TAPPI International Flexible Packaging & Extrusion Division
2024 FlexPack PLACE Conference
April 14-17, 2024 • San Diego, CA • Wyndham San Diego Bayside

Balancing MD Tear Strength and Impact Strength in Multilayer Films: A Comprehensive Study on the Effects of DDR and Core Layer Composition

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Introduction and Background

Introduction

- High tear and puncture resistance are paramount in applications such as packaging, agriculture, and construction, where the film is exposed to various environmental stresses. Achieving both high tear and high puncture resistance simultaneously is a challenging endeavor due to the inherent trade-offs in material design.
- High draw down ratios (DDR's) have become common in industry to maximize production. This in turn can cause a decrease in physical properties.

Background

- Select resins are known for enhanced MD tear strength when exposed to increased DDR's. Other resins are known for superior impact strength properties.
- Would a co-ex structure of these products generate a balanced MD tear and impact strength film?

Study Objectives

Hypothesis

- Strategically placing a high impact resistant material between a high MD tear resistant material will achieve a well-balanced film at high drawdown ratios.

Objectives

- Determine if there are significant benefits to both impact puncture and MD tear properties by co-extruding three high-performance sLLDPE resins (Product A, Product B, and Product C).

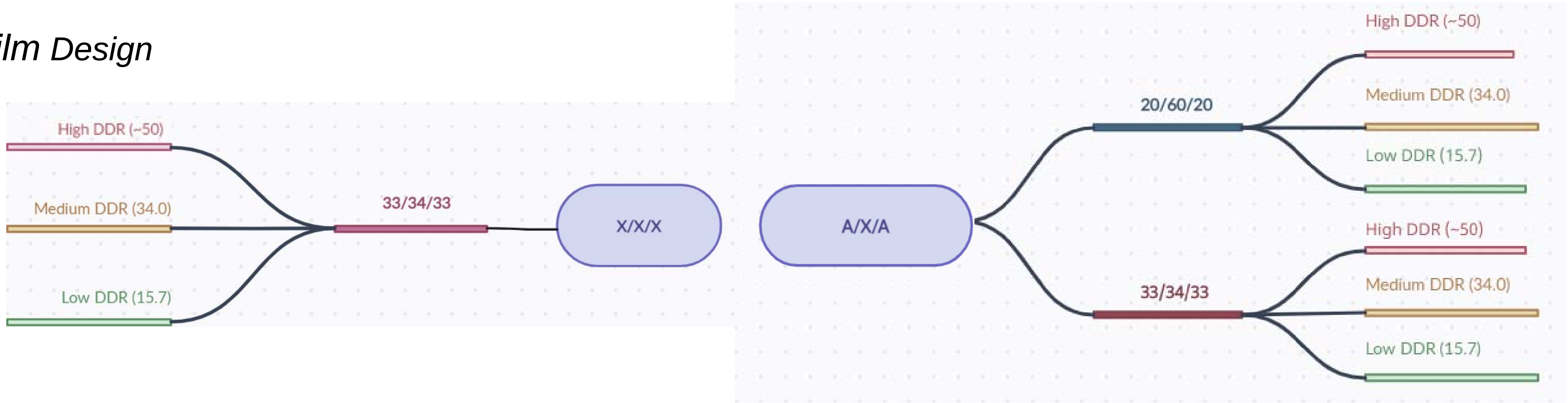
- Determine if the co-ex structures behave like Product A, Product B, or Product C at high drawdown ratios.

Experimental Products and Film Design

Materials

Reference Name (Benefit)	Product	Co-monomer	Melt Index (gm/10min)	Density (g/cm^3)
Product A (MD Tear)	sLLDPE	Octene	0.65	0.9160
Product B (Impact Strength)	sLLDPE	Octene	0.85	0.9185
Product C (Impact Strength)	sLLDPE	Octene	0.85	0.9130

Film Design



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Experimental Equipment

Equipment and Testing

- Brampton 9-layer co-extrusion line
  - 225 lb/h
  - 85 mil die pin
  - 30:1 L/D, 1.5” diameter screws
  - Dual lip air ring
  - Internal bubble cooling (IBC)
- Physical Testing
  - Elmendorf Tear (ASTM D1922)
  - Puncture (ASTM D5748-95)
  - Dynatup (ASTM D7192)
  - Gloss (ASTM D22457-13)
  - Haze (ASTM D1003-7)

Brampton 9-layer line at NOVA Chemicals Center for Performance Applications

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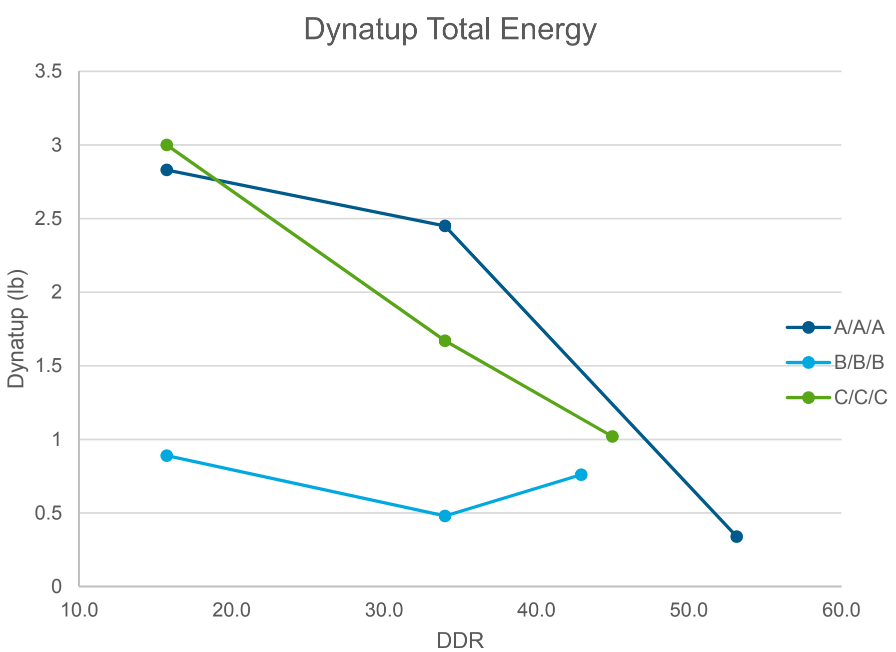
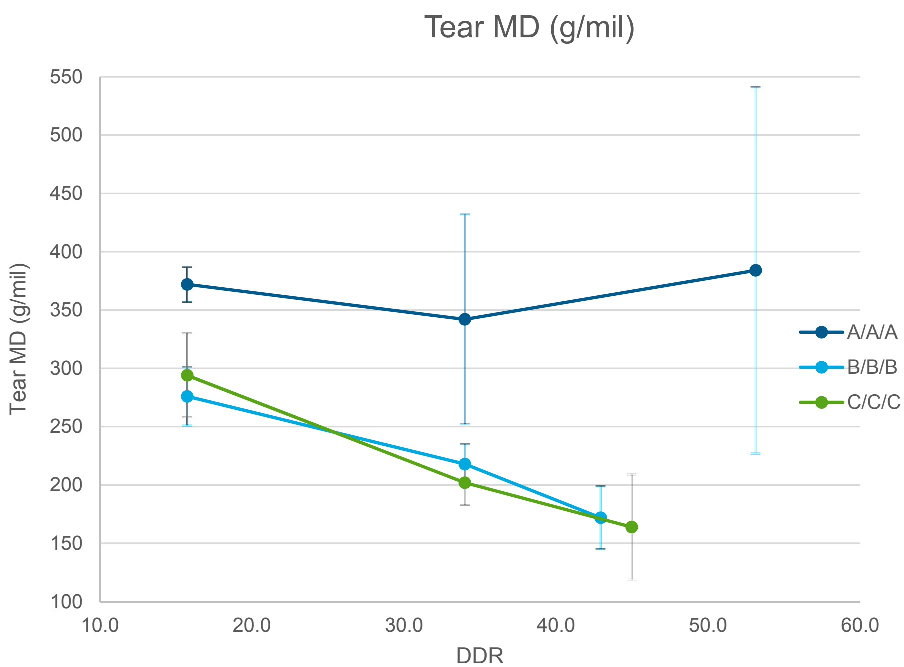
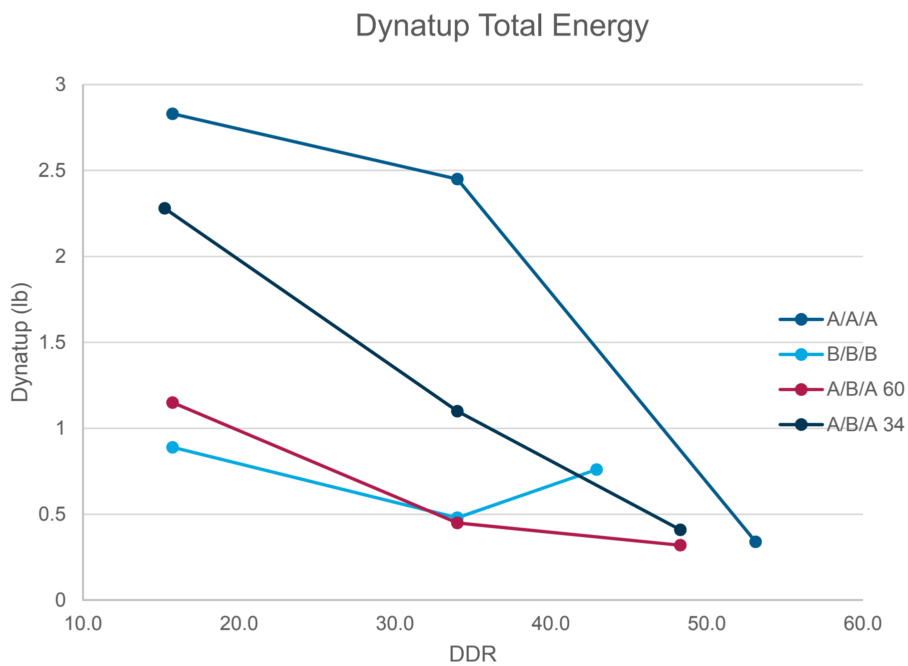
Influence of DDR on Monolayer Films

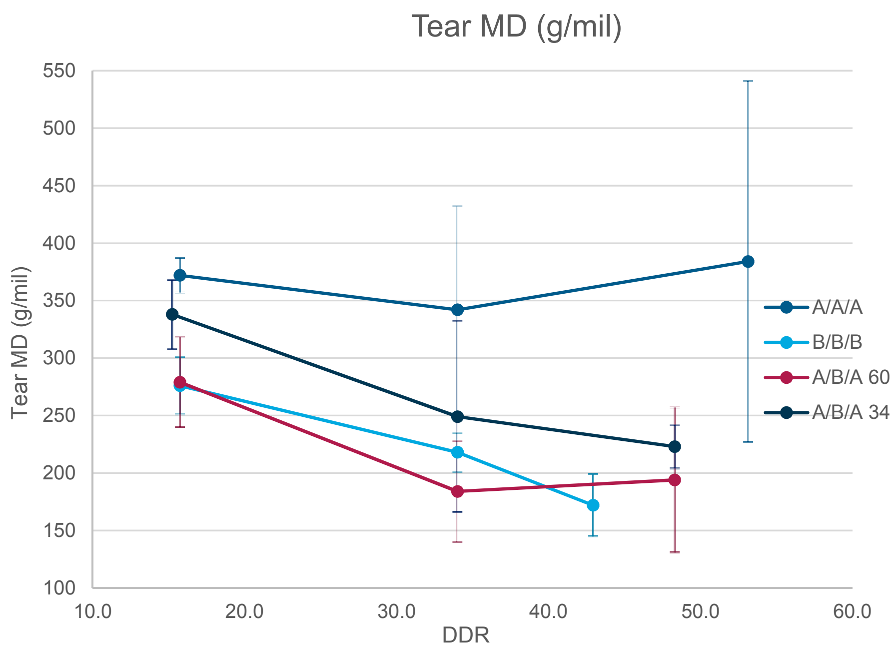




Product A has reduced impact resistance at high DDR's, but maintains MD Tear properties exceptionally well

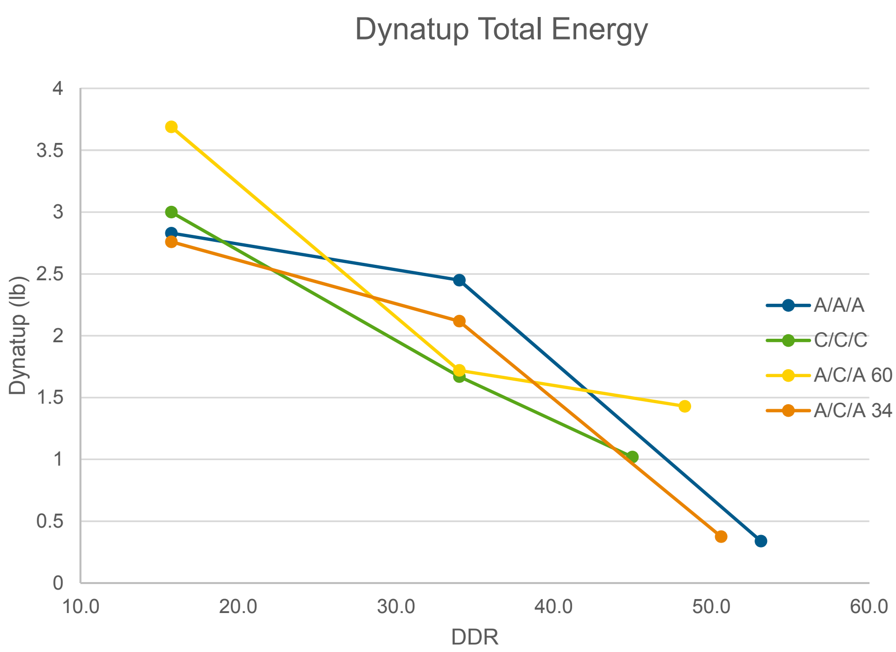
Dynatup and Tear in A/B/A Structures

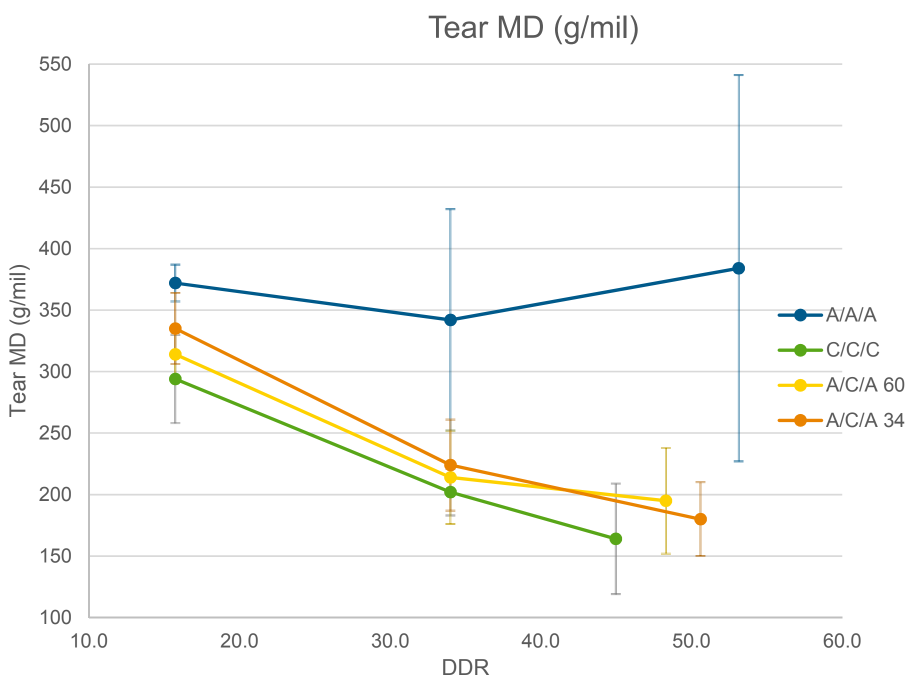




Co-ex structures with Product B do not show an improvement in Dynatup at high DDR’s, though we do see a boost in MD Tear performance over B/B/B monolayer. High skin layers generated better Tear performance.

Dynatup and Tear in A/C/A Structures





Co-ex structure with Product C show small improvement in Dynatup over C/C/C monolayer product. MD Tear once again shows a slight boost over C/C/C monolayer product.

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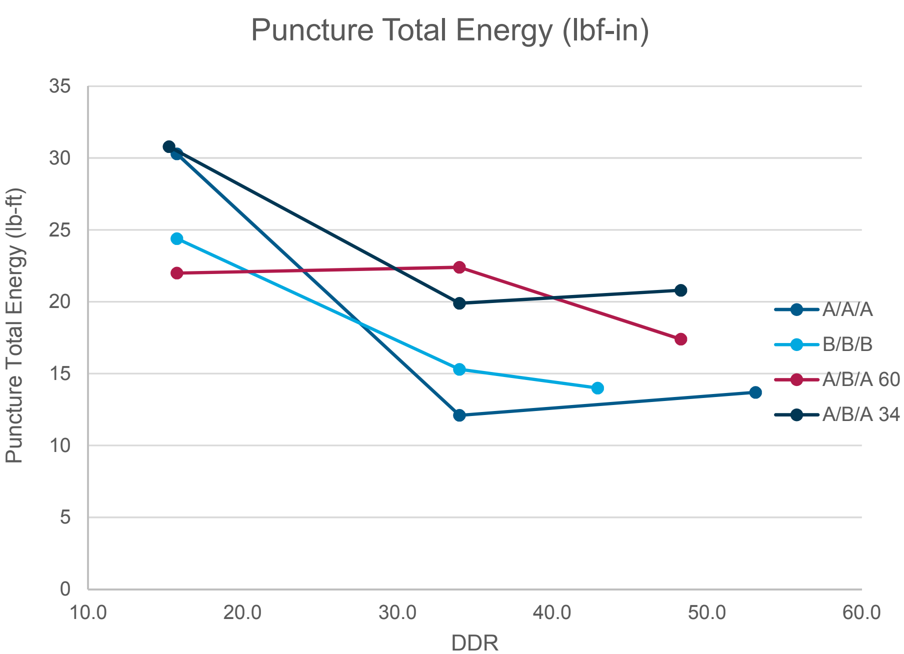
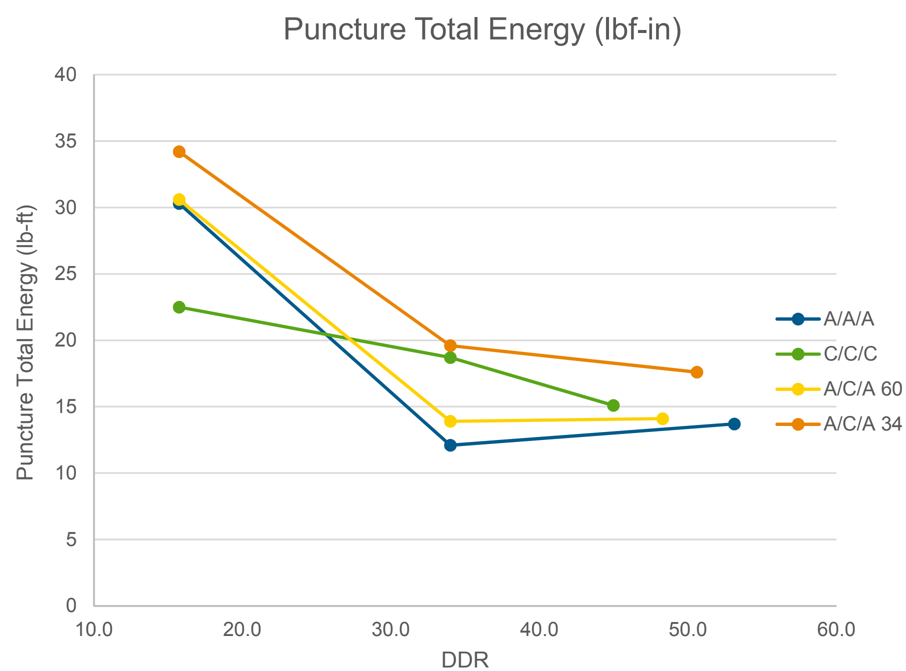
What about Slow Puncture?





ASTM puncture shows co-ex films can achieve impact resistance greater than either monolayer structure at high DDR’s

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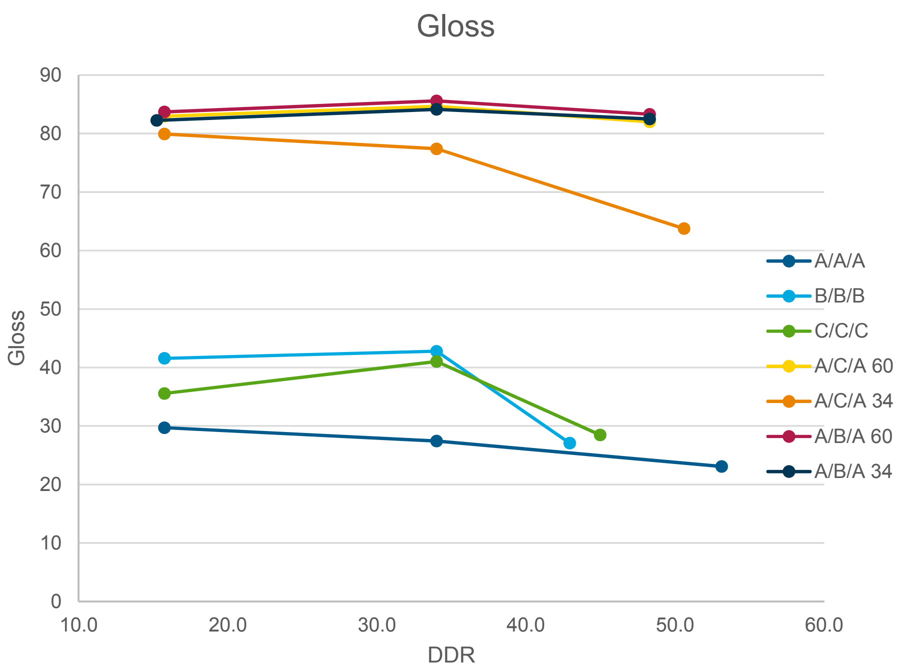
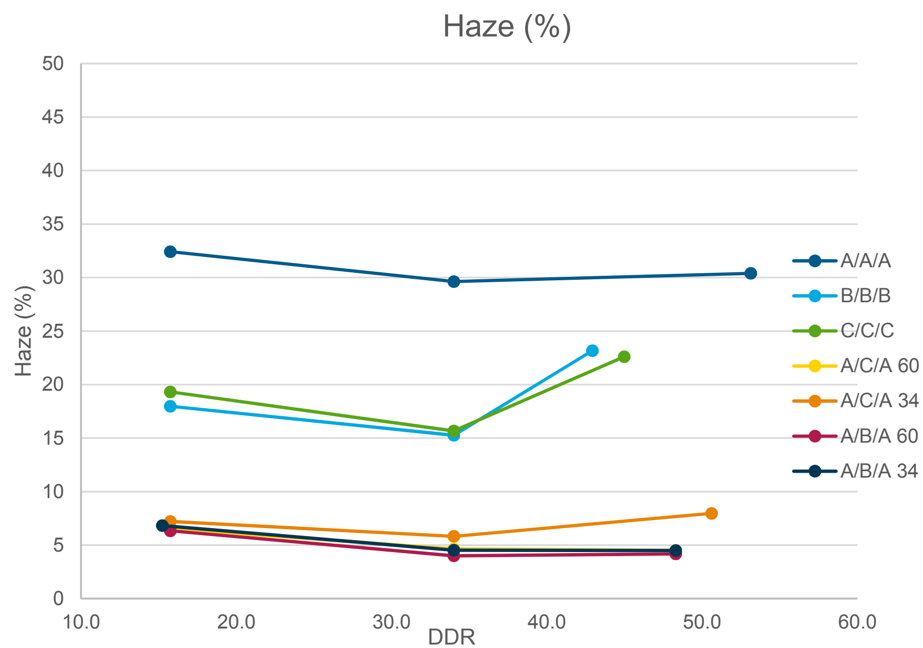
...A Surprise for Optics!





Significant improvement in both Gloss and Haze when combining materials into a multilayer structure.

Conclusion and Next Steps

1) Strategically placing materials in a co-ex structure can deliver a film with improved physical performance at high DDR's, sometimes with properties exceeding that of the incumbents.

2) While the improvement in dynatup and tear were modest, the improvement in optics were substantial for the co-ex films.

3) Further work will be conducted to better understand the technical and commercial opportunities of this phenomenon.

Thank you

Special thanks to Norman Aubee and James Bryant
for their support on this project