ITZ-396 Polymer Modifier MB for Shrink Film Application

Elimination of LDPE in Shrink Films and Potential for Down-gauging

Ingenia's INABLE product line – supporting your Circular Economy efforts

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Presentation Outline

- Why modify shrink film properties?
- Lab studies and performance results – Slides 4–13
- Commercial trials and performance results – Slides 14–18
- Application trial – shrink tunnel processing and package performance – Slides 19-22
- Down-gauging study – LLDPE only films – Slides 23-26
- Down-gauging study – 10% LDPE films – Slides 27-30
- Summary – Slides 31-34

Comparison of LDPE vs. LLDPE for Heat Shrink Film Application

Low density polyethylene (LDPE)

- Excellent heat shrink performance
- Good printability
- Weak mechanical properties
- Good bubble stability
- High cost

Linear Low Density Polyethylene (o-LLDPE)

- Poor heat shrink performance
- Good printability
- Strong mechanical properties
- Poor bubble stability
- Low cost

Opportunity - sustainability improvement and cost reduction with removal of LDPE/gauge reduction and resultant property improvement.

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Ingenia Lab Study - Processing Conditions and Material

- Monolayer blown film extrusion line is used. (Diameter:42mm L/D:26)
- All the films are produced at 2 mil thickness and BUR~ 2.
- Film extrusion temperature of 200°C.
- The screw speed is 15 rpm on a 42 mm diameter L/D:26 screw with a typical output of 30 lbs/h.
- o-LLDPE MI:1 & LDPE MI:0.22 is used in this study.

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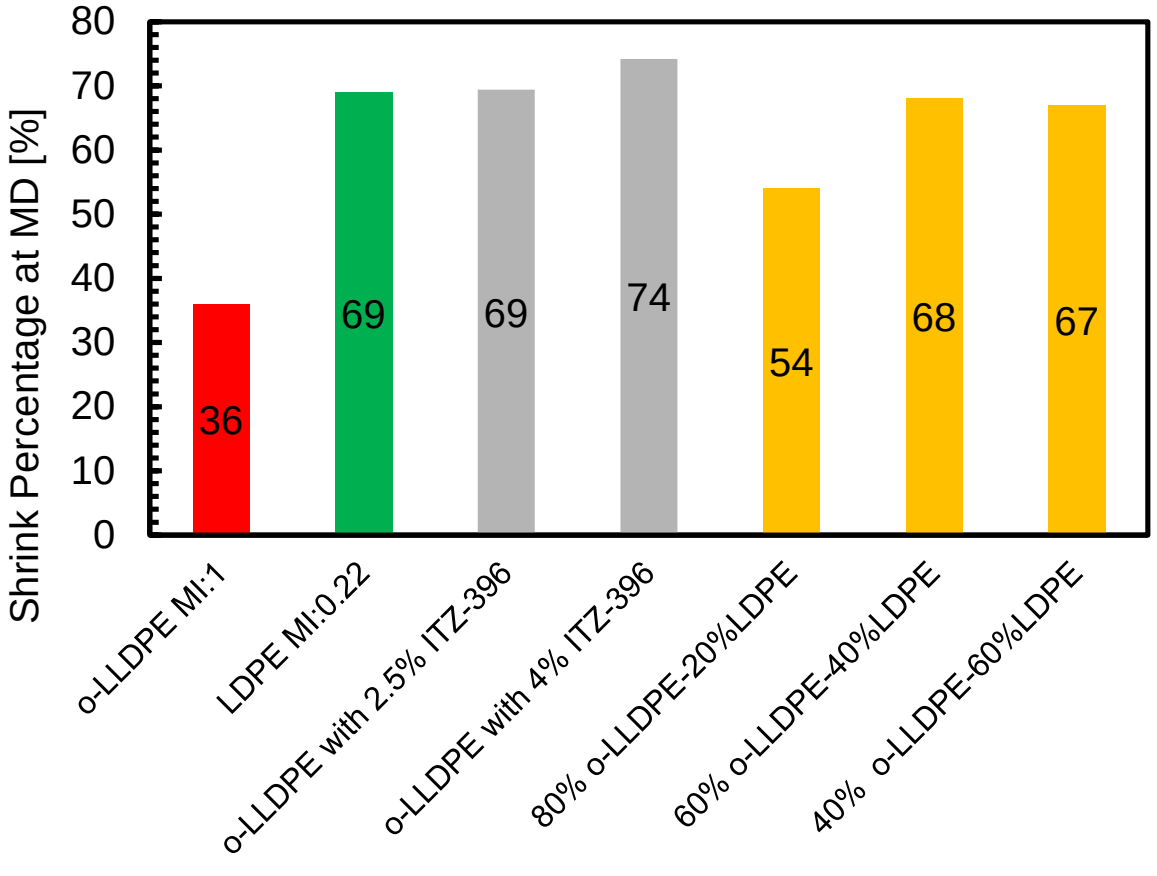
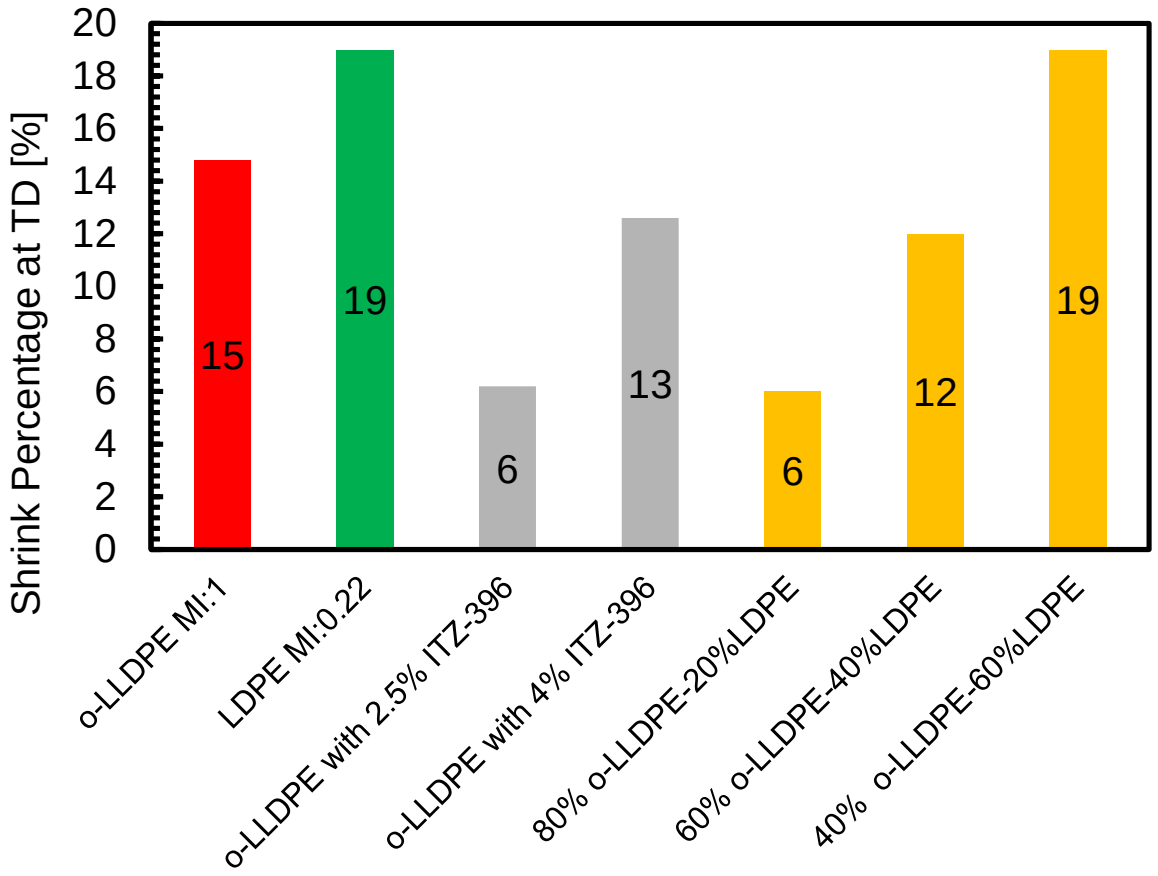
Ingenia ITZ-396 - Shrink Properties





- Heat shrink properties similar to LDPE can be obtained when Ingenia MB is added to o-LLDPE MI:1.
- Heat shrink percentage in the MD can be tailored between 35%-70%.

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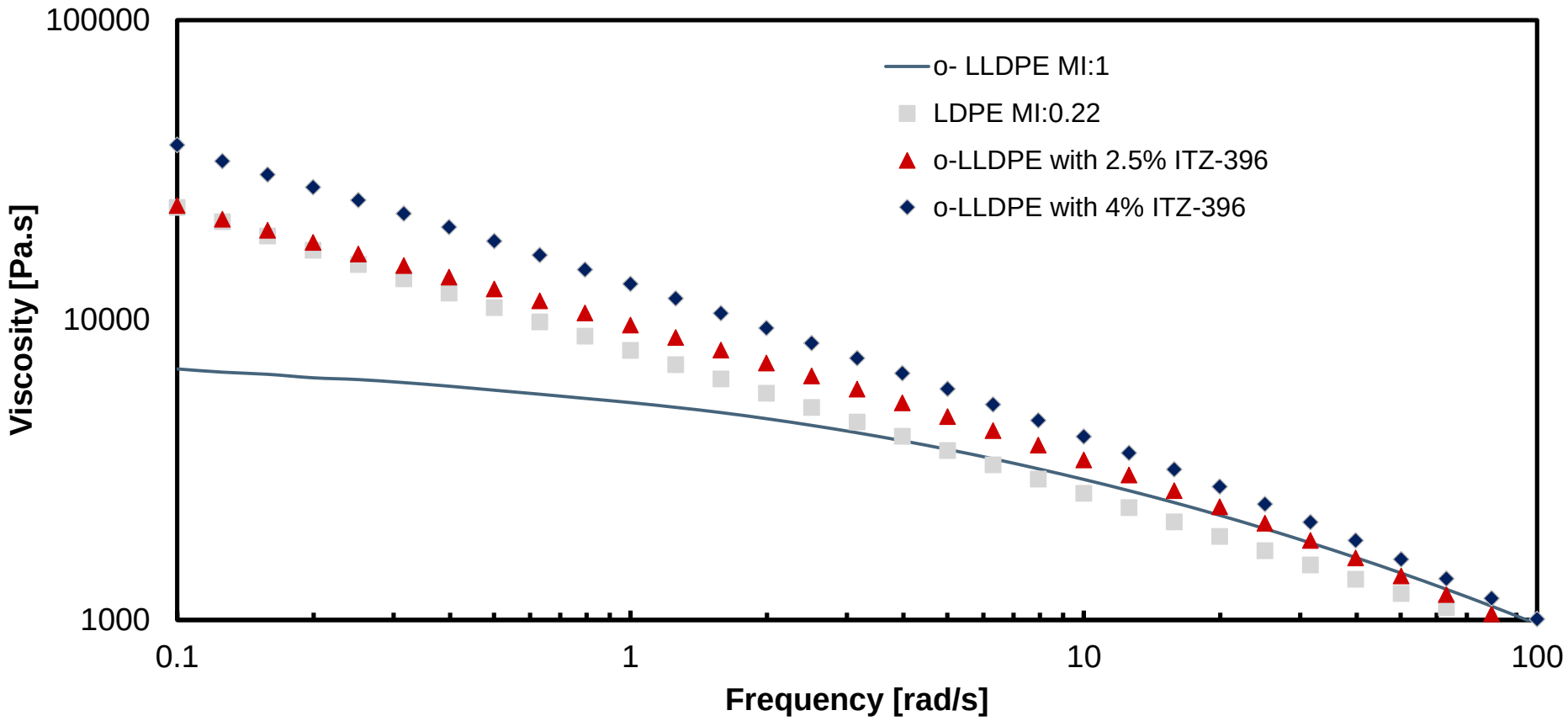
Ingenia ITZ-396 - Flow Properties



- o-LLDPE MI:1 flow properties can be altered to match with commercially available film grade LDPE MI:0.22 by using Ingenia ITZ-396.

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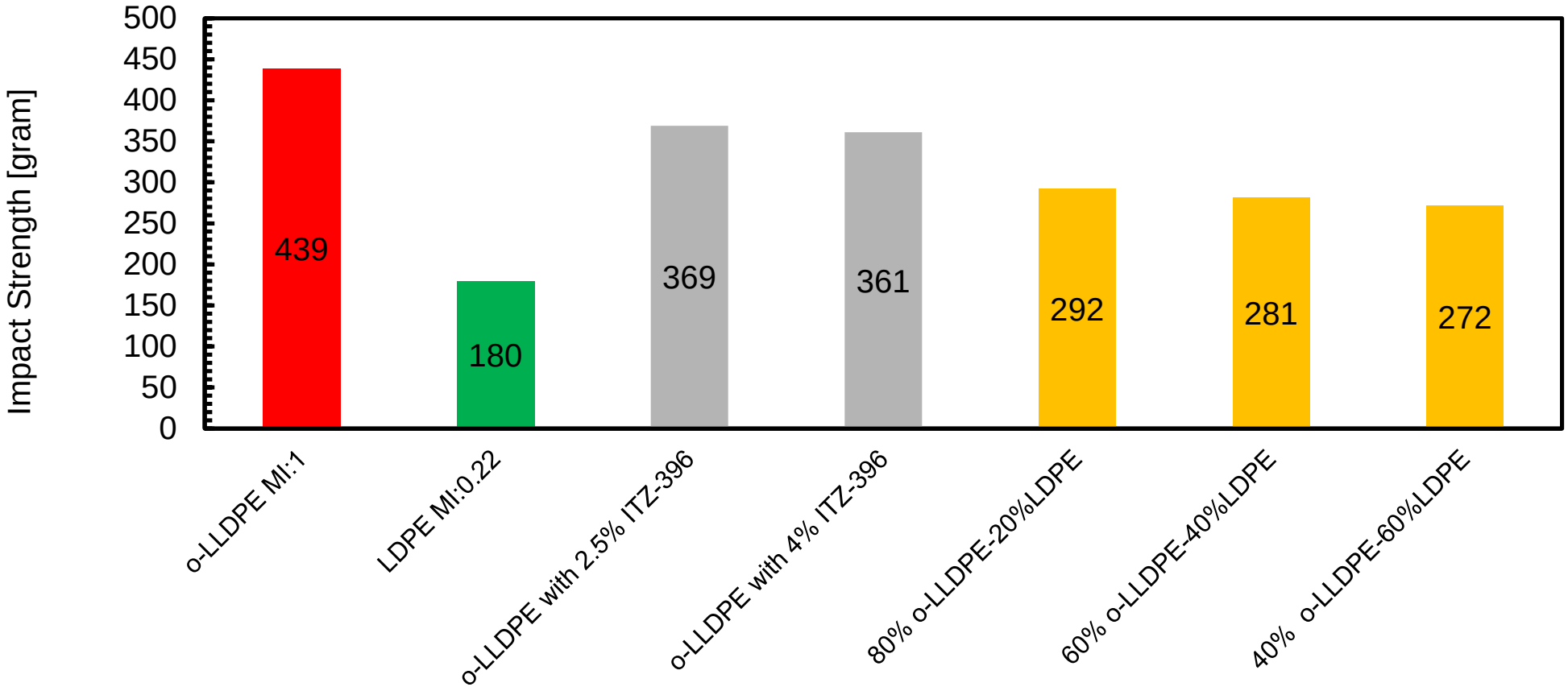
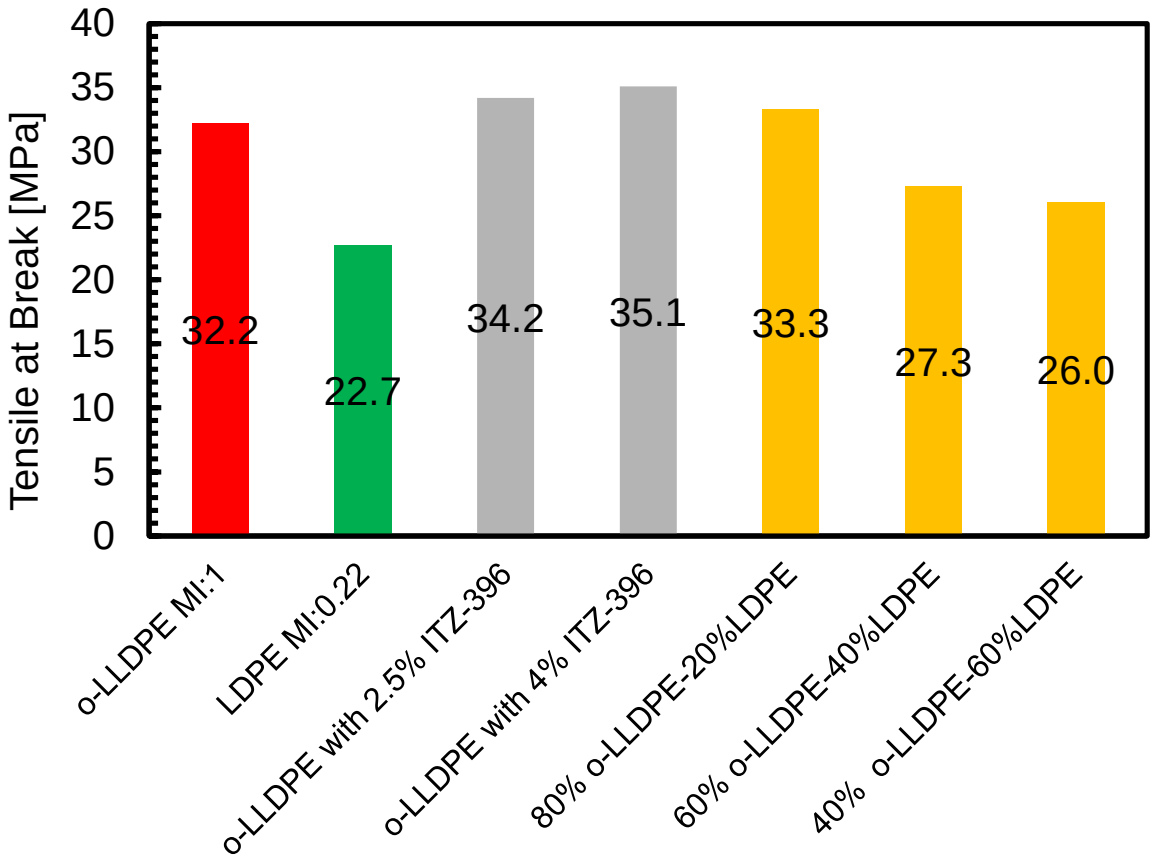
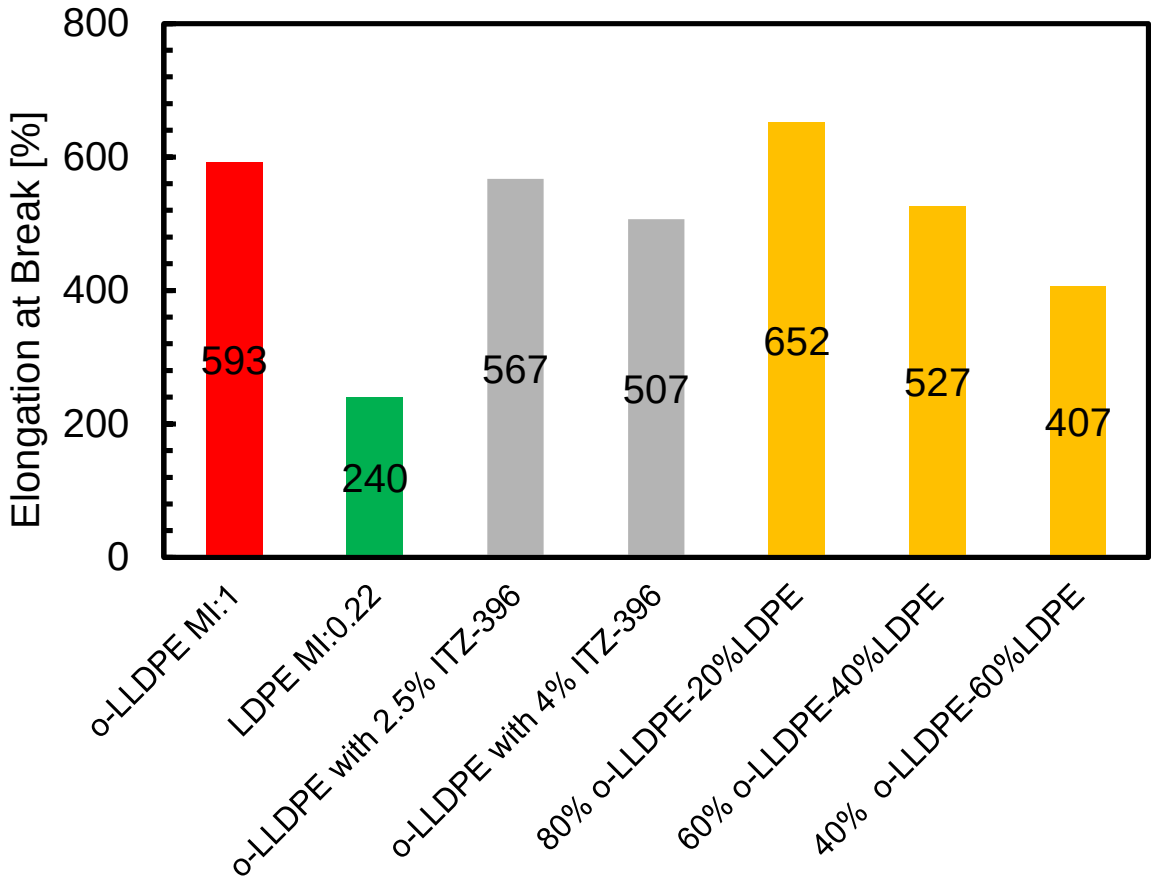
Ingenia ITZ-396 - Impact Properties



- o-LLDPE MI:1 can be modified with minimal sacrifice of impact properties and provides better results vs. LDPE containing blends.

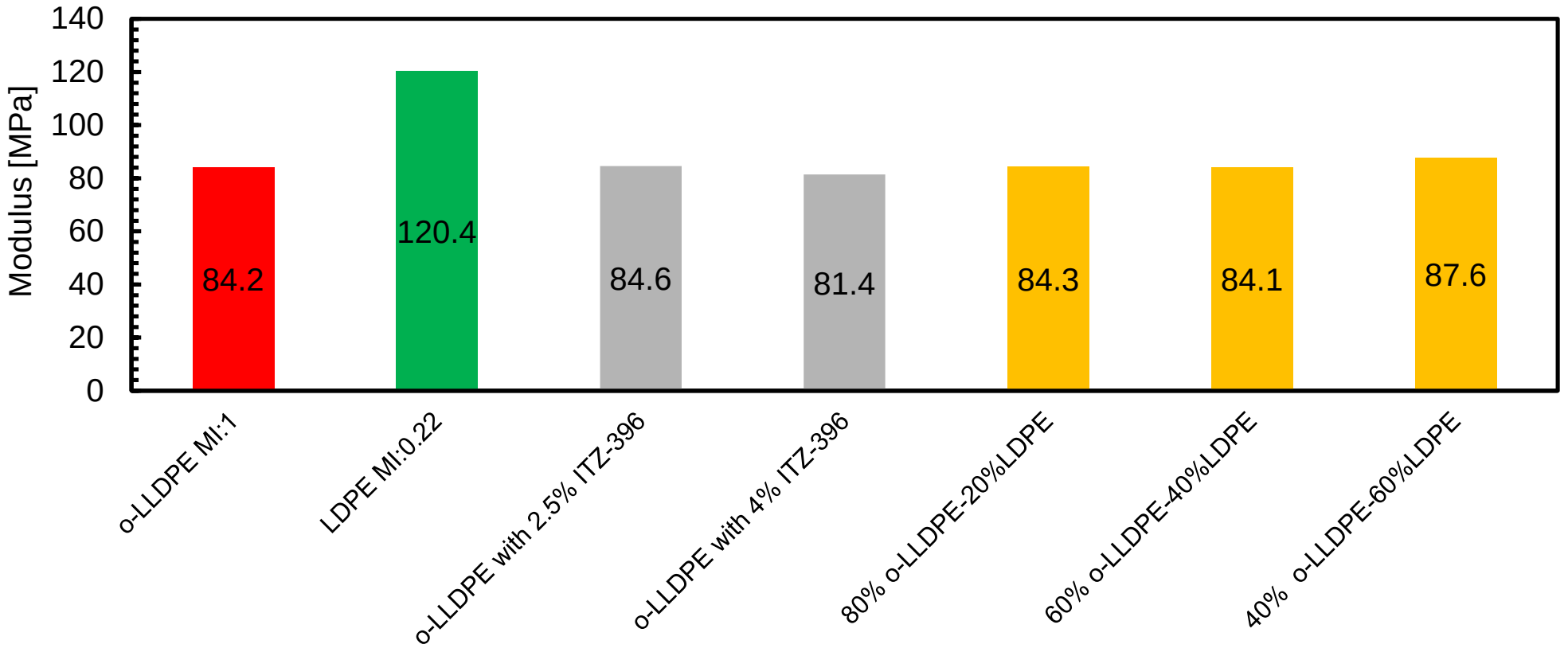
Ingenia ITZ-396 - Tensile Properties





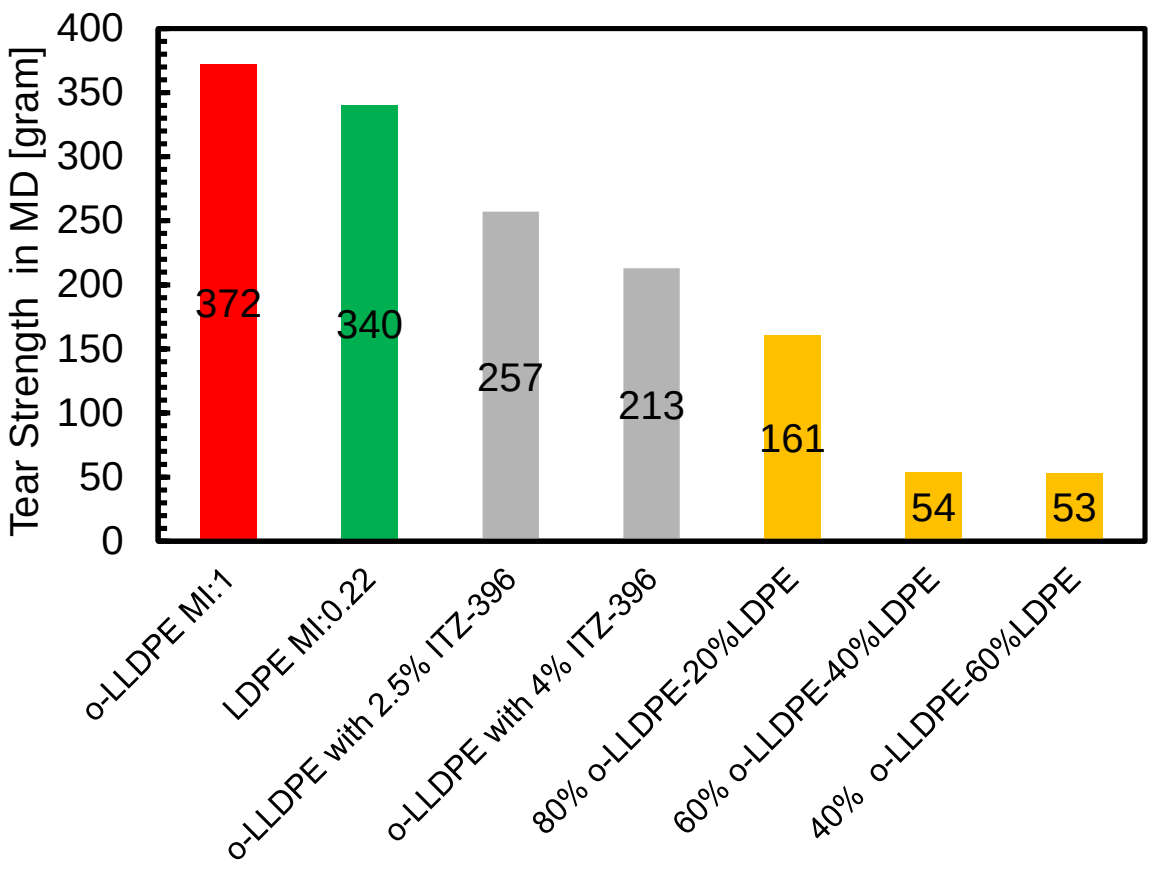
- o-LLDPE MI:1 shrink properties can be modified without sacrificing tensile properties.
- Tensile tests are conducted in MD.

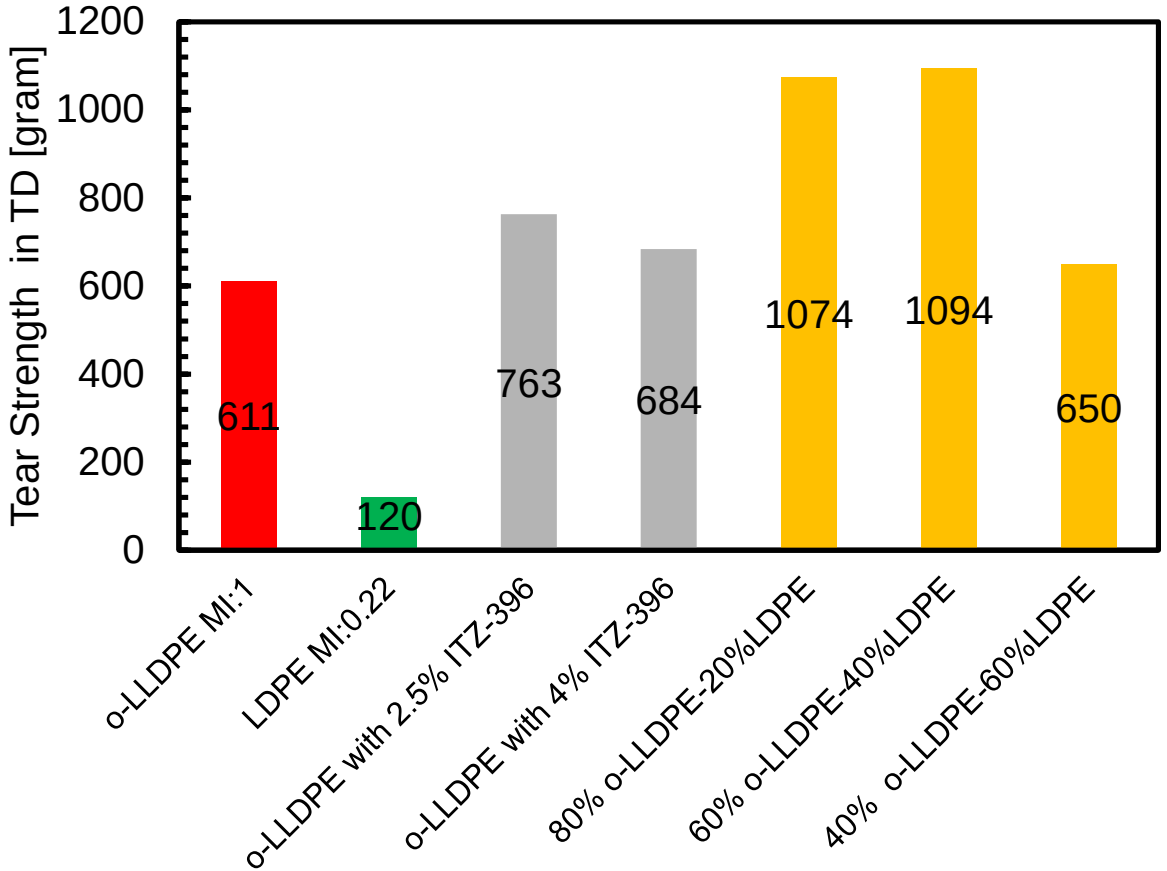
Ingenia ITZ-396 - Tensile Properties



- o-LLDPE MI:1 shrink properties can be modified without sacrificing tensile properties.

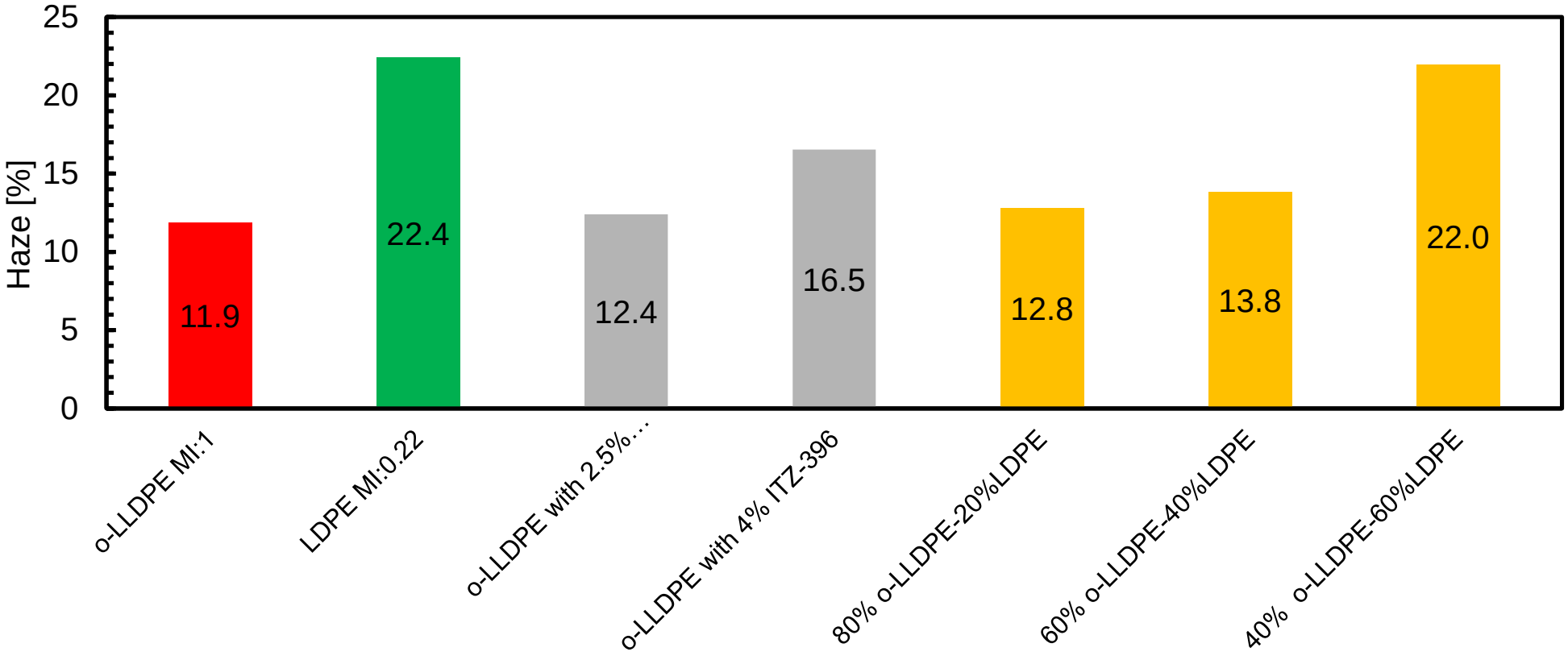
Ingenia ITZ-396 - Tear Properties





- o-LLDPE MI:1 shrink properties can be modified without sacrificing tear strength properties.

Ingenia ITZ-396 - Optical Properties



- Haze results are prior to shrinking process.
- After modifying o-LLDPE with Ingenia ITZ-396, the haze of o-LLDPE increases slightly.
- After modifying o-LLDPE with ITZ-396, the haze is better than LDPE MI:0.22 used in this study.

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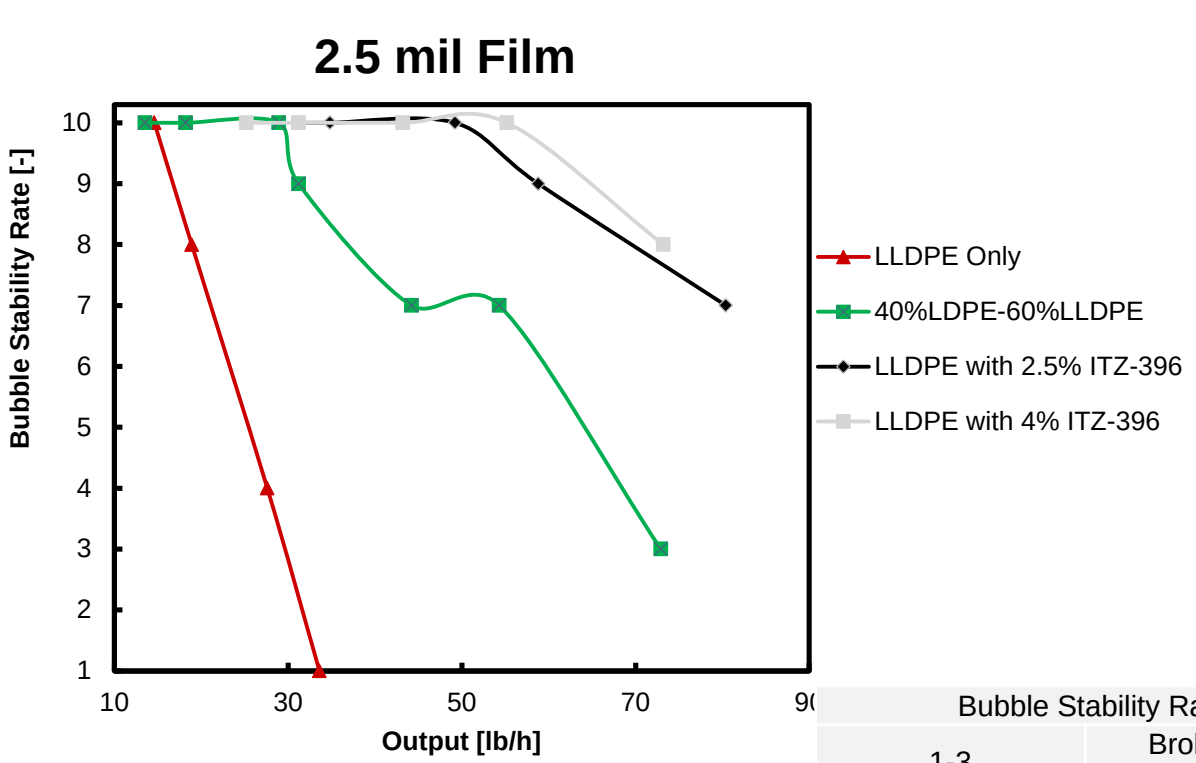
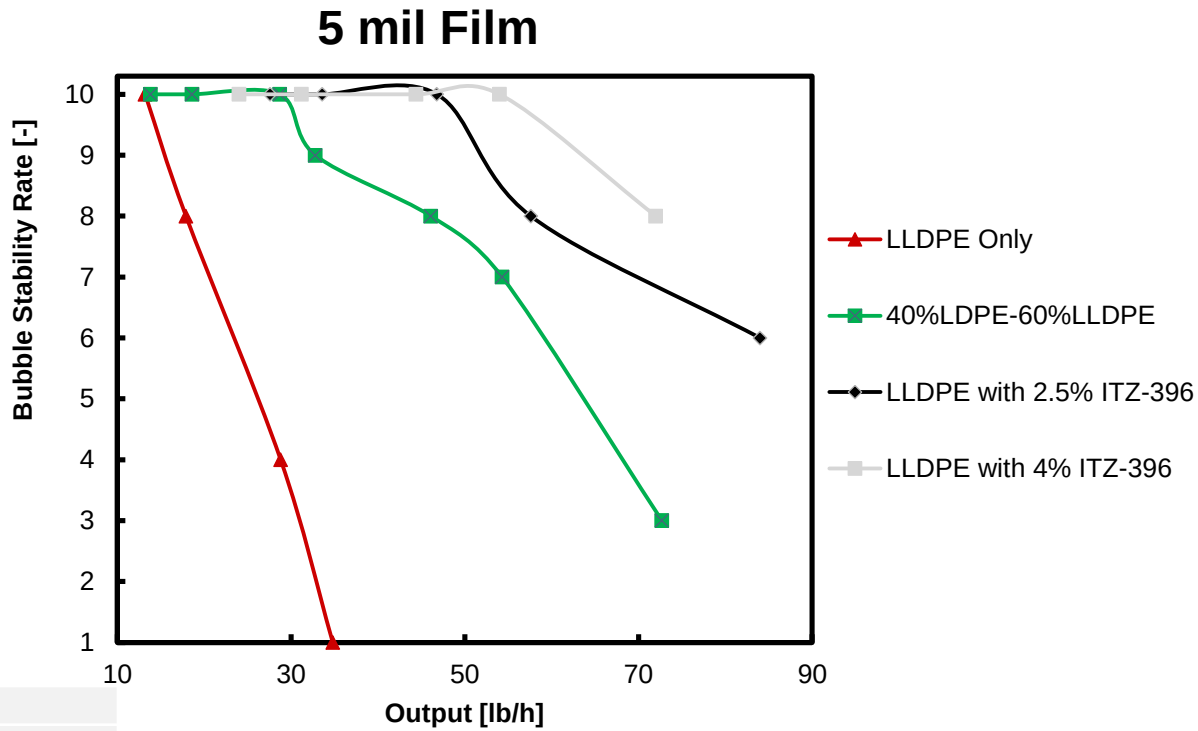
Ingenia ITZ-396 – Bubble Stability





Bubble Stability Rate	
1-3	Broken/Very Unstable
4-7	Unstable
8-9	Stable
10	Very Stable

- Temperature is 190°C. BUR is ~ 2.
- LLDPE with ITZ-396 is more stable than LLDPE only and 40%LDPE-60%LLDPE films at both 2.5 mil and 5 mil thickness.

Summary of Lab Study

- It is possible to remove LDPE in heat shrink film application through addition of Polymer Modifier ITZ-396, maintain shrink properties and improve mechanical properties.

Ingenia ITZ-396 provides:

- Tailored heat shrink properties to meet specific needs.
- Better tensile properties compared to LDPE blends.
- Better impact properties compared to LDPE blends.
- Better bubble stability compared to LLDPE alone.

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Commercial Trials Experience - Conditions and Observations

- Commercial films produced at 2.75 mils.

Experiment Number	Film Name	Observation
Commercially Available Film	LDPE rich blend	Base Film. Printed in secondary step.
2.5% ITZ396	2.5% ITZ396/97.5% LLDPE MI:1	Smooth trial. Excellent bubble stability.
4% ITZ396	4% ITZ396/96% LLDPE MI:1	Smooth trial. Excellent bubble stability.

- BUR = 2.5
- Film extrusion temperature of ~200°C.
- Results shared in following slides are indicative, trials in specific resins and processing conditions are required to validate for your application requirements.

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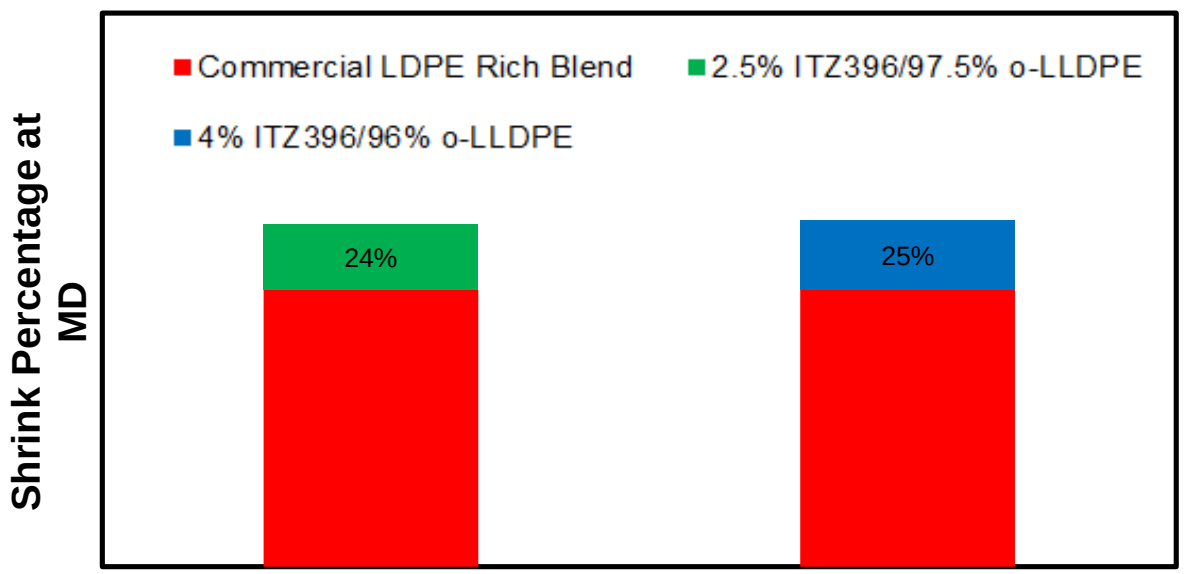
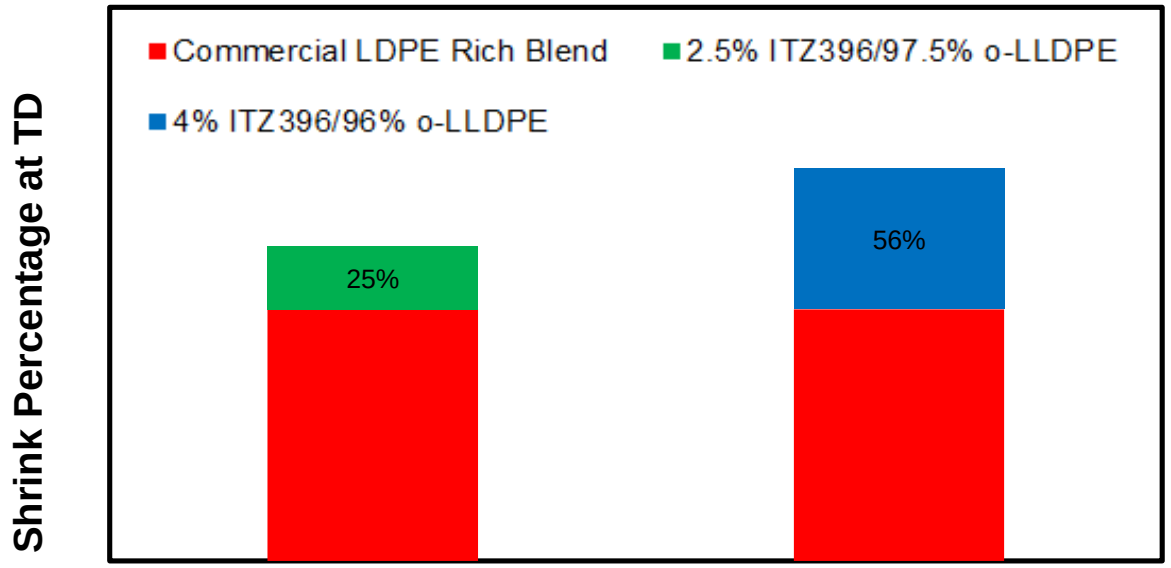
Shrink Properties (Internal Test Method)





- The shrink properties in both MD and TD are improved (upwards of 24%) compared to Commercial LDPE Rich Blend.

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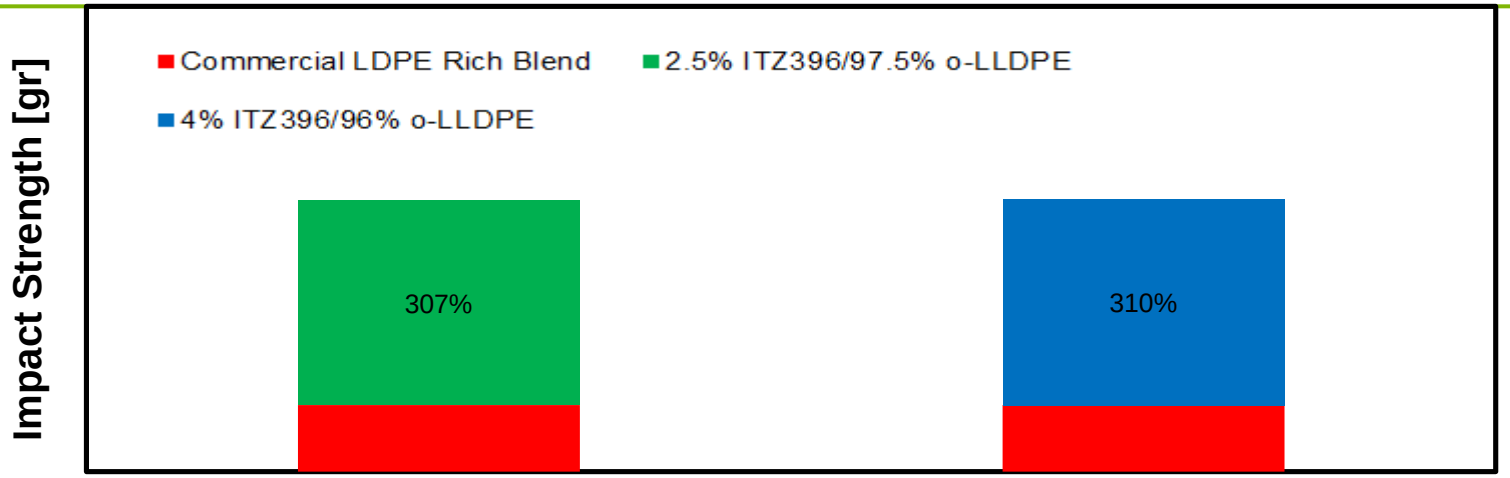
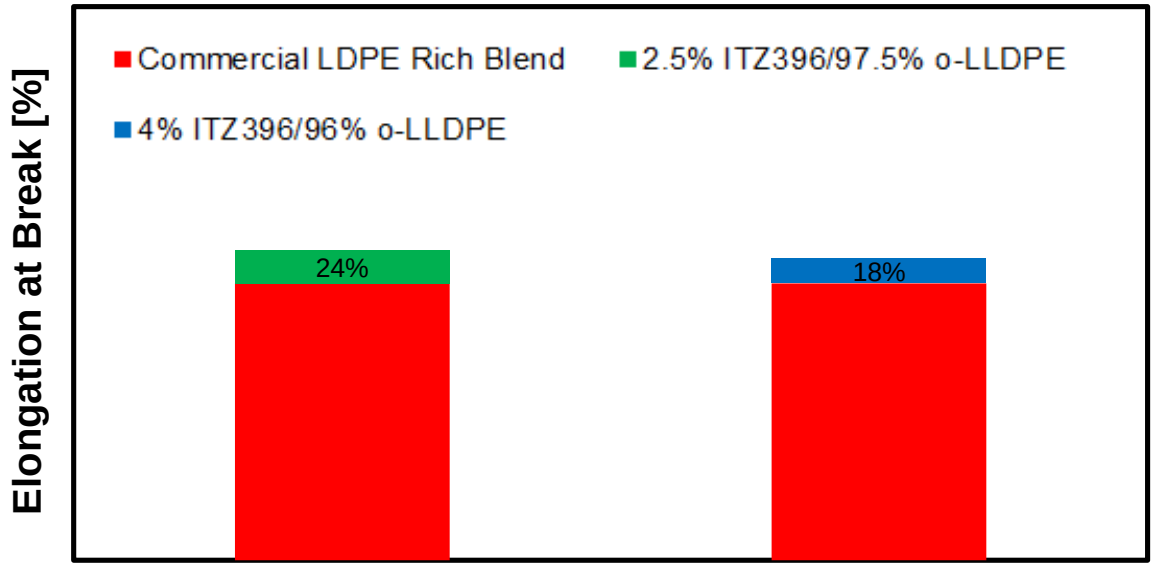
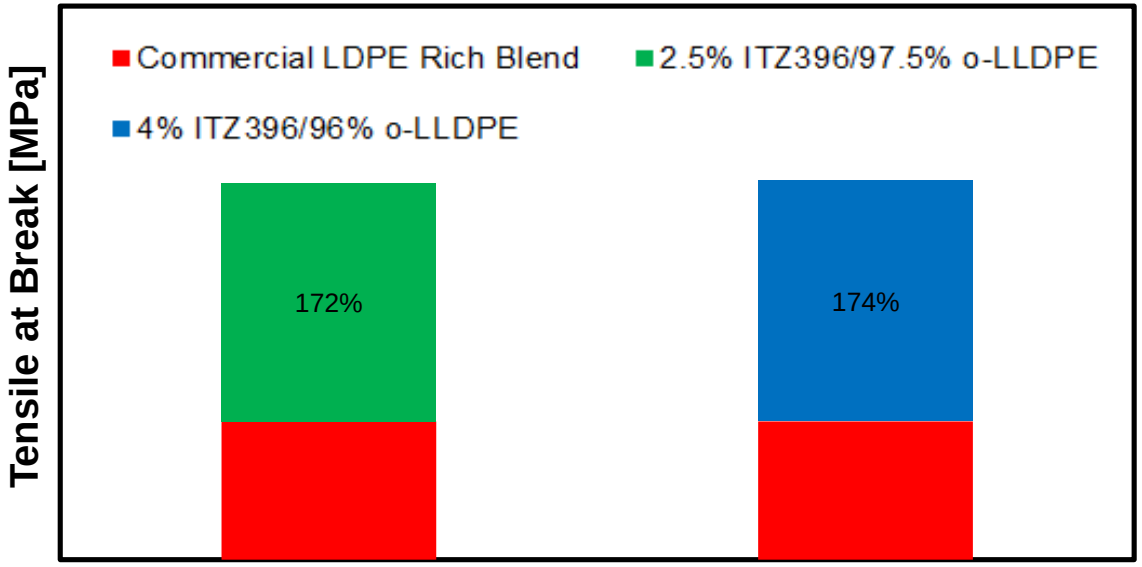
Mechanical Properties

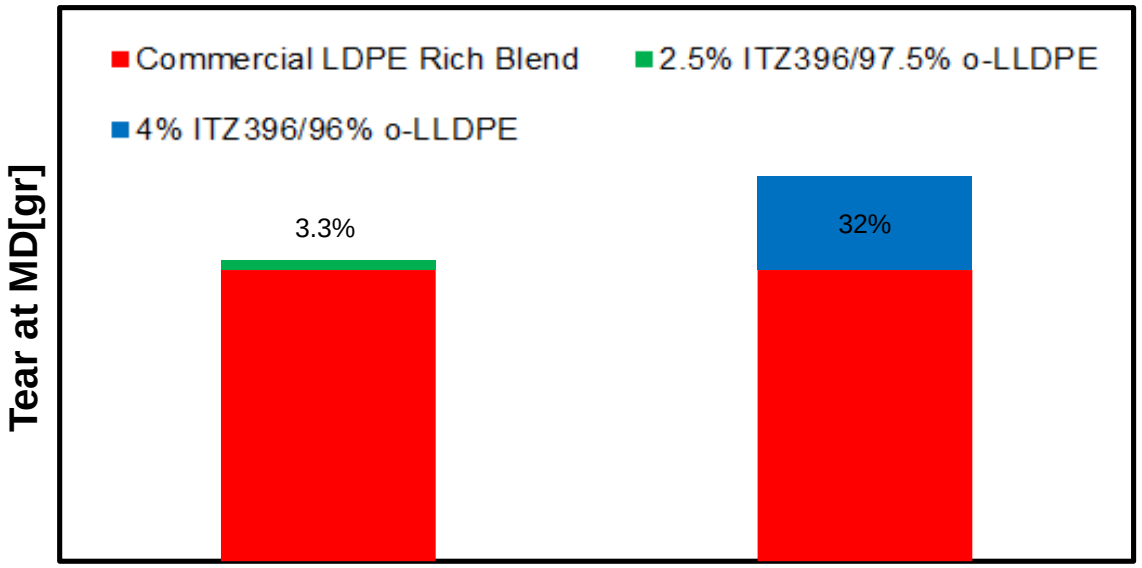


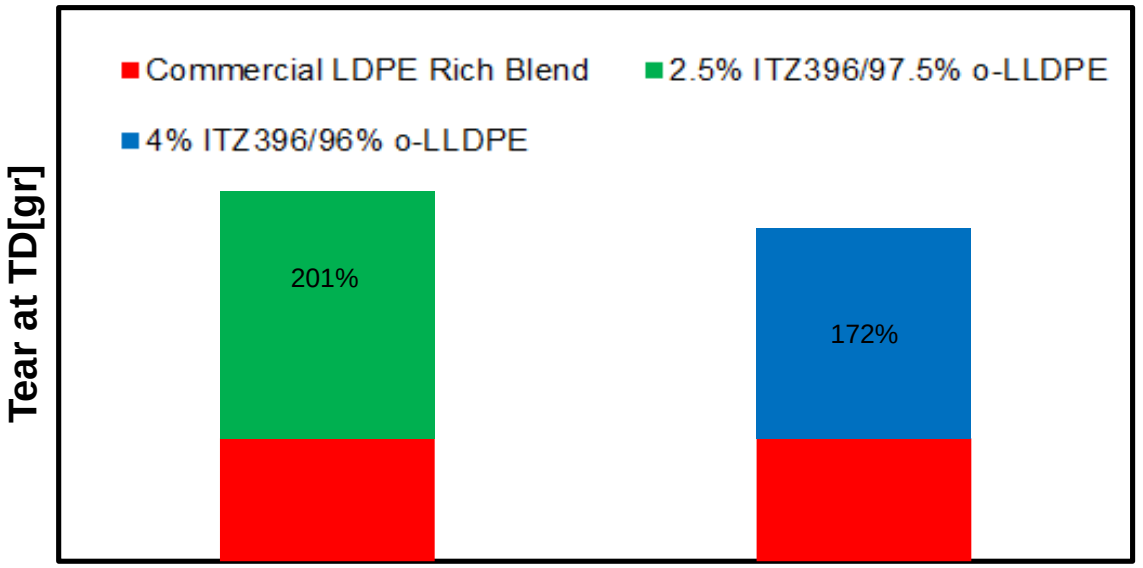
- Significant % increase obtained for impact and tensile properties with ITZ-396 trials compared to Commercial LDPE rich blend.

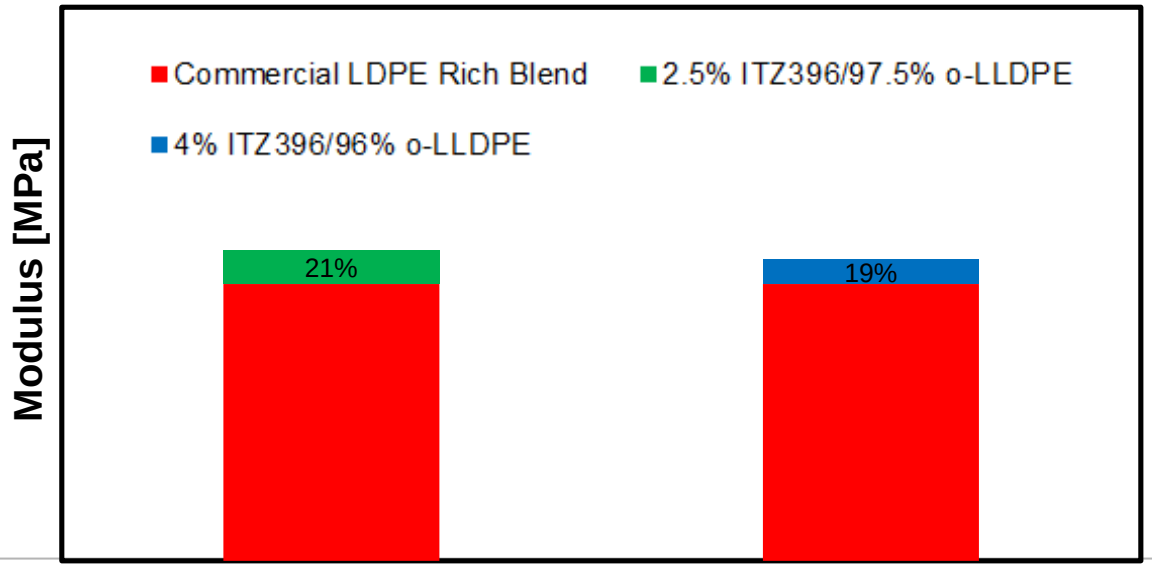




Mechanical Properties







- Both MD and TD tear properties are improved with ITZ-396 trials compared to commercial LDPE rich blend.
- Tensile modulus is improved compared to commercial LDPE rich blend.

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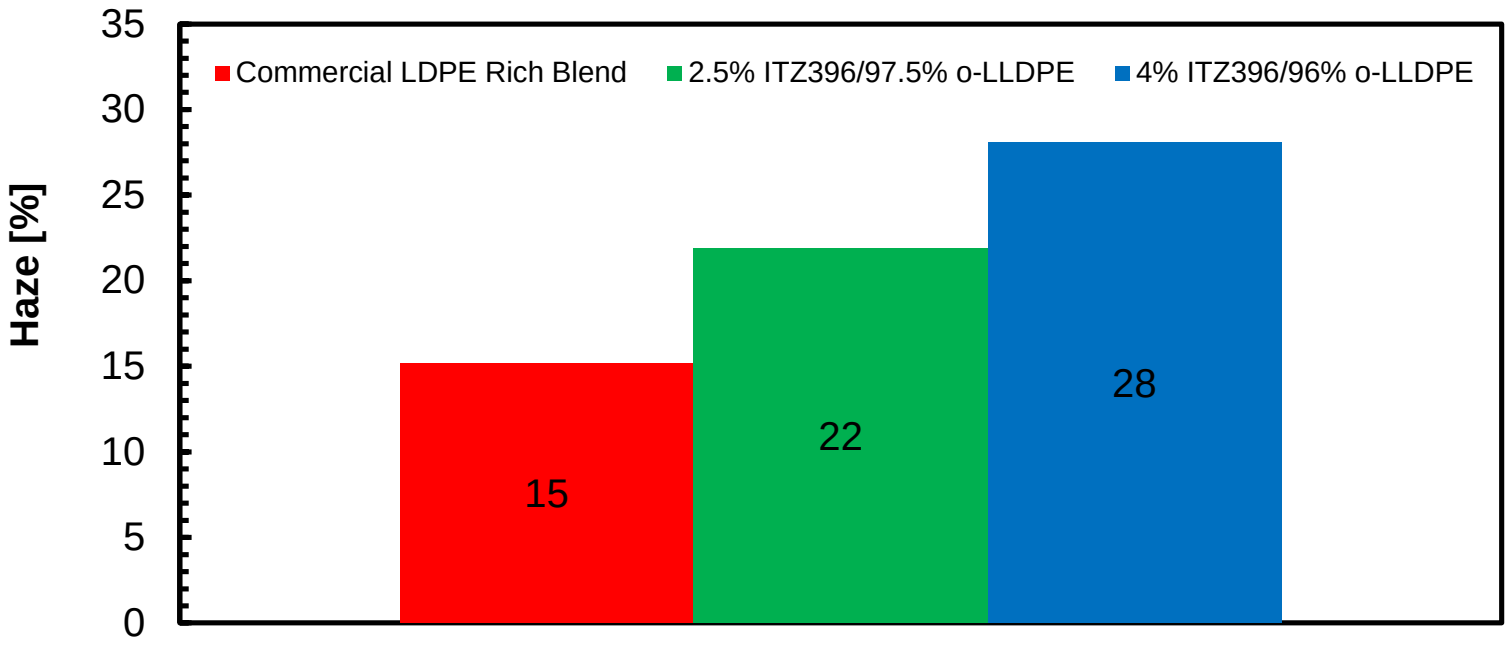
Optical Properties



- Haze % increased vs. the Commercial LDPE rich blend.
- With improved mechanical properties of films made with ITZ396 in o-LLDPE, down-gauging of the film is possible, thereby reducing any negative impact to haze results.

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Shrink Tunnel Trial

- Tunnel Conveyor Temperature Set Point: 105°C.
- Base Tunnel Temperature Set Point: 230°C.
- Tunnel Height: 14.5 inch.
- Maximum Tunnel Speed Variance: 12%.
- Base Tunnel Blower Speed:1400rpm.
- The conveyor is moving when there is no sample inside the tunnel.

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Shrink Tunnel Trial

- 24 packs of water bottle packaging were examined and tested.

Shrink Tunnel Trial

Commercial Package-1

Commercial Package-2

Trial Package (Ingenia)

	After Shrink	
	Thickness [mi]	Haze [%]
Commercial Package-1	2.3-2.7	13.47
Commercial Package-2	2.6-3.1	14.33
Trial Package	2.6-3.2	17.12

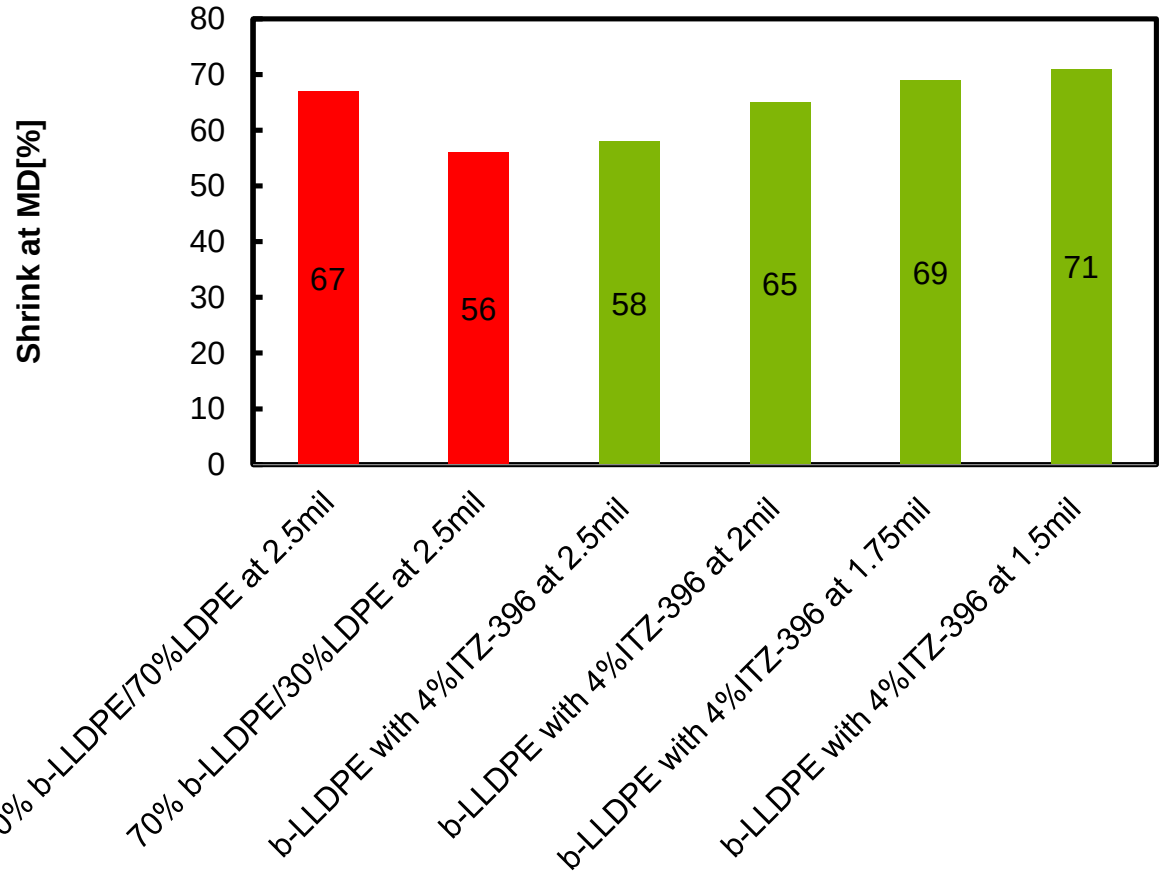
Shrink Tunnel Trial

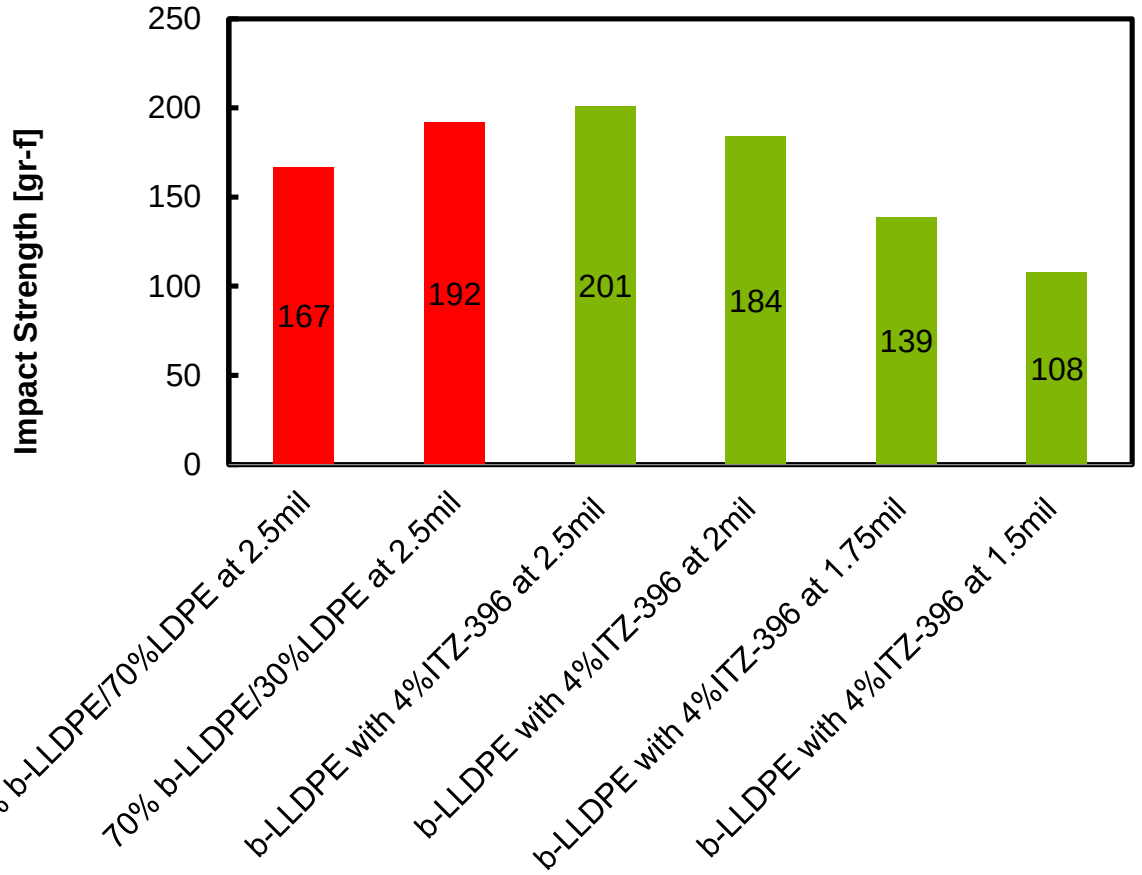
Experiment Number
Film 1 (2.5% ITZ396)
Film 2 (4% ITZ396)
Film 3 (2.5% ITZ396 with 10%LDPE)

	5 times Drop Test	2-point Swing Test	1 point Swing Test	Film Tightness	Finger Poke
Film 1	Pass	Pass	Pass	+++++	+++++
Film 2	Pass	Pass	Pass	+++++	+++++
Film 3	Pass	Pass	Pass	+++++	++++

- While +++++ indicates best performance, + represents the worst performance.
- The shrink tunnel trial are completed by 3rd party lab.
- No film cutting issues reported.
- Very good shrink performance reported.
- Additional water bottle company internal tests completed with cases from this trial. All film structures passed.

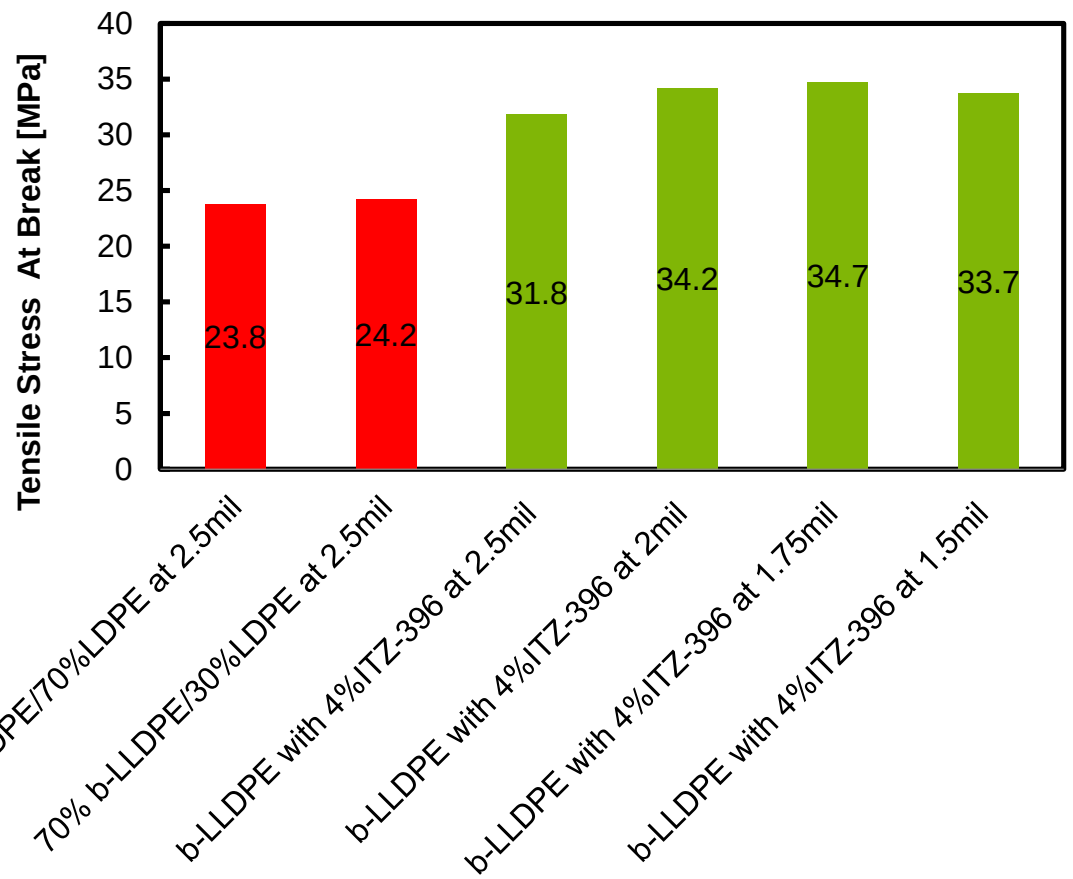
Down Gauging Opportunity without LDPE

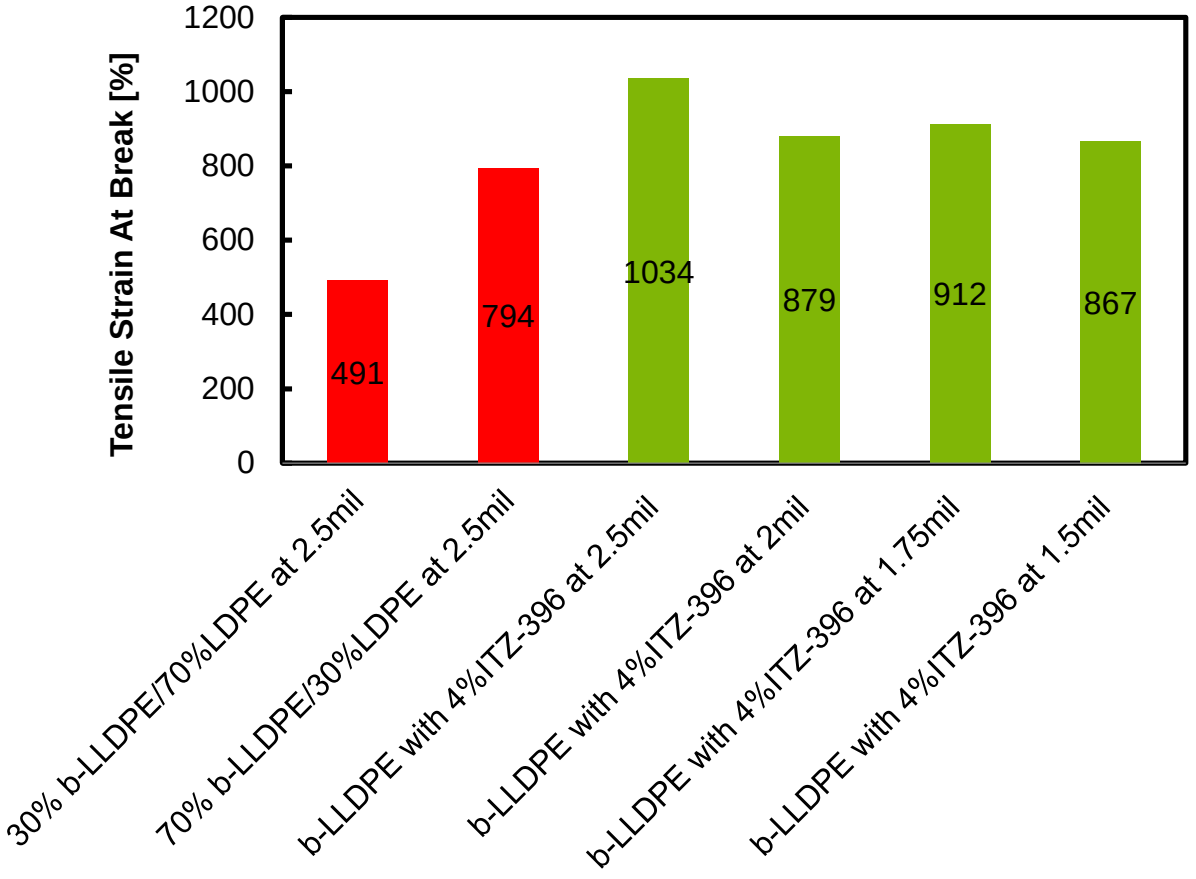




- 20% gauge reduction is possible without sacrificing shrink and impact properties.

Down Gauging Opportunity without LDPE





- 40% gauge reduction is possible without sacrificing tensile properties.

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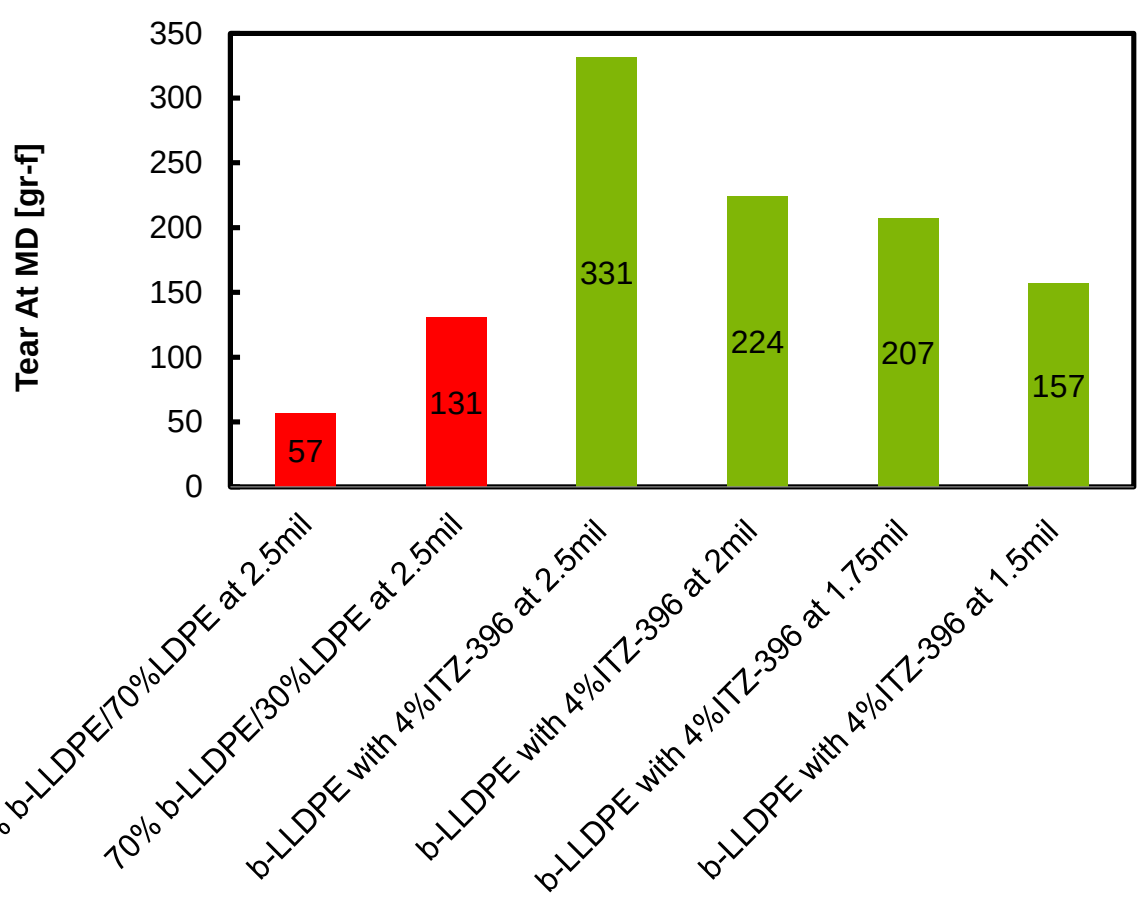
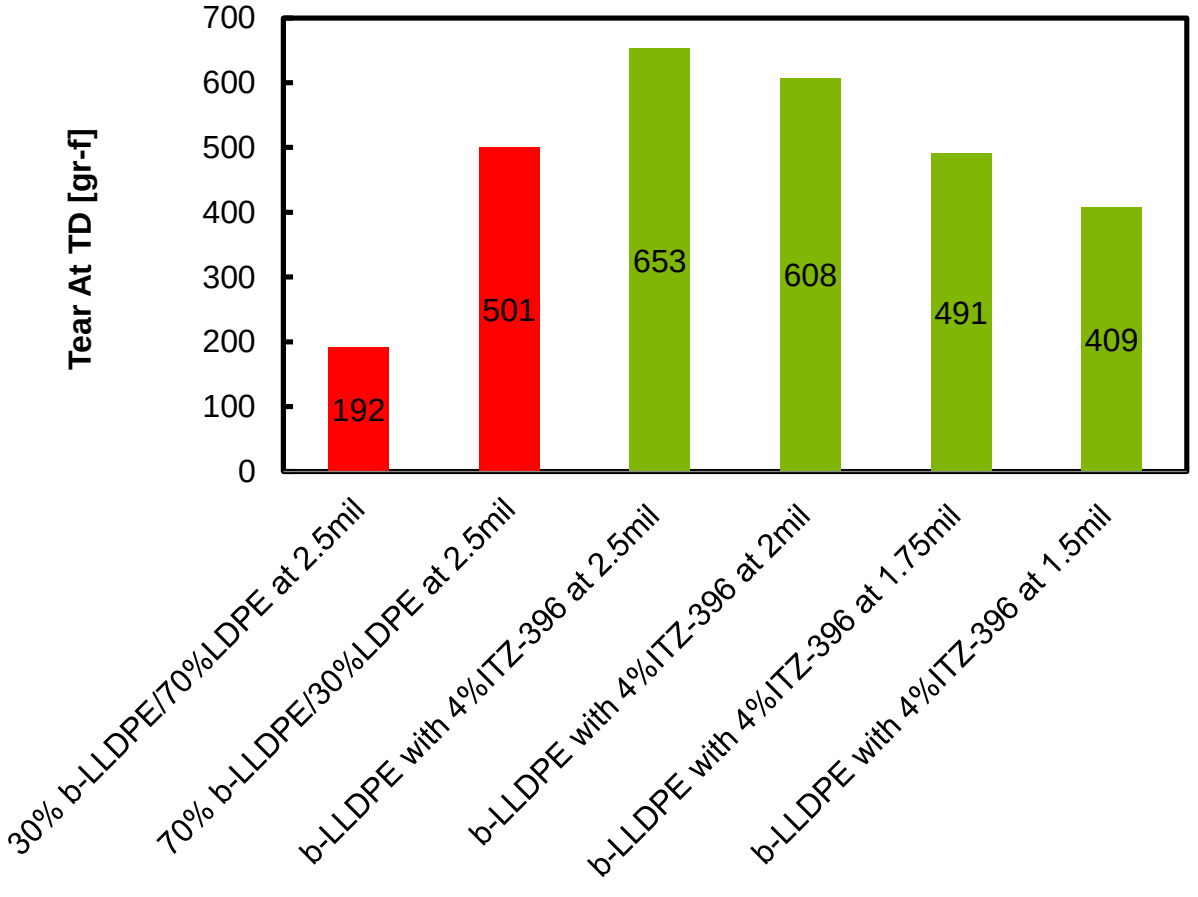
Down Gauging Opportunity without LDPE





- 30% gauge reduction is possible without sacrificing tear properties.

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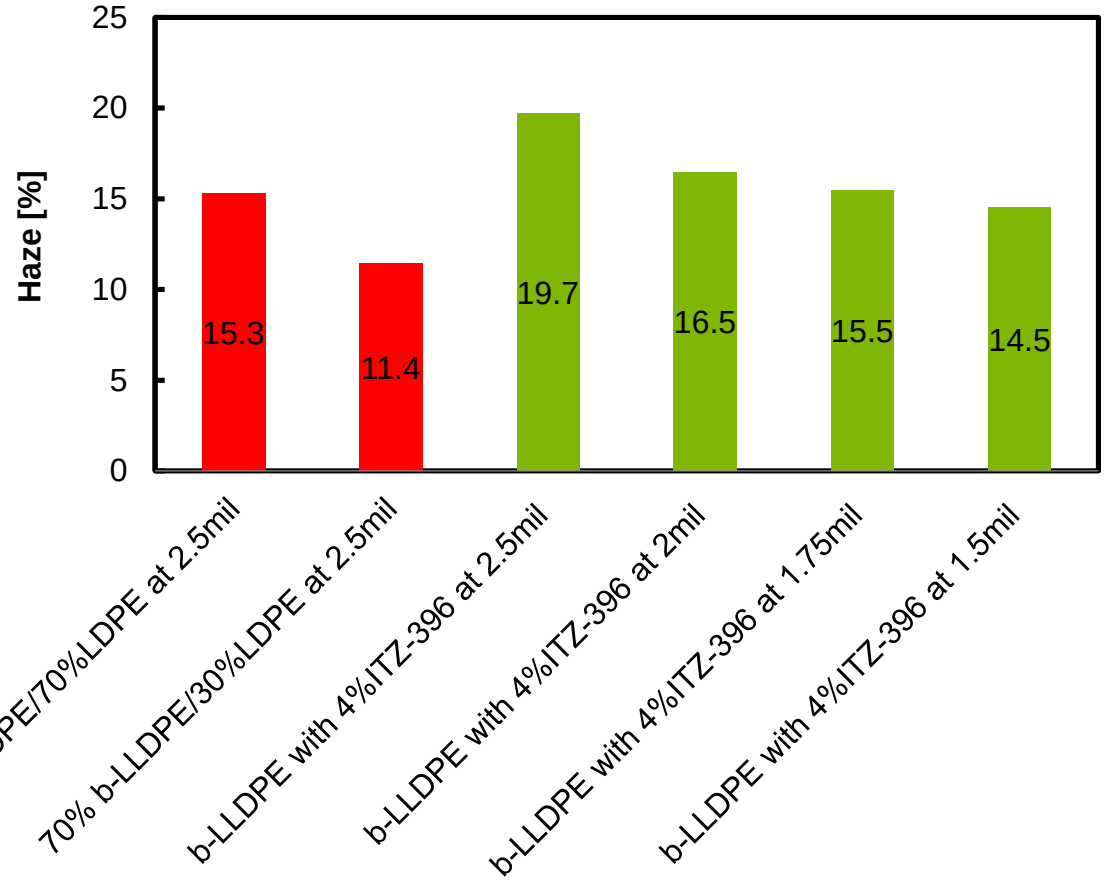
Down Gauging Opportunity without LDPE



- With 20 to 30% gauge reduction, haze properties of LLDPE/ITZ-396 films becomes similar to standard LDPE/LLDPE blends.

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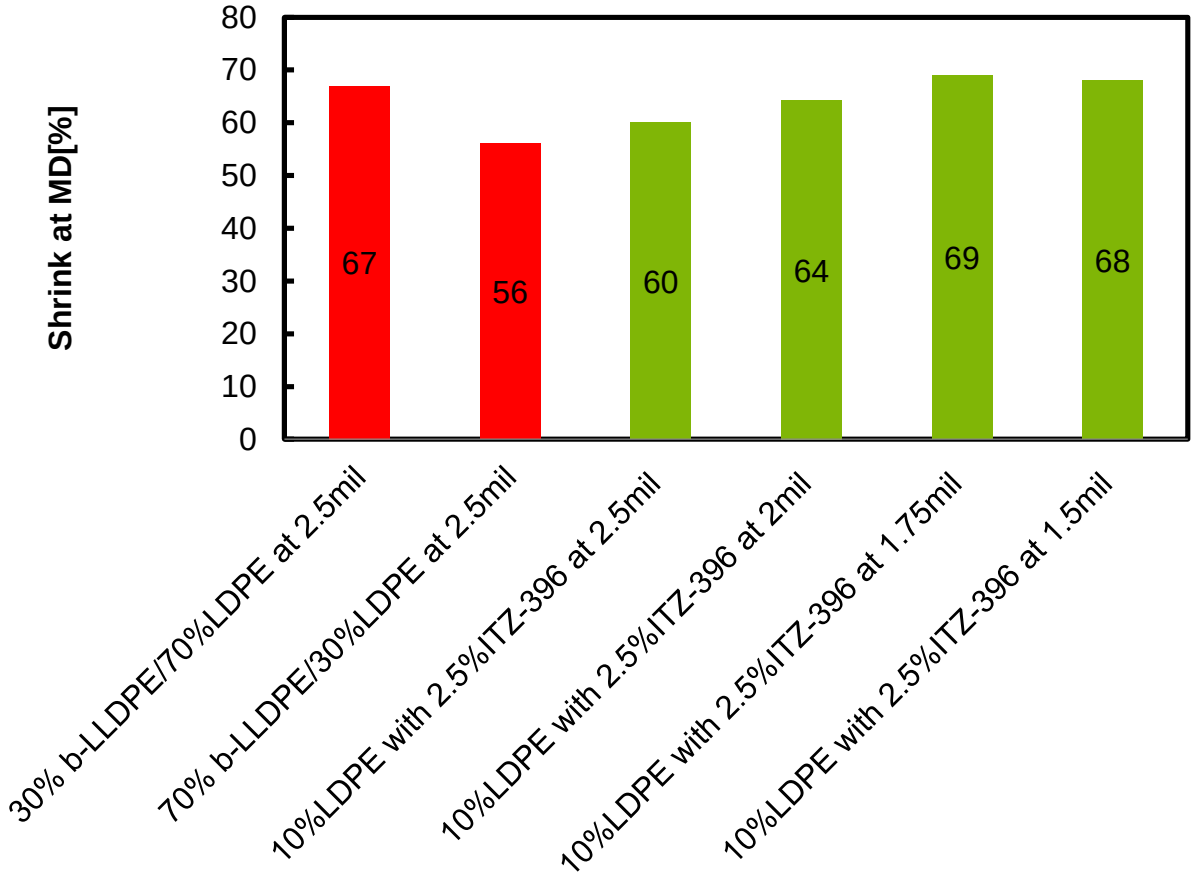
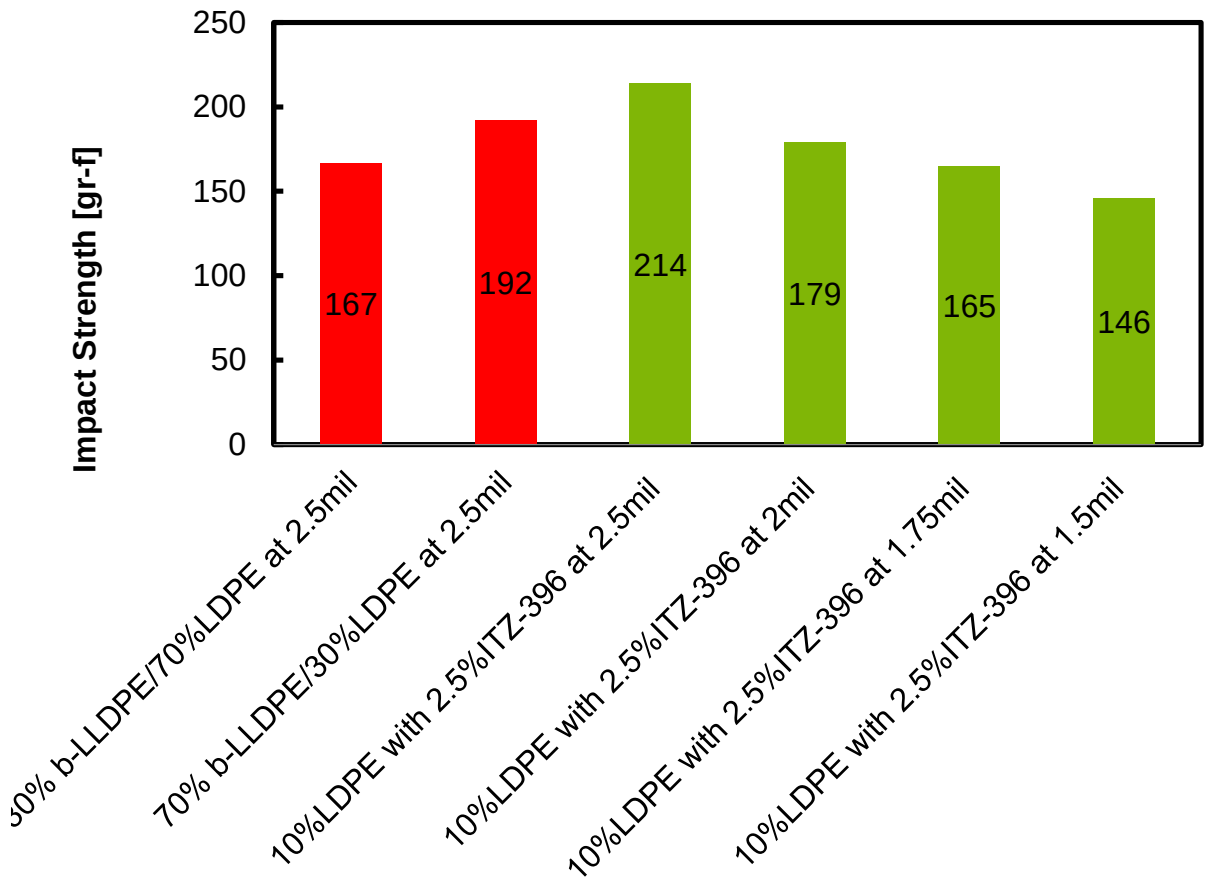
Down Gauging Opportunity with 10% LDPE





- 20% gauge reduction is possible without sacrificing shrink and impact properties with films containing 2.5% ITZ-396 and 10% LDPE.

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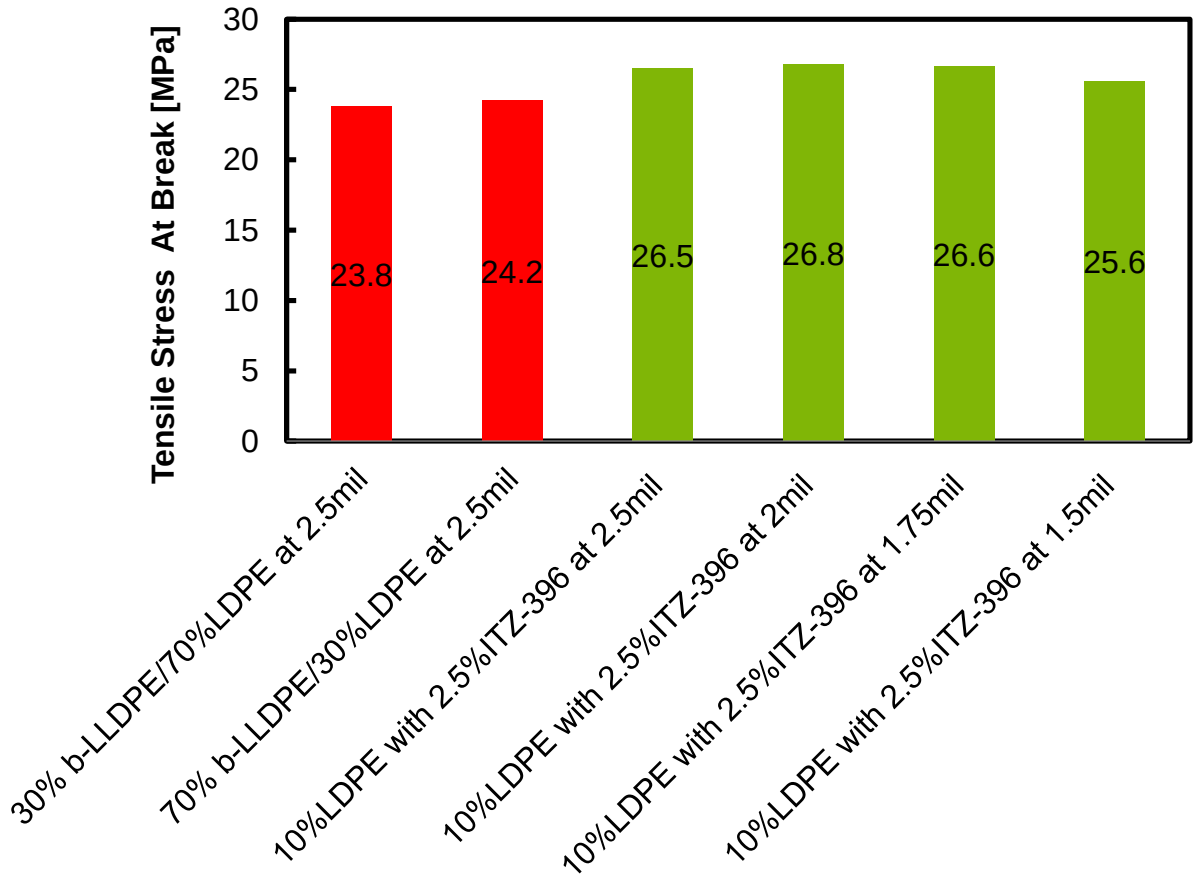
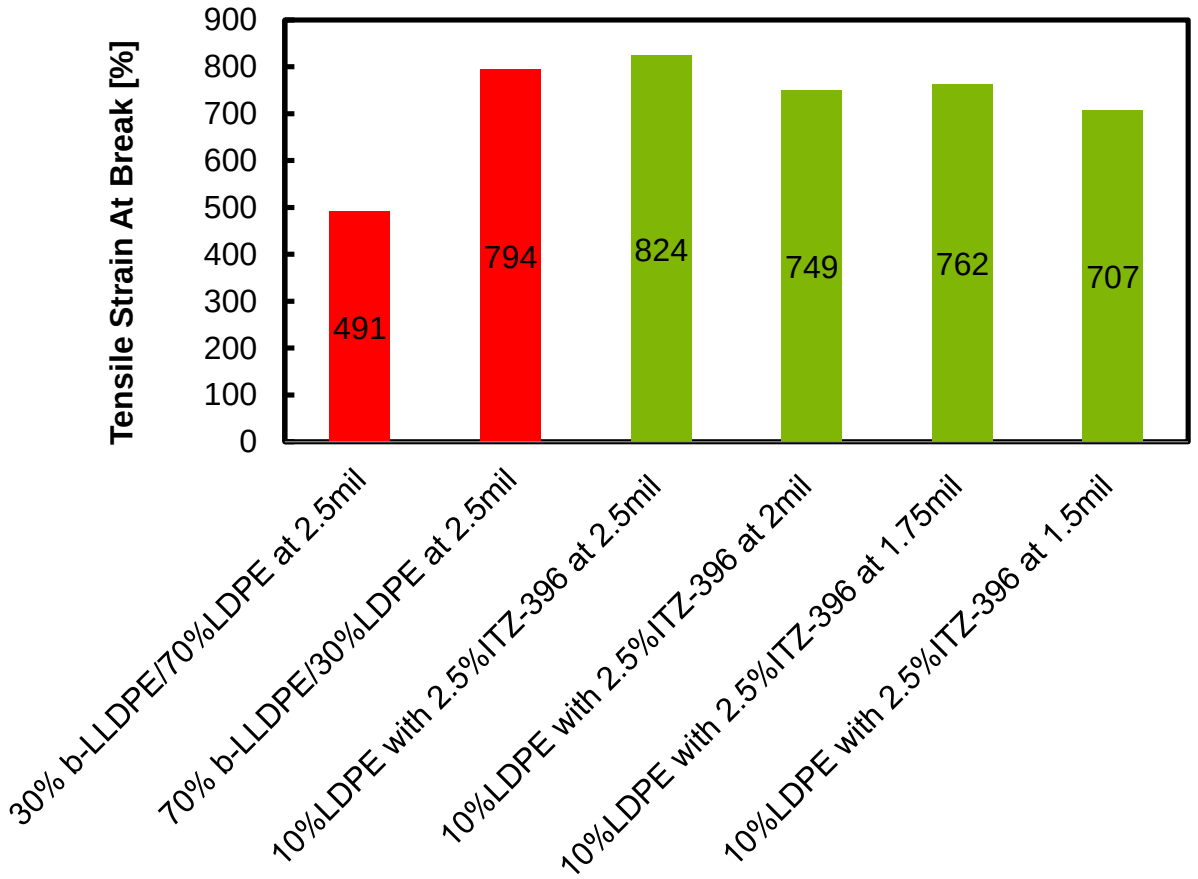
Down Gauging Opportunity with 10% LDPE





- 20 to 30% gauge reduction is possible without sacrificing tensile properties with films containing 2.5% ITZ-396 and 10% LDPE.

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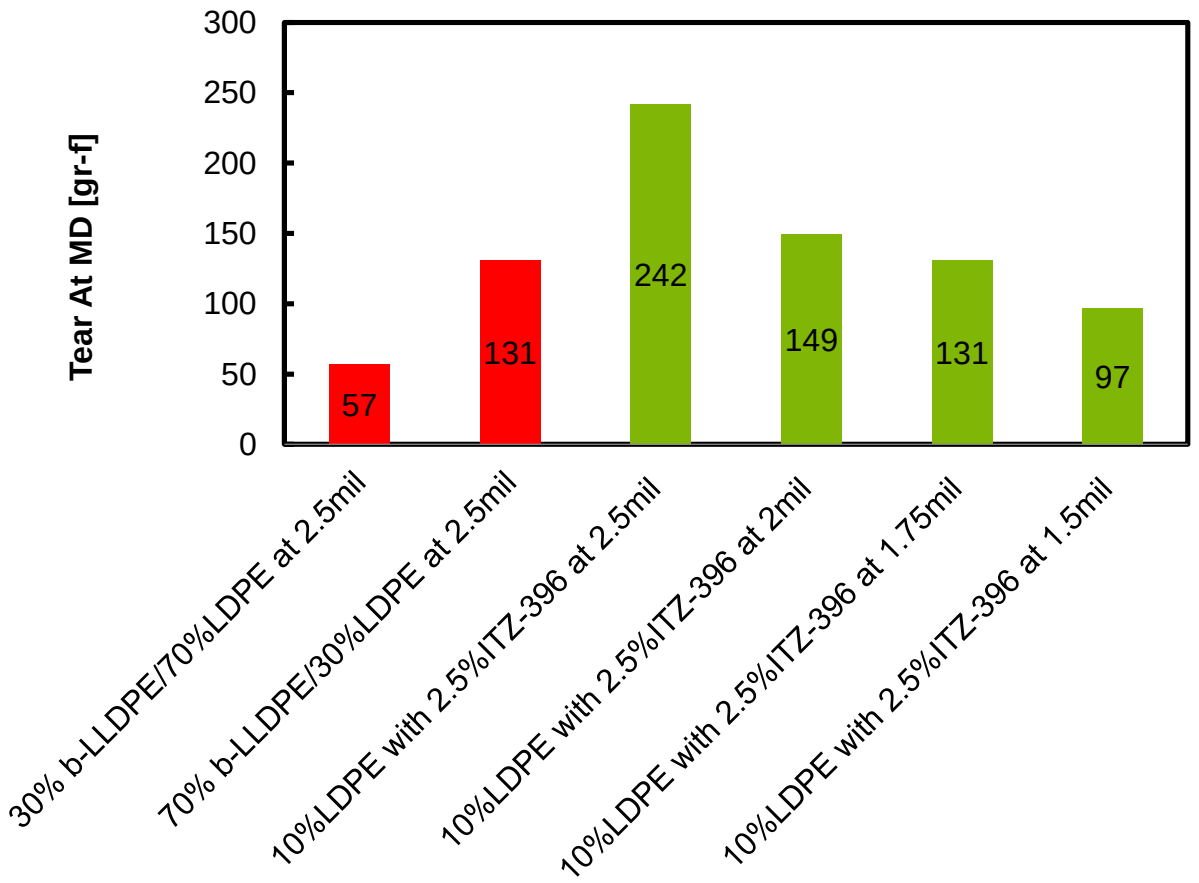
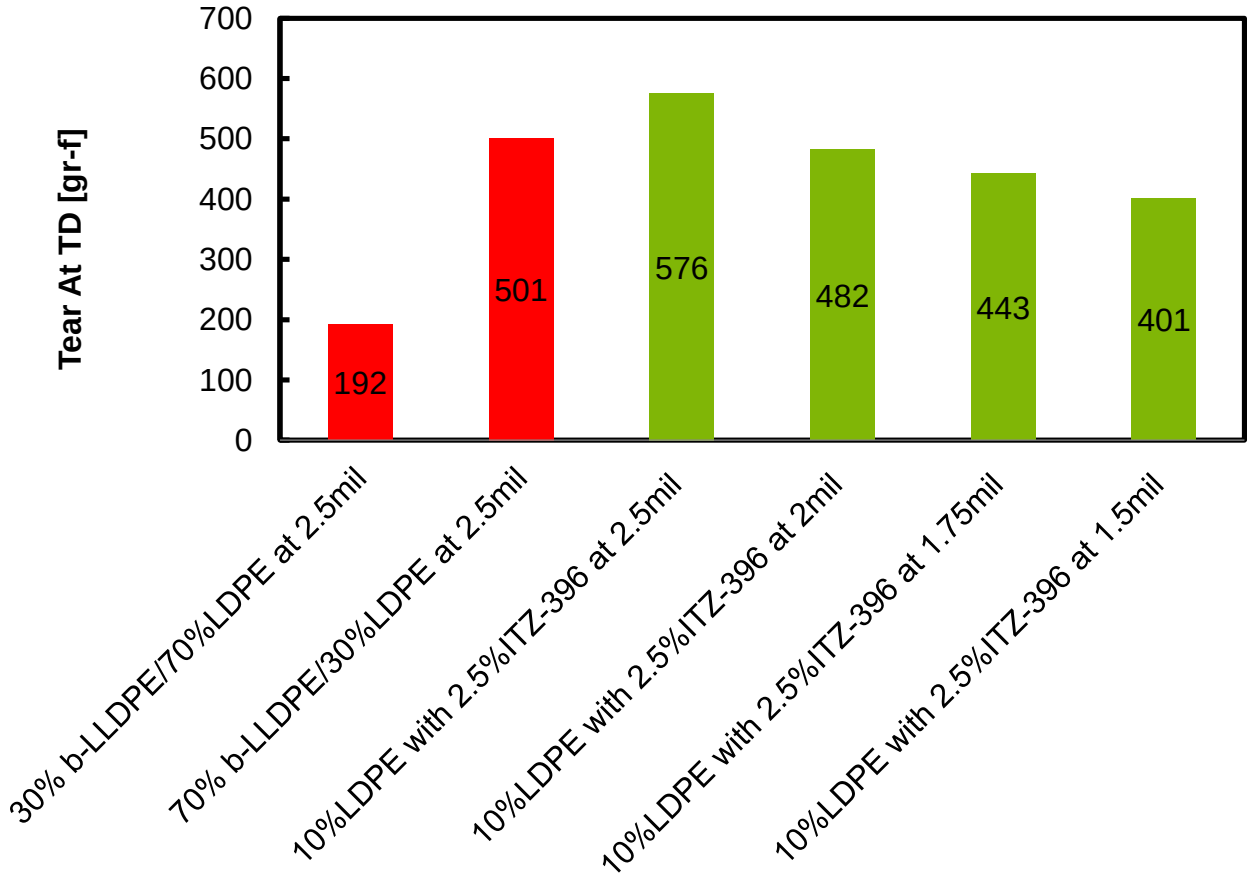
Down Gauging Opportunity with 10% LDPE





- 20 to 30% gauge reduction is possible without sacrificing tear properties with films containing 2.5% ITZ-396 and 10% LDPE.

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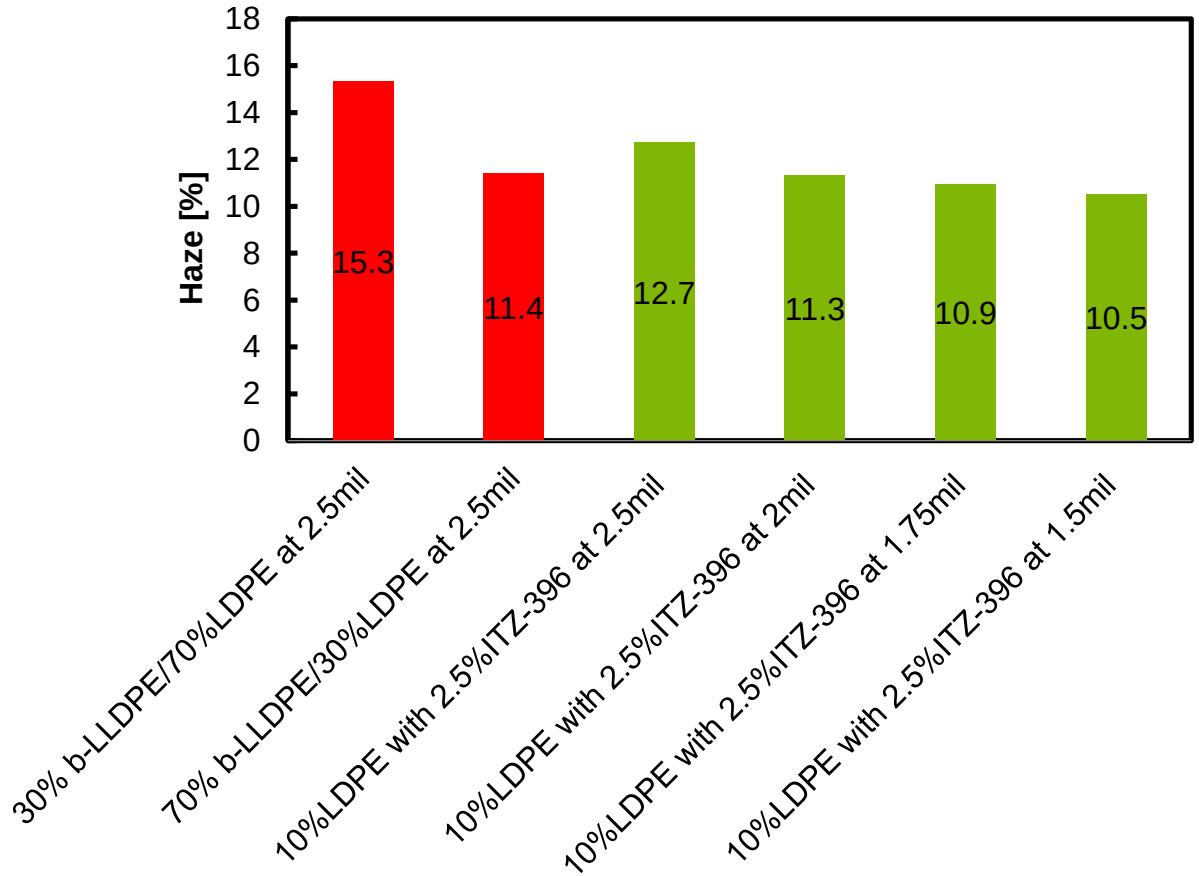
Down Gauging Opportunity with 10% LDPE



- With 20% gauge reduction, haze properties of LLDPE/ITZ-396 films become similar to standard LDPE/LLDPE blends.

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Summary of Down Gauging Opportunity

- There is a minimum of 20% gauge reduction opportunity for films containing ITZ-396 without sacrificing:
    - Shrink Properties
    - Tensile Properties
    - Impact Properties
    - Tear Properties

- The negative effect of ITZ-396 on haze is minimized with 20% gauge reduction.

- Gauge reduction further minimizes the potential for any cutting issue when films are cut prior to entering shrink tunnel.

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Summary of Trial Experience vs. LDPE Rich Blends

- Improved shrink properties are obtained with INABLE ITZ-396 in LLDPE.
- Improved impact, tensile and tear properties are obtained with INABLE ITZ-396 in LLDPE.
- Haze increases with the addition of INABLE ITZ-396, need to monitor specific packaging applications to ensure acceptable. However, thinner films are now possible, so haze impact can be minimized.
- Savings on total film cost due to reduced resin costs with **LLDPE versus LDPE.**
- Since the mechanical and shrink properties are much better than LDPE rich blend films, **down-gauging leads to further total film cost savings.**
- Improved mechanical properties allows for potential use of recycle content at same gauge.
- **Sustainable** product choice (less film per kg of product pkg'd) & **FDA compliant**

- Note - Material Transfer/Confidential Disclosure Agreement is required prior to sample release of ITZ396 product.

Shrink Film Cost Benefit Analysis

- Film recipe material cost assumption = 60cpp
- Gauge reduction of 20% = 12cpp material cost save
- Gauge reduction of 30% = 18cpp material cost save

- ITZ-396 cost = 2.50USD/LB
- Use at 2.5% LDR = 6cpp additional material cost

- Range of expected film cost savings = 6 to 12cpp

- **At 9cpp cost save, if process 1 MM lb of shrink film = 90,000 USD savings**

- **At 9cpp cost save, if process 10 MM lb of shrink film = 900,000 USD savings**

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TRIAL RECOMMENDATIONS

To provide recommendations for your trials using ITZ-396 the following information regarding your application is required:

- What is the LDPE-LLDPE ratio used in current product?
- What type of LLDPE are you using? Octene, hexene or butene.
- What is the grade name of LLDPE?
- What is the MI of LLDPE?
- What is the MI of LDPE?
- What is the running conditions for base film? Temperature, RPM and BUR.
- What is the film application?

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