



Controlled Lowering of Peel Forces Using Polybutene-1 (PB-1)

John Laszewski – LyondellBasell



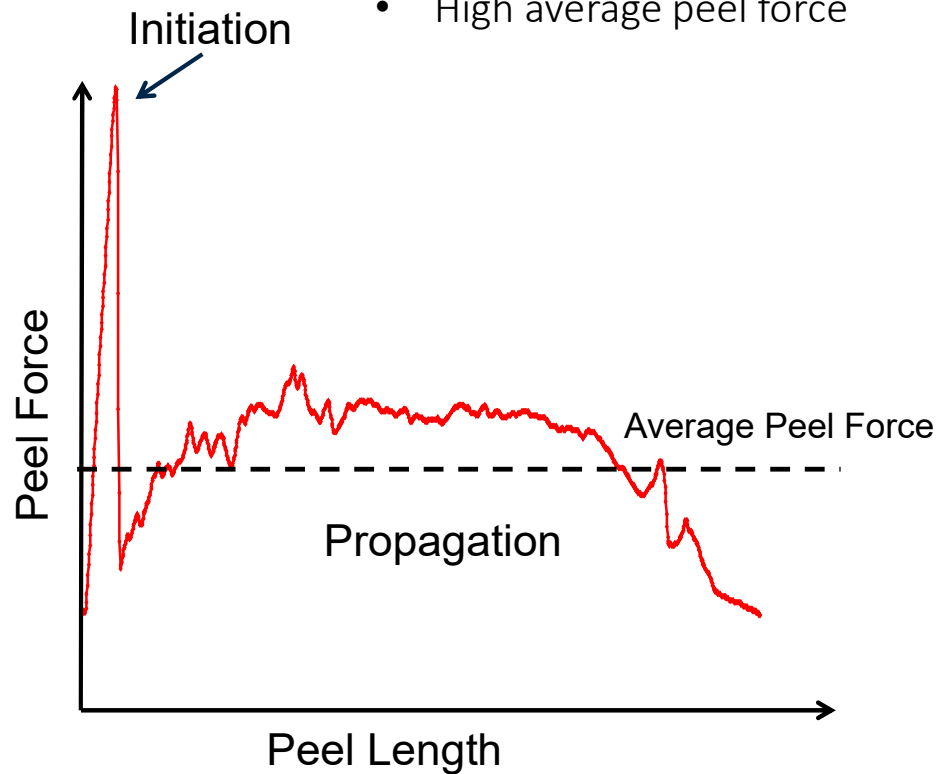
Overview

- Seal-Peel Basics
- Introduction to PB-1
- Experimental Methods
- Results
 - Effect of PB-1 on Seal Strength
 - Comparison Various PB-1 Grades
 - Time Effect
 - Electron Microscopy
- Conclusion



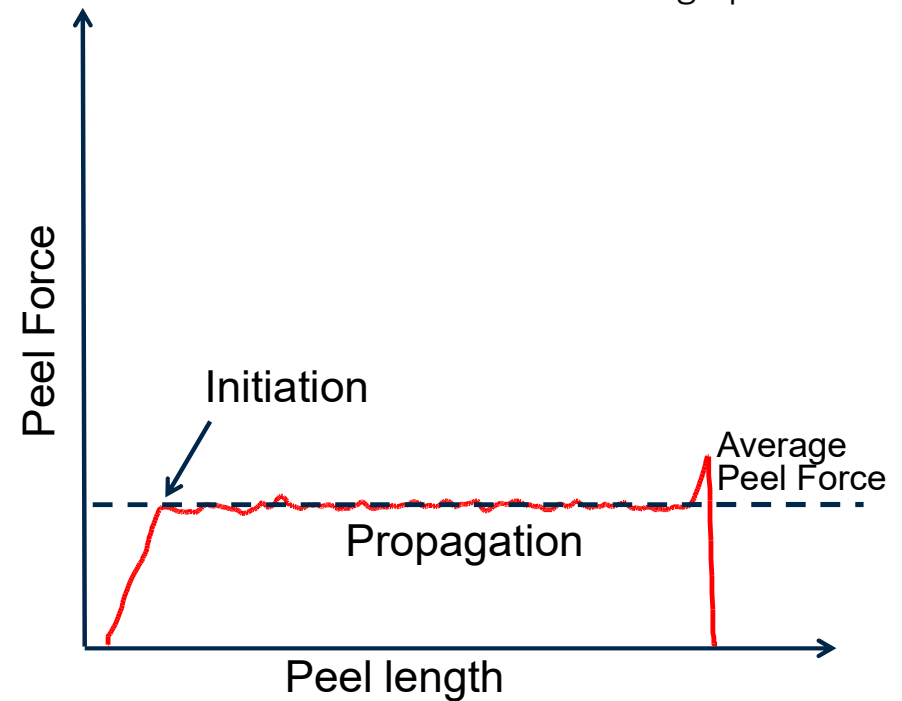
Typical Heat Seal Peel

- High initiation energy
- Uncontrolled peel
- High average peel force



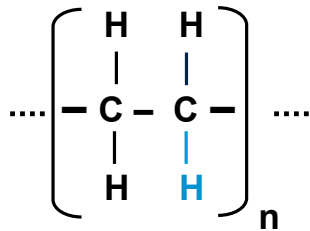
Ideal Heat Seal Peel

- Initiation energy equal to propagation energy
- Smooth and controlled peel
- Lower average peel force





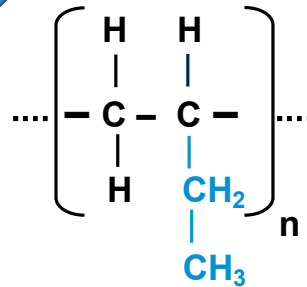
Introduction to PB-1



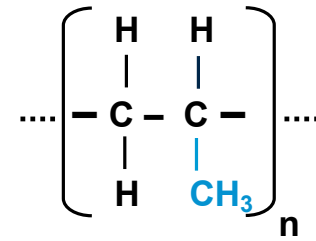
Polyethylene



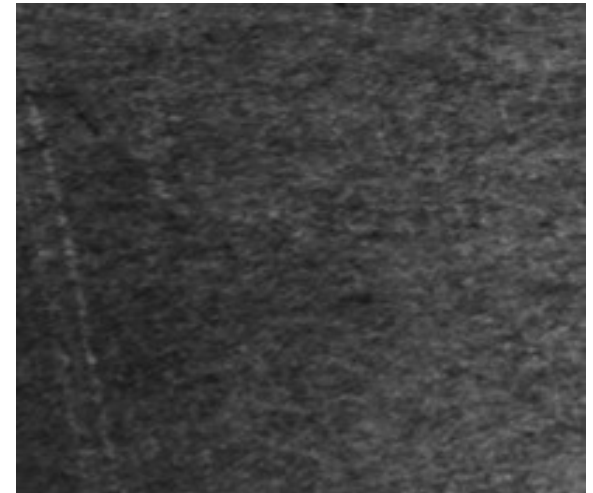
Two phases but easily dispersed



Polybutene-1



Polypropylene

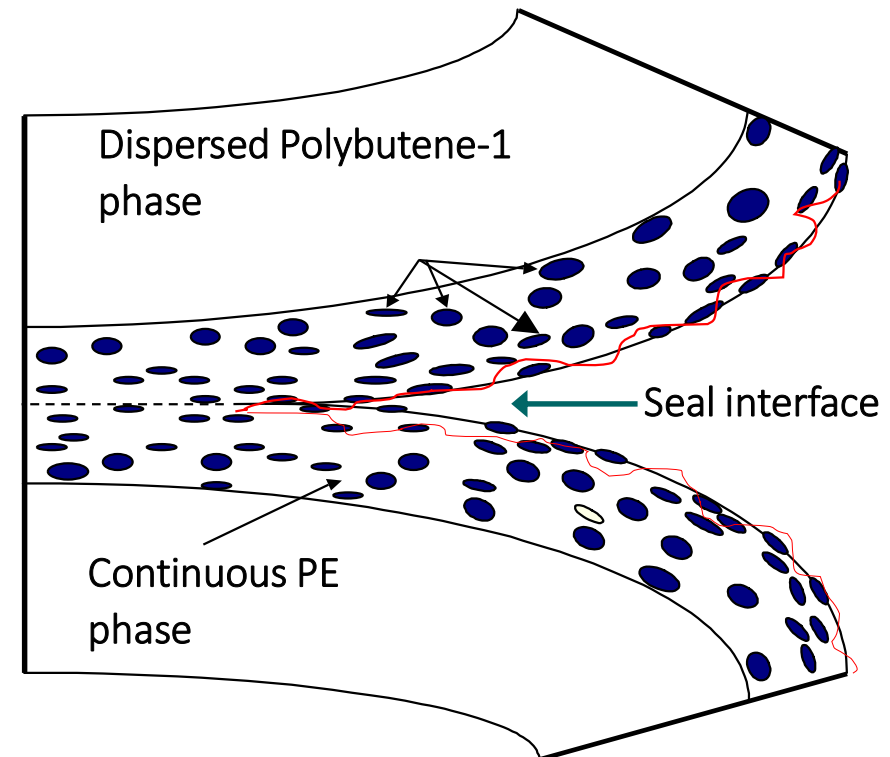


One continuous phase



Polybutene-1 (PB-1)

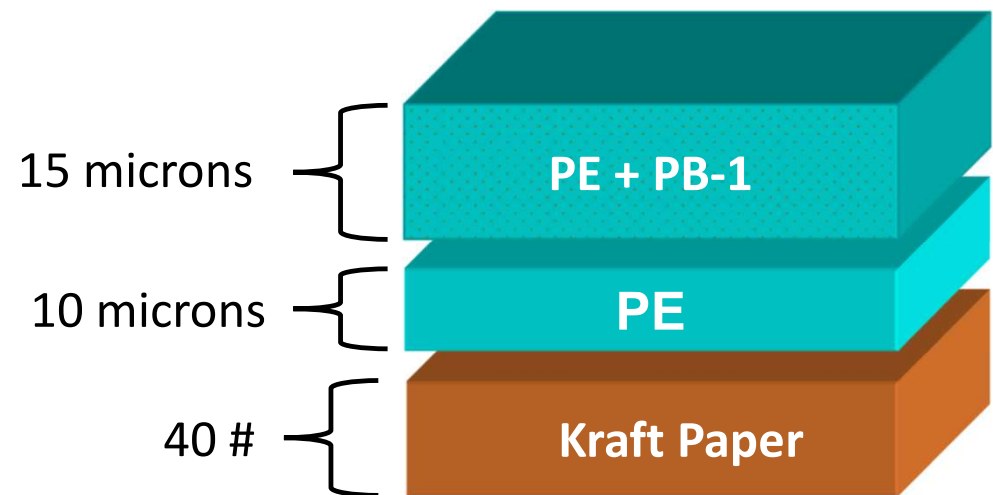
- Thermoplastic polyolefin
- Phase-incompatible with polyethylene
- Phase-compatible with polypropylene
- Unique solid-state recrystallization
 - Occurs over 7-10 days
- Used in blown and cast film to make easy-peel structures
 - Bags and Pouches
 - Lidding Stock
 - Sterilizable Applications





Methods

- Trials ran on 30-inch-wide extrusion coating line at LYB application lab
 - 500 feet/min
 - 615°F at die
- Coextruded LDPE with LDPE/PB-1 blend on to 40# Kraft Paper
- All samples were sealed to themselves
- Samples were sealed and peeled at LYB's physical testing lab
 - 4.5" x 1" samples
 - Sealed at 40 PSI for 0.5 seconds
 - Peeled with Instron tensile tester
 - 8.0 in/min crosshead speed
- Increased seal temperature until delamination peel



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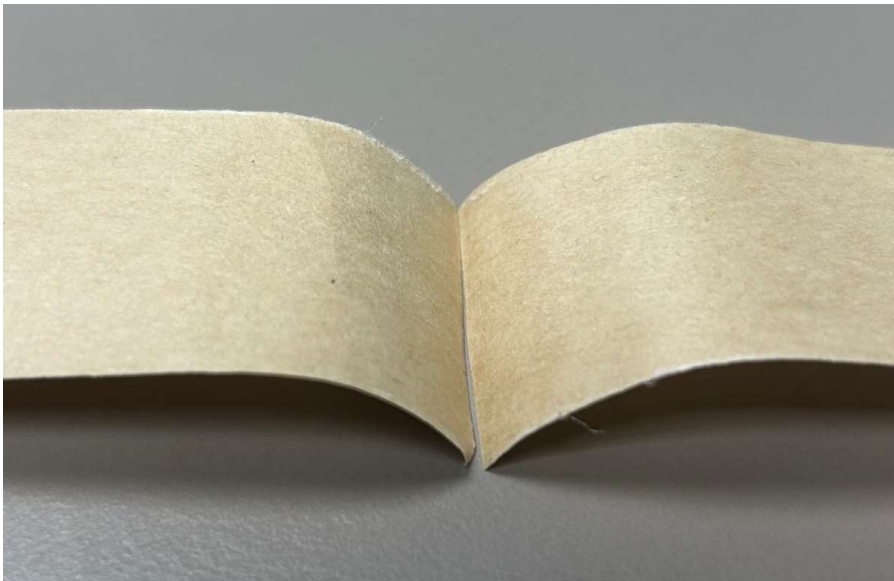
Grade Name	Polymer Type	Referenced as	Melt Index (190 °C, 2.16 kg, g/10min)	Density (g/cm ³)
<i>Toppyl</i> PB0110M	Polybutene-1	Homopolymer 1	0.4	0.915
<i>Koattro</i> PB0300M	Polybutene-1	Homopolymer 2	4.0	0.915
<i>Toppyl</i> PB8640M	Polybutene-1	Copolymer 1	0.9	0.906
<i>Toppyl</i> PB8340M	Polybutene-1	Copolymer 2	4.0	0.906
<i>Petrothene</i> NA214000	Low Density Polyethylene	Polyethylene	10.0	0.918

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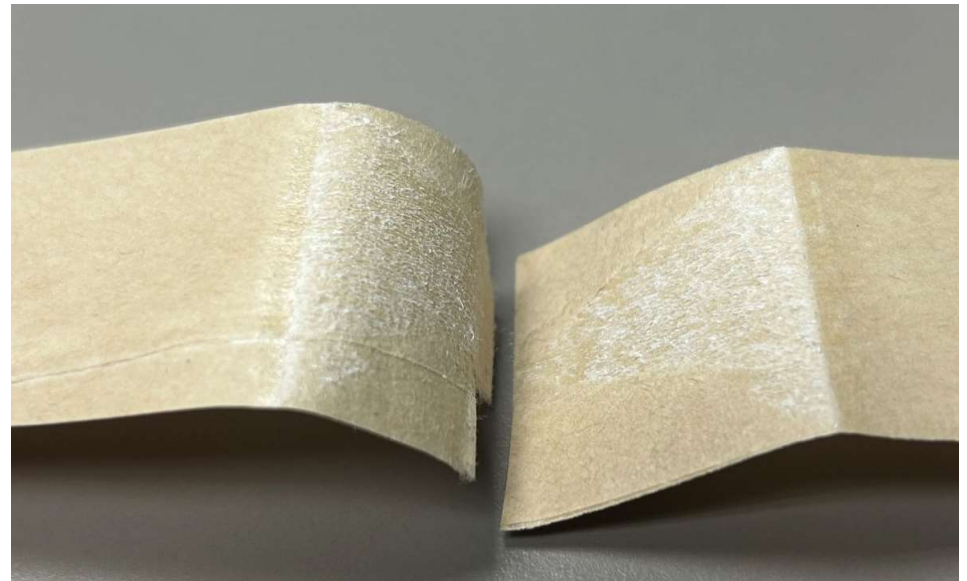
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Cohesive Peel

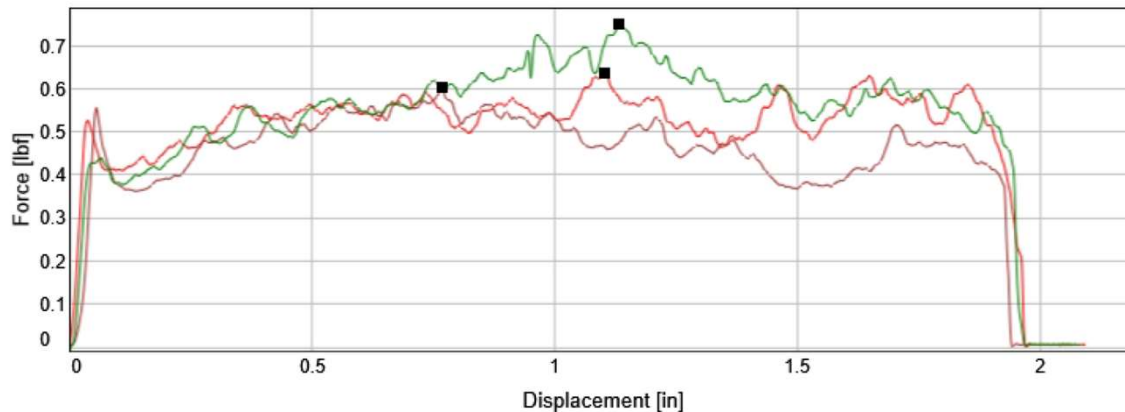


Delamination Peel



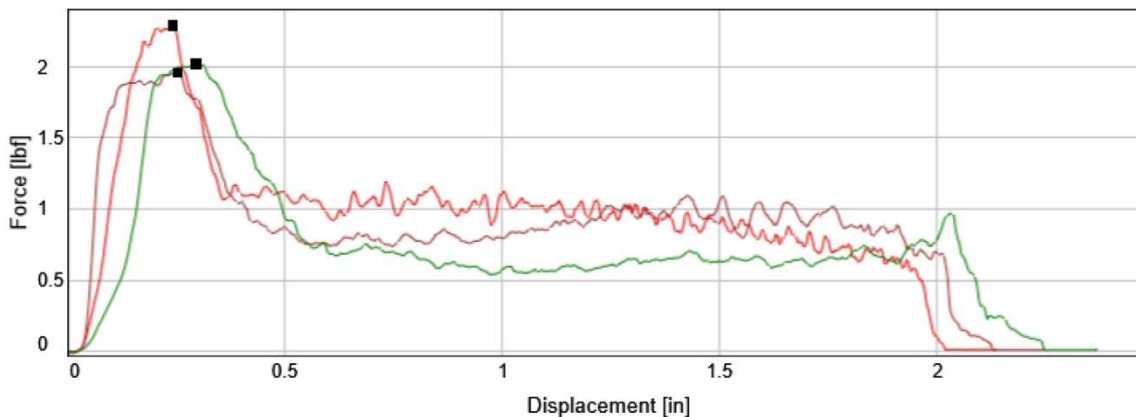


20% Copolymer 1 Sealed at 120°C



- Cohesive peel
- 0.53 lbf average peel force
- Controlled peel

0% PB-1 Control Sealed at 95°C

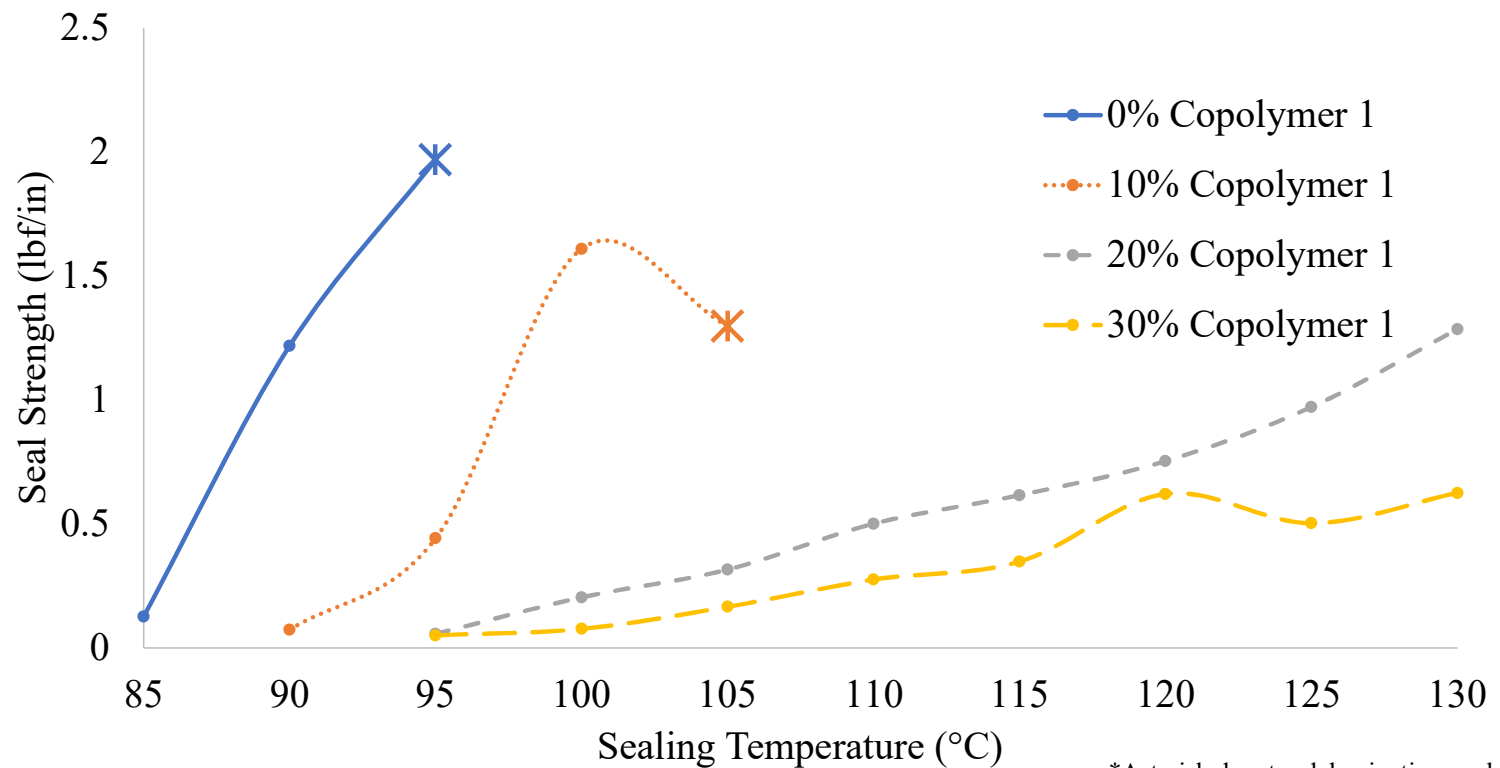


- Delamination peel
- 0.94 lbf average peel force
- Uncontrolled peel – high initiation energy



Tailored Peel Force

- As little as 10% PB-1 lowers seal strength
 - 20% and 30% PB-1 further lowers seal strength
- Broader sealing temperature window

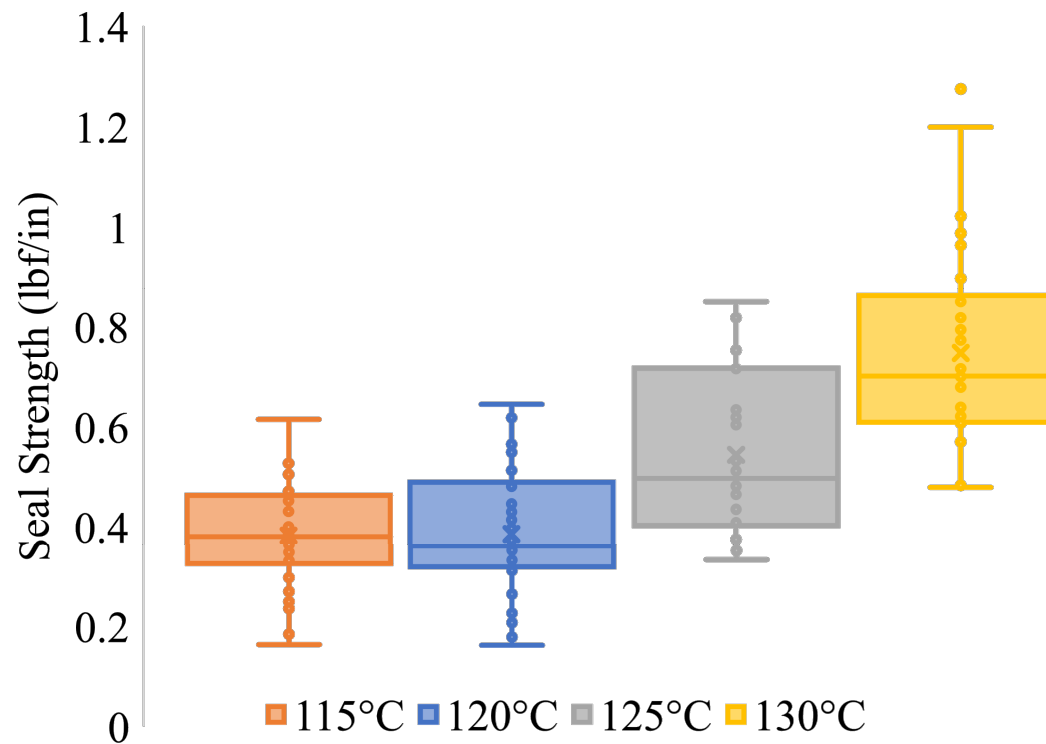


*Asterisk denotes delamination peel



Seal Strength Consistency

20%
Copolymer 1,
N=30

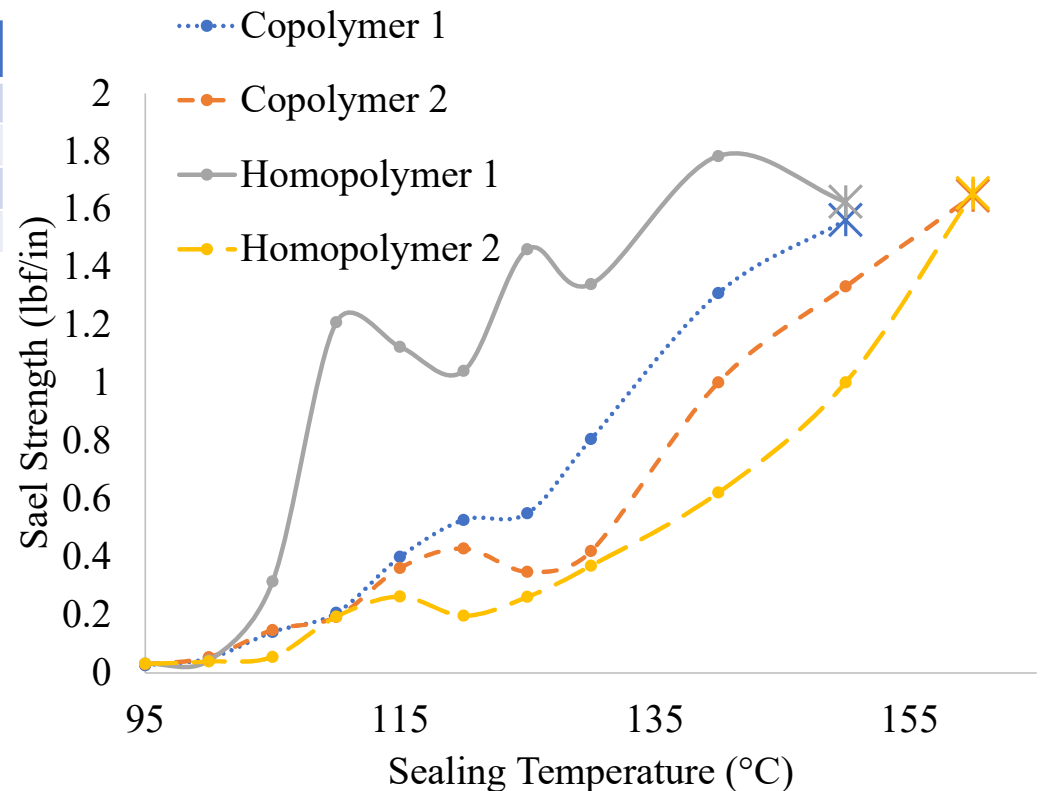




PB-1 Grade Selection

Polymer	Melt Index (g/10 min)	Density (g/cm ³)
Homopolymer 1	0.4	0.915
Homopolymer 2	4.0	0.915
Copolymer 1	0.9	0.906
Copolymer 2	4.0	0.906

- 20% PB-1
- All 4 PB-1 grades lowered seal strength relative to unmodified control
- High MI PB-1 grades were most effective

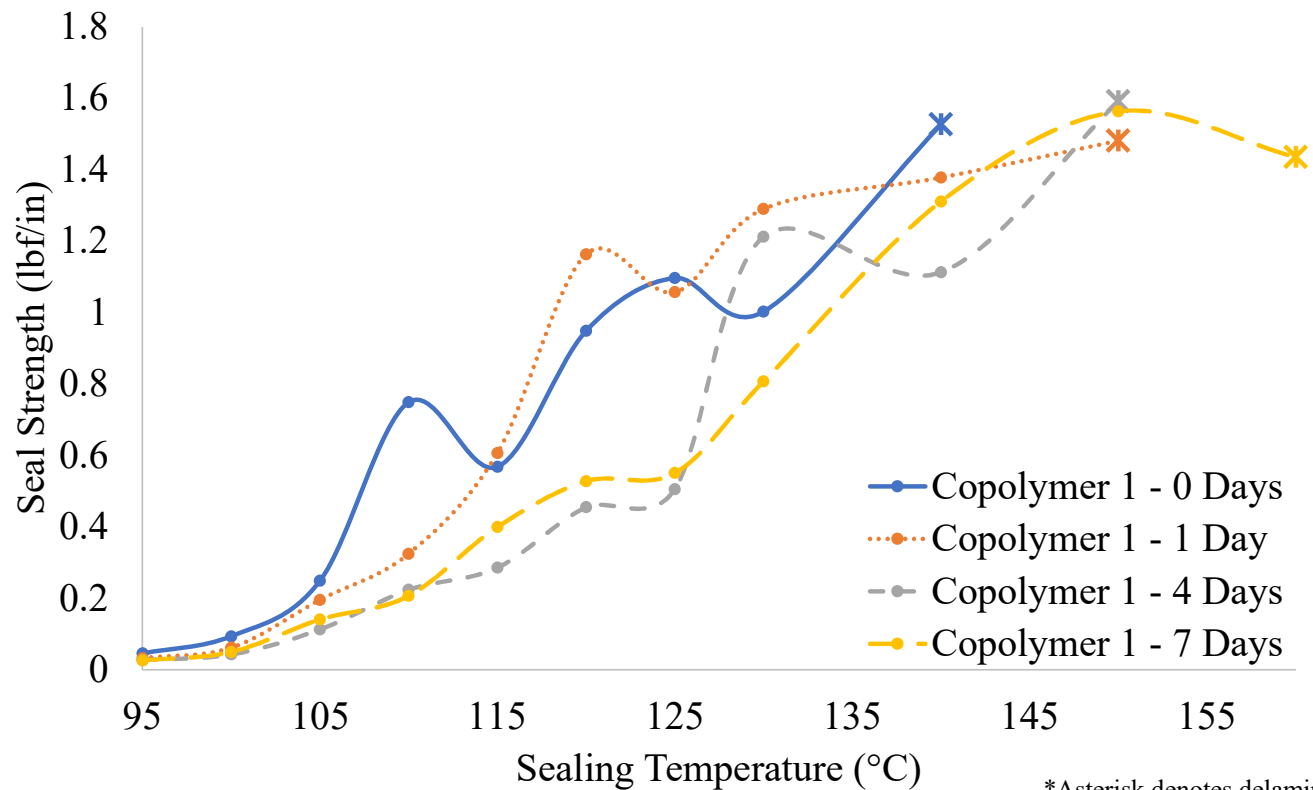


*Asterisk denotes delamination peel



Time from Extrusion to Sealing

- Seal strength decreases with greater time after extrusion before sealing
- Possibly due to recrystallization phenomenon of PB-1



*Asterisk denotes delamination peel



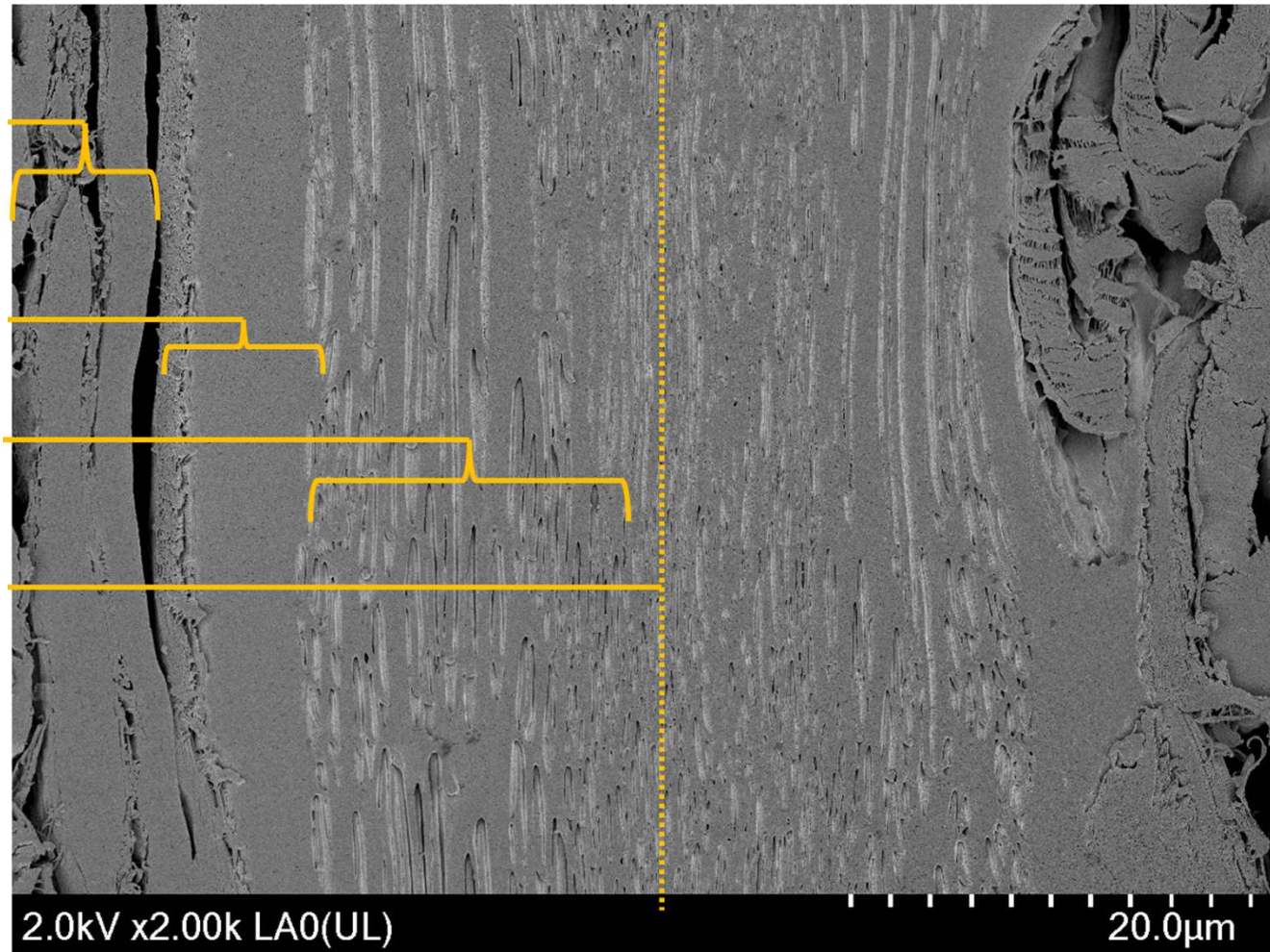
Scanning Electron Micrograph

Kraft Paper

Polyethylene
Core Layer

Polyethylene
+ PB-1 Seal
Layer

Seal Interface

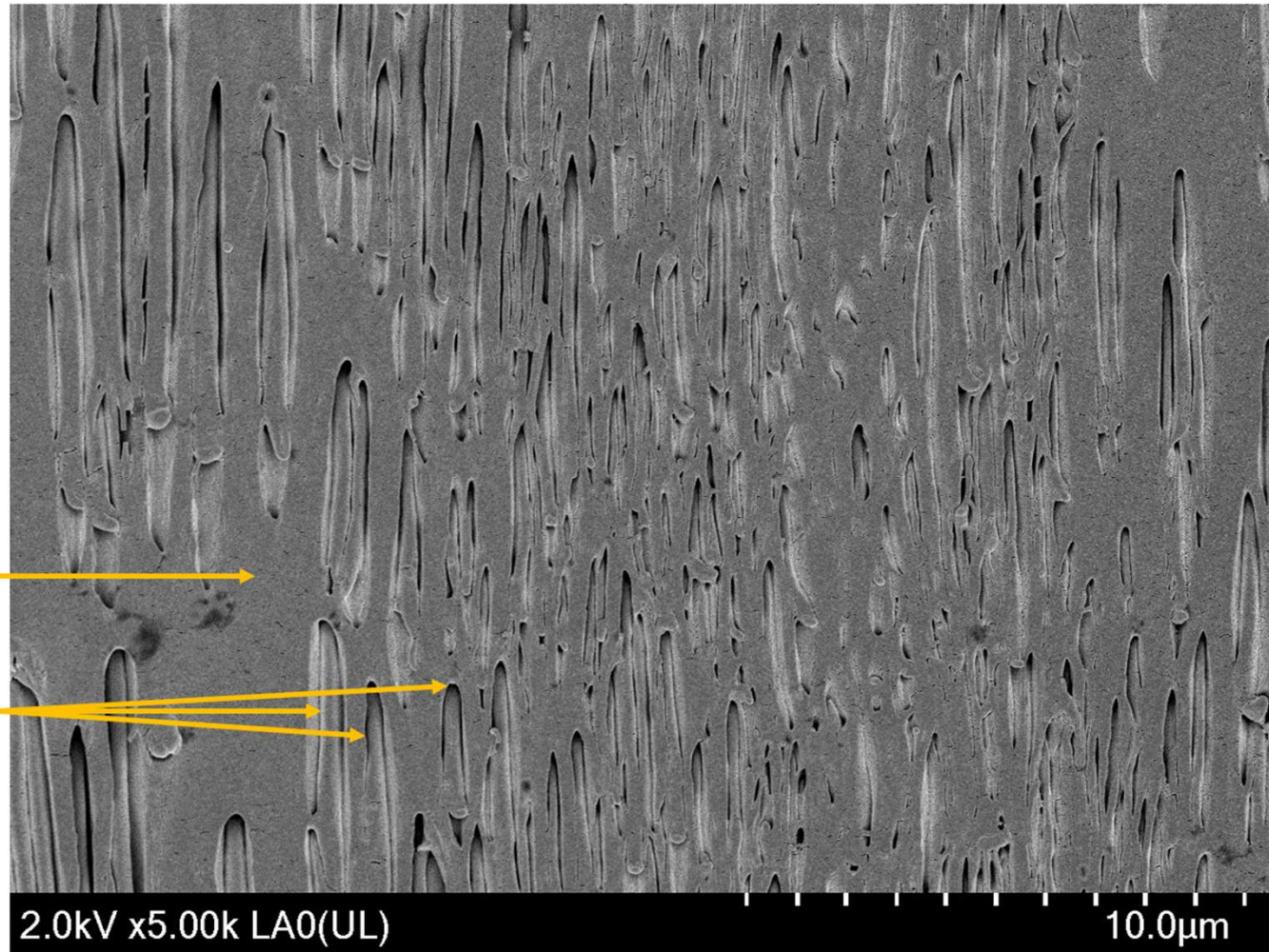




Scanning Electron Micrograph

Continuous
Polyethylene
Phase

Dispersed
PB-1 Domains



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Next Steps

- Collaborate with downstream converters
- Formulate for sealing to other substrates
- Evaluate various LDPE grades
- Explore a range of operating conditions



Conclusions

- PB-1 can be used in extrusion coating to:
 - Lower average seal strength
 - Create smooth and controlled peels
 - Widen sealing window
- Of the PB-1 grades trialed, the highest MI grades were most effective
- Increasing time between extrusion and sealing lowered average seal strength

Questions?

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