Key Considerations for Today’s Collation Shrinkable Film Packaging

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Presentation Goals and Content

• Market Introduction
• Heat Shrinkable Collation Film Principles
• Processing Considerations
• Packaging Considerations
• Three-Tiered Shrink Film Proposal
• Examples of Varied Performance Levels (data)
Market Reflections – US Shrink Market

• Total Shrink Market estimated at 800 mm lbs. consumption per year (NOVA Chemicals estimate – various internal sources)
• Annual growth – 3% estimated
• Potential Emerging Applications:
  • E-commerce Applications
  • Canned specialty drinks
  • Beer can collation wrap

Shrink Film Market Estimates

- 45%: Biaxially Oriented Polyethylene Shrink Films
- 40%: High Performance Collated Shrink Films
- 15%: Commodity and Industrial Shrink Films

Note: Thoughts expressed by the author are the opinions of the author based on a variety of sources and NOVA Chemicals' internal opinions.
The Shrink Packaging Triangle

Each phase of Production – Critical to End-Use Performance

Blown Film Line – Simplified Model

Transverse Direction

Machine Direction

Blown Film Bubble

Shrink Film Process/Performance Linkage

Heating Element

Blown Film Line – Simplified Model

Shrink Wrapper & Heated Shrink Tunnel
Shrink Packaging Relationships

End-Use Package

- Extrusion Conditions
- Shrink Tunnel Influences
- CoEx Layer Ratio
- Resin Type Selection
- Film Density
Envisioning Shrinkage in Collation Shrink Films

- **Blow-up Ratio** is key to correct orientation balance (machine-direction vs transverse direction)
- **Bubble Cooling** – chilled-air freezes molecules in an elongated stressed position (Solid Film with potential shrink energy)
- **Shrink Film Reheating** – allows the molecules to relax/contract – Partial relief of internal stresses

1) Molecules possess potential energy as they are oriented in an unnatural position, during the film blowing process…
2) When reheated in a shrink tunnel, shrink film gains molecular chain mobility, relaxes and contracts or shrinks
Collation Shrink – Negotiating Stiffness/Toughness Balance

What properties are needed in a shrink film?

- **Low stiffness, low toughness**, low shrink tension
- **High stiffness, high toughness**, high shrink tension
- **High stiffness, low toughness**, improved film cutting, medium shrink tension
- **Low stiffness, high toughness**, moderate shrink tension

Stiffness 1%

Secant Modulus

Resin Density

Highest Toughness

Lowest Toughness

Higher Melt Index (MI) LDPE

Lowest MI LDPE

Butene LLDPE

Hexene LLDPE

Octene LLDPE

- **Lowest Toughness**
- **Lowest MI LDPE**
- **Butene LLDPE**
- **Hexene LLDPE**
- **Octene LLDPE**

Higher Melt Index (MI) LDPE
### Basic 3-Layer Collation Shrink Design

<table>
<thead>
<tr>
<th>Material</th>
<th>Suggested Location</th>
<th>Purpose</th>
<th>Layer Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fractional melt index LDPE</td>
<td>Core layer</td>
<td>Shrink energy and speed</td>
<td>30-50% Core</td>
</tr>
<tr>
<td>MDPE</td>
<td>Core layer</td>
<td>Stiffness and toughness</td>
<td>20-30% Core</td>
</tr>
<tr>
<td>HDPE</td>
<td>Core layer</td>
<td>Stiffness</td>
<td>20-30% Core</td>
</tr>
<tr>
<td>Clarity sLLDPE</td>
<td>Skin Layers</td>
<td>Toughness and Optics</td>
<td>100% of Inner and Outer</td>
</tr>
</tbody>
</table>

15/70/15 Layer Ratio Coex Shrink Film Example
Collation Shrink – Pack Considerations

- Machine direction generally is applied around longest side
- Machine direction - Critical for holding force – Typically (60-80% MD% air shrink)
- Transverse direction – Pulls slack across pack and ensures a fully formed bullseye end for pack (0-20% TD% air shrink)
- Forming around bottle contours, caps etc important for package integrity
- Bullseye size – constrain articles during handling
- Non-wrinkled bullseye edge, minimal shoulder wrinkles
- Adequate tensile yield at the bullseye
More heat is not always better…..

Optimize heat and conveyer speed

Shrink Tunnel Optimization (Model for Illustration Purposes Only)

Optimizing Shrink Packaging Force in Shrink Tunnel

- Highest shrink force for best package

- Shrink Force MD (kg)

- Shrink Percentage MD (%)
Collation Shrink Packaging Considerations

Example: Collation Bottle Shrink Overwrap

6 Pack - No Cardboard

12 Pack - Cardboard Bottom Sheet

18 Pack - Cardboard Bottom Sheet

24 Pack - 35 Pack Cardboard Tray
Collation Shrink – Object Geometry Considerations

Conventional vs. Nested

Pad restricts film coverage around bottles

- Staggered/Nested object, pack-geometry
- Stabilizes objects significantly (with a 3-point contact)
- Versus standard rectangular packs much more solid
- Reduces packaging (corrugated trays and pads)
- Increased opportunity for interlocking packs for more stable skids

- Film-only format
- Unrestricted by pads or trays
- Shrink film forms to the voids, creates an egg carton effect
- Far superior shrink pack (relative to conventional)
<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Level</td>
<td>Lower pack weight, clear packs, for Economy and Performance</td>
</tr>
<tr>
<td>Mid Level</td>
<td>Medium pack weight, versatile offering for Consumer and Grocery multi-packs</td>
</tr>
<tr>
<td>High Level</td>
<td>Larger Pack weight, Branded Product, Emerging printed pack formats</td>
</tr>
</tbody>
</table>
Collation Shrink Grades - Three Tiered Performance

<table>
<thead>
<tr>
<th>Product Designation</th>
<th>Nominal Melt Index (dg/min)</th>
<th>Density g/cc</th>
<th>Description</th>
<th>Grade Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.3</td>
<td>0.920</td>
<td>Homopolymer LDPE</td>
<td>NOVAPOL® LF-Y320-A</td>
</tr>
<tr>
<td>B</td>
<td>0.8</td>
<td>0.919</td>
<td>Butene LLDPE</td>
<td>NOVAPOL PF-Y818-BPX</td>
</tr>
<tr>
<td>C</td>
<td>0.8</td>
<td>0.926</td>
<td>Butene MDPE</td>
<td>NOVAPOL PD-3547-FP</td>
</tr>
<tr>
<td>D</td>
<td>0.8</td>
<td>0.934</td>
<td>Hexene MDPE</td>
<td>SCLAIR® TF-Y534-IP</td>
</tr>
<tr>
<td>F</td>
<td>1.0</td>
<td>0.916</td>
<td>Octene sLLDPE</td>
<td>SPs116-C</td>
</tr>
<tr>
<td>G</td>
<td>1.0</td>
<td>0.958</td>
<td>Homopolymer HDPE</td>
<td>SCLAIR 19K</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Performance Level</th>
<th>15% Skin Layer</th>
<th>70% Core Layer</th>
<th>15% Skin Layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Level</td>
<td>100% Resin B</td>
<td>40% resin A / 60% <strong>Resin C</strong></td>
<td>100% Resin B</td>
</tr>
<tr>
<td>Mid-Level (Variation 1)</td>
<td>100% <strong>Resin F</strong></td>
<td>40% Resin A / 30% <strong>Resin C</strong> / 30% <strong>Resin G</strong></td>
<td>100% <strong>Resin F</strong></td>
</tr>
<tr>
<td>High Level</td>
<td>100% resin F</td>
<td>40% Resin A / 30% <strong>Resin D</strong> / 30% <strong>Resin G</strong></td>
<td>100% Resin F</td>
</tr>
</tbody>
</table>
## Proposal for Three Tiered Performance Levels

### Three Tiered Performance Level Examples

<table>
<thead>
<tr>
<th>Property</th>
<th>Base Level</th>
<th>Mid Level</th>
<th>High Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normalized Dart Impact (g/micron/g/mil)</td>
<td>4.0/101</td>
<td>4.3/109</td>
<td>3.9/100</td>
</tr>
<tr>
<td>1% Secant Modulus Machine Direction MD (Mpa)</td>
<td>248</td>
<td>264</td>
<td>349</td>
</tr>
<tr>
<td>1% Secant Modulus Transverse Direction TD (Mpa)</td>
<td>266</td>
<td>311</td>
<td>280</td>
</tr>
<tr>
<td>Calculated Composite Film density (g/cc)</td>
<td>0.922</td>
<td>0.931</td>
<td>0.933</td>
</tr>
<tr>
<td>Tensile Yield Strength MD (Mpa)</td>
<td>13</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>Tensile Yield Strength TD (Mpa)</td>
<td>14</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>Haze (%)</td>
<td>8</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>Puncture (J/mm)</td>
<td>33</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Average Film Thickness (microns/mils)</td>
<td>58.4/2.3</td>
<td>58.4/2.3</td>
<td>55.9/2.2</td>
</tr>
</tbody>
</table>
Increasing film composite density skews percent shrink activation temperature higher as a function of melting point.
Applied Package Shrink Force by Proposed Performance Level

- **Base Level Shrink Film**
- **Mid-Level Shrink Film**
- **High Performance Shrink Film**

Conveyor Speed (Feet Per Minute) vs. KG Force
Key Technical Points

• Extrusion processing conditions: (E.g. Blow-up ratio) and suitable resin selection are important in Collation shrink production

• Considerations: degree of shrink force, product weight, life cycle handling, product geometry, printing requirements, die sizing (printing considered)

• Sustainable Packaging: Where possible create shrink film pack designs that eliminate packaging supports like pads and trays to reduce packaging weight and volume

• Companion Resins: Various linear-backbone companion resins in sLLDPE, LLDPE, MDPE and HDPE can be used to enhance properties and performance

• Long Chain Molecular Branching: LDPE is needed for shrink energy and rate of shrink

• Three Tiered Product Portfolio: for shrink film offerings to service the marketplace - Avoid customization where possible for production efficiencies sake…
Collation Shrink Summary

Collation Shrink Packaging Films are:

• Well-positioned for non-traditional growth opportunities in a changing world (e-commerce, canned specialty drinks, canned beer)

• Suitable for material replacement - weight reductions by a factor of 10* (relative to cardboard or rigid polyethylene) - Shipping weights down

• High Recycle Potential -100% polyethylene films

• Raw Material Fixed Cost Savings - (E.g: polyethylene vs cardboard)

• Ideal surface for print graphics

• Excellent Product Branding - viewing window potential

• Reduction in secondary packaging (E.g: slip pads and trays)
Acknowledgements
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