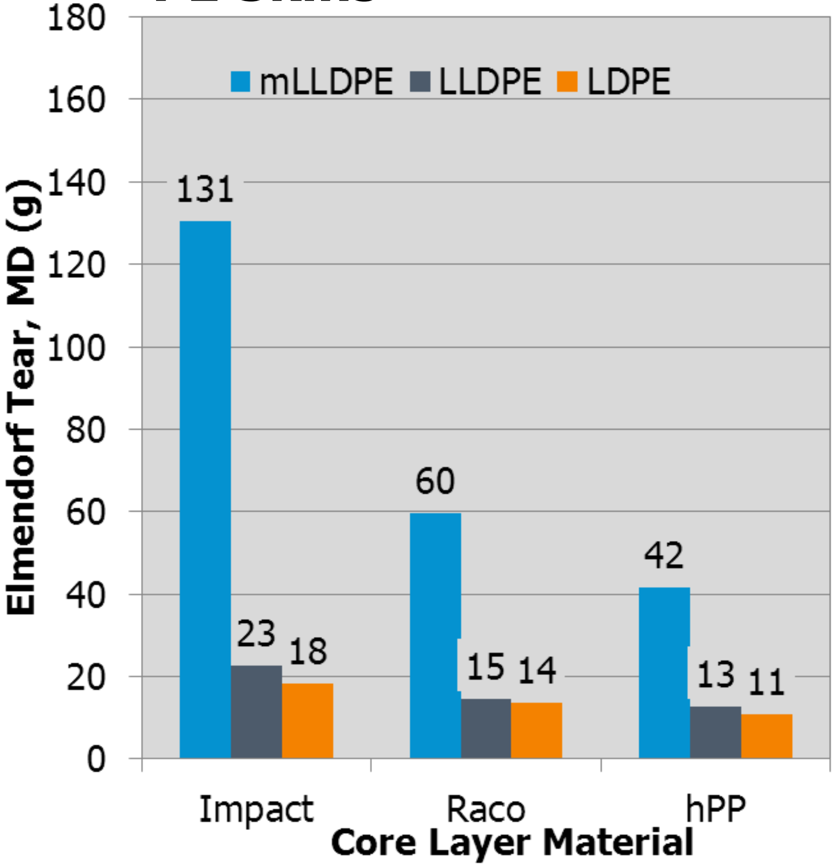
Elmendorf Tear (Mach. Dir.) – ASTM D1922



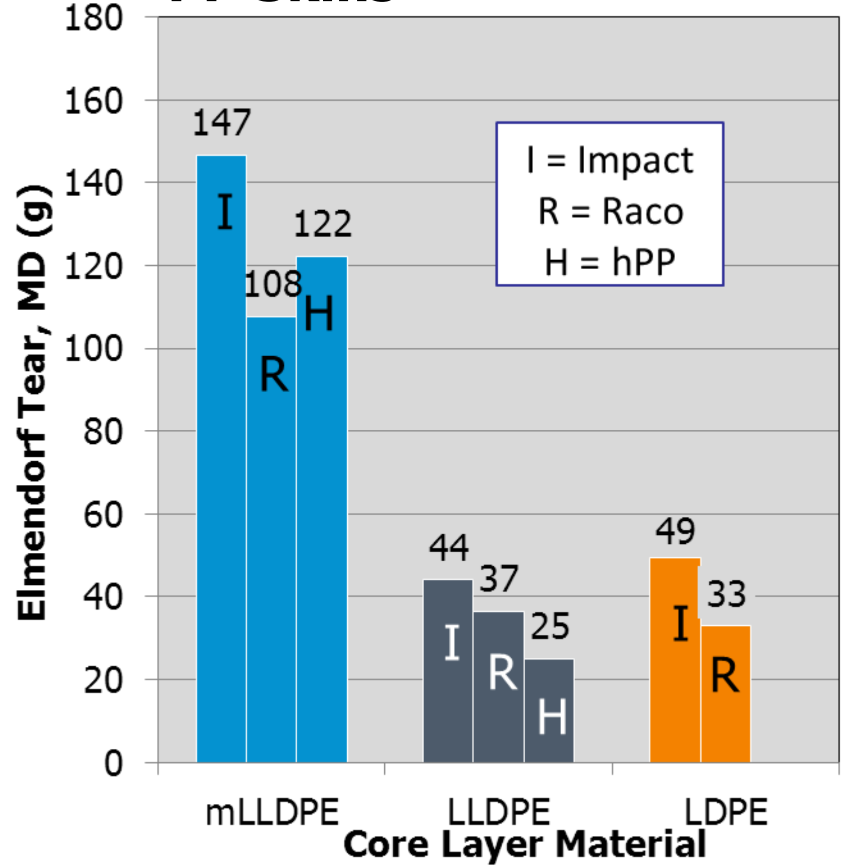
Improves with PP Skins, mLLDPE or Impact Copolymer content

Elmendorf Tear (MD) – Alternate Views

PE Skins

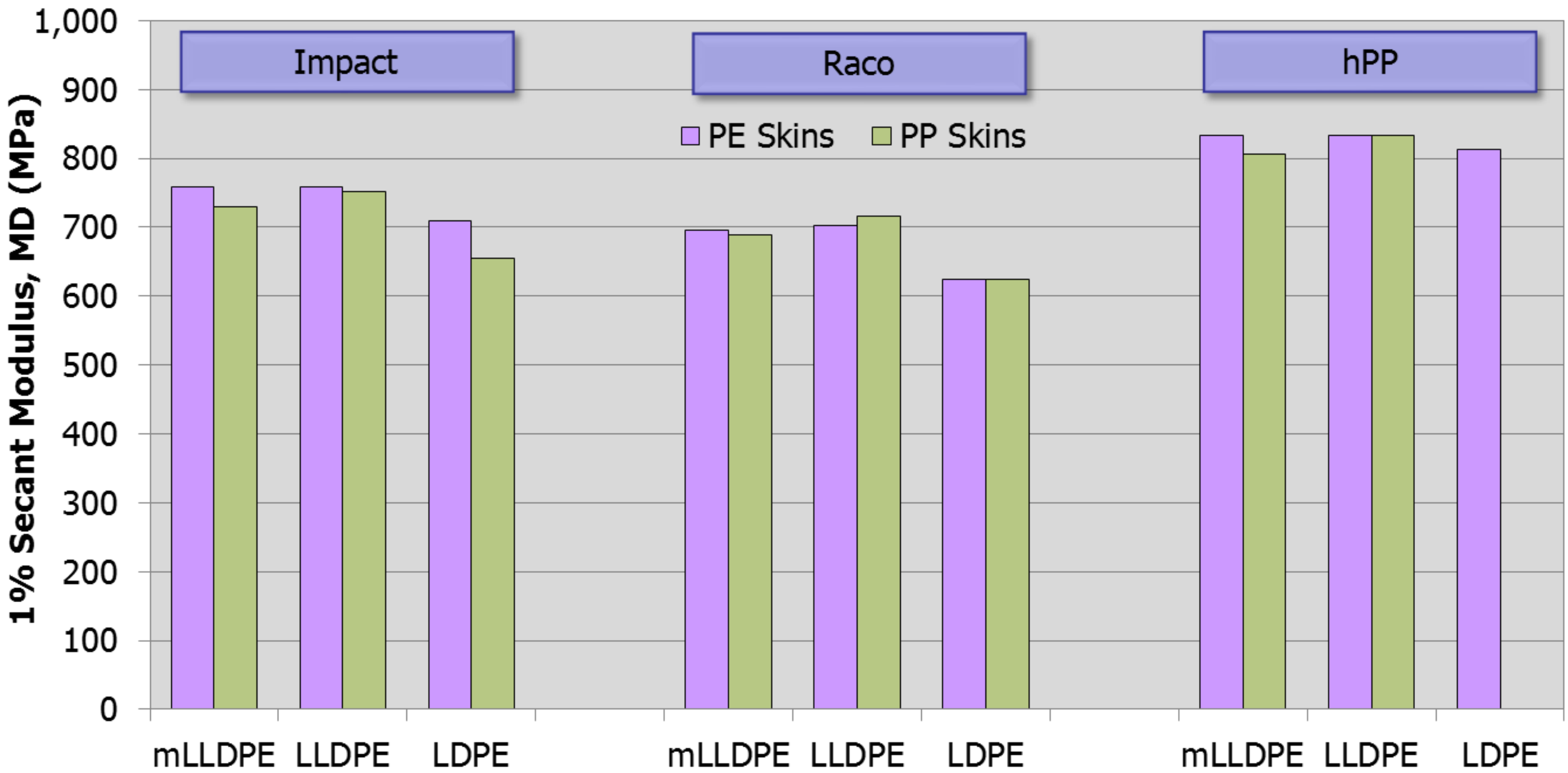


PP Skins



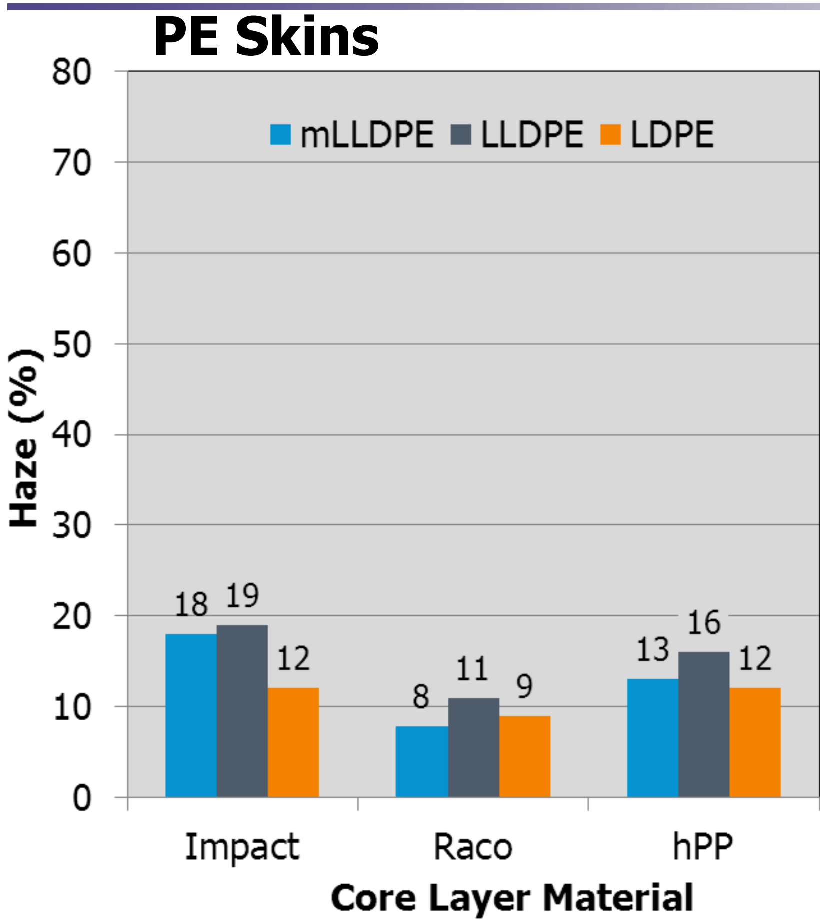
Improves with PP Skins, mLLDPE or Impact Copolymer content

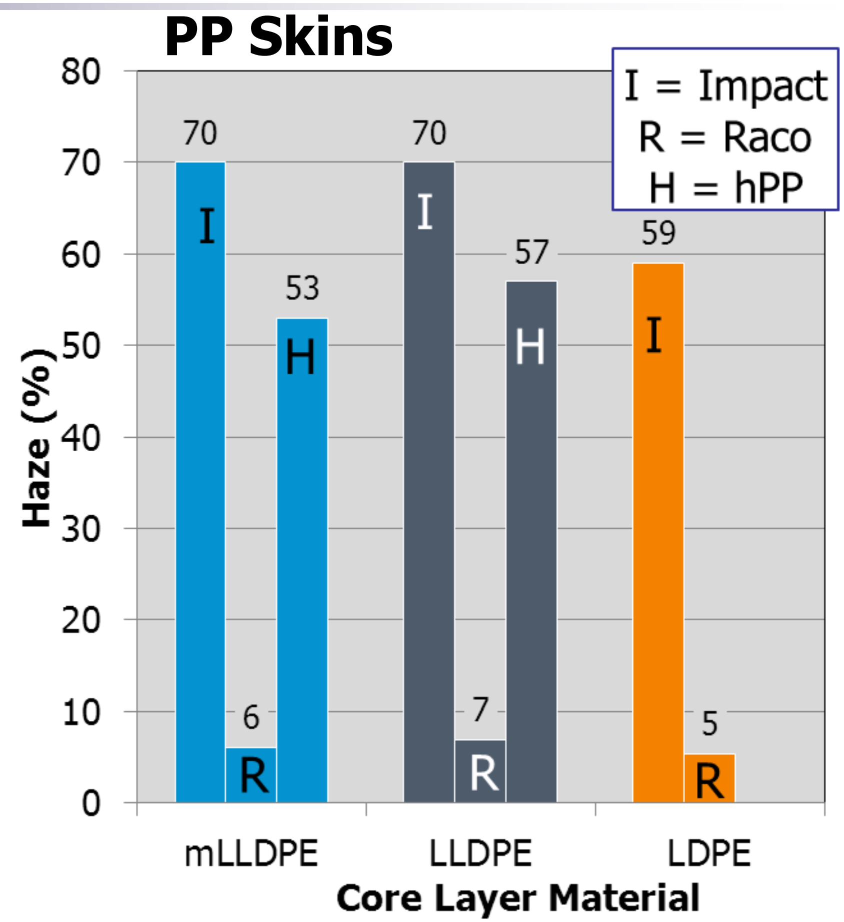
1% Secant Modulus (Mach. Dir.) – ASTM D882



Depends on material choice, not location within structure. hPP gives higher modulus to structure.

Haze – ASTM D1003





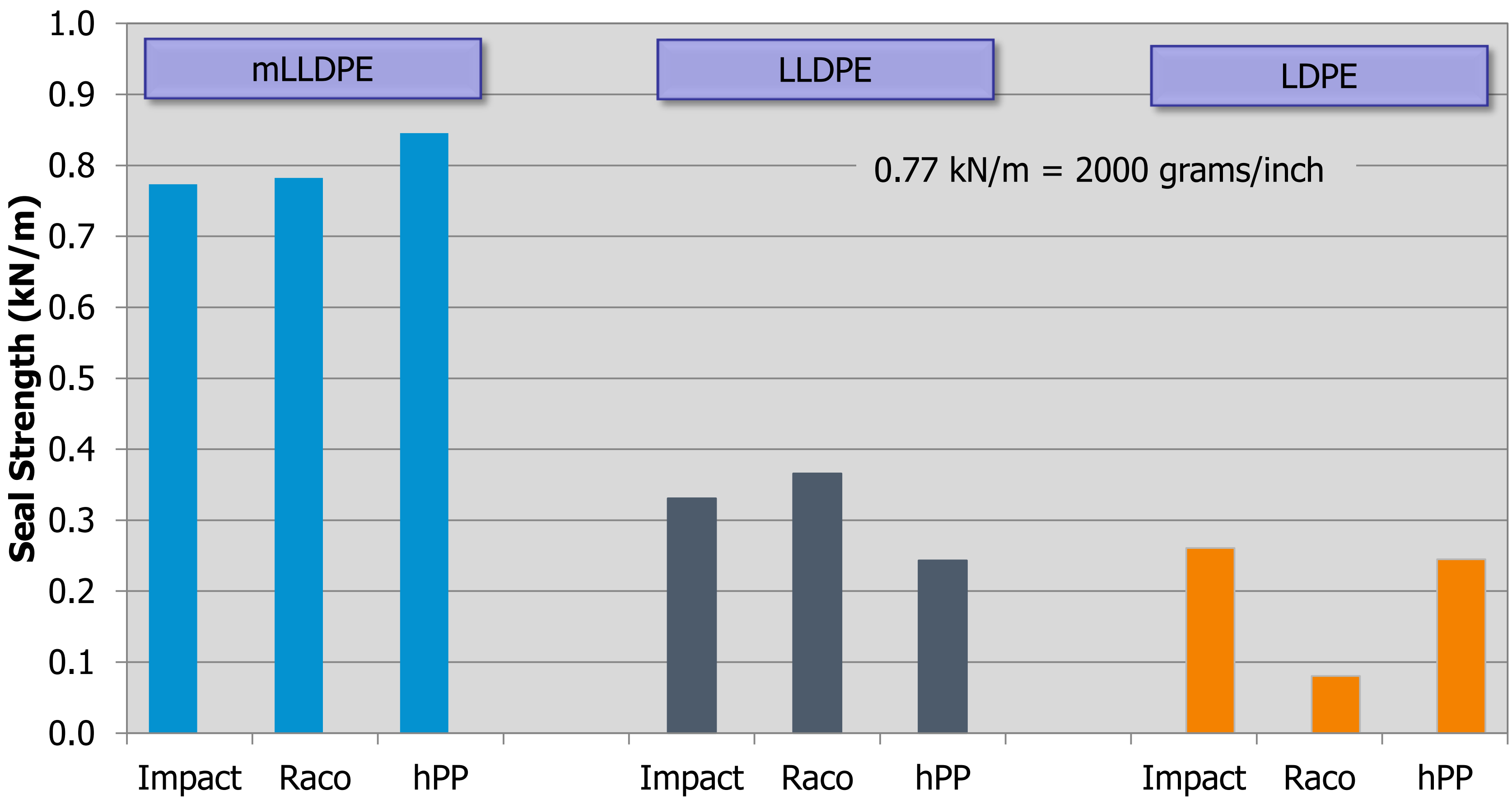
Controlled by surface layers, but some "internal" haze contribution

Interlayer Adhesion

- Polypropylene / Polyethylene structures uncommon in industry
  - Limited awareness of adhesion performance between layers
  - Adhesion important to heat seal performance

- Performance Testing
  - Heat seal multilayer films (PE skins) to fusion
    - 275 kPa, 2 seconds dwell time, 168^{o}C
  - Test seal strength by tensile T-peel test
    - 305 mm/minute crosshead speed

Adhesion Test Results – ASTM F88



mLLDPE shows enhanced adhesion to all 3 PP types

Conclusions

	Polyethylene Skins			Polypropylene Skins		
	mLLDPE	LLDPE	LDPE	Impact	Raco	hPP
Dart Drop	+++	++	++	++	+	+
MD Tear	+++	+	+	++	+	+
Modulus						Skin/Core
Haze				-	+++	-
Adhesion	Skin/Core					

- Highlighted cells indicate improved performance based on material type and layer choice
- Cell contents (+/- signs) indicate relative rank for that property
  - Only listed if significant differences present

Potential Application Benefits

- Modulus improvement
- Down-gauging opportunities
- Density improvement
- Heat resistance improvement
- Improved hot-tack performance

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