Highly Efficient LDPE Resins for Extrusion Coating Applications

Presented by:
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Development Leader
The Dow Chemical Company

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Agenda

~ Introduction to the extrusion coating market and performance needs

~ Technical preference for autoclave type LDPE

~ Availability of LDPE

~ What new tubular grades of LDPE offer in performance

~ Conclusions & Future
Introduction

1. Extrusion coating provides for the enhancement of substrates
2. Autoclave LDPE has been the most commonly applied material for over the past 50 years

<table>
<thead>
<tr>
<th>Convertor</th>
<th>End Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>★ Processability</td>
<td>Sealability</td>
</tr>
<tr>
<td>★ Melt Strength</td>
<td>Barrier (WVTR)</td>
</tr>
<tr>
<td>Availability</td>
<td>Strength, Toughness</td>
</tr>
<tr>
<td>Cost Effectiveness</td>
<td>Adhesive Bonding</td>
</tr>
<tr>
<td></td>
<td>Organoleptics</td>
</tr>
</tbody>
</table>
Autoclave vs Tubular LDPE
Molecular weight distribution of an autoclave produced LDPE vs one produced on a conventional tubular asset.
LDPE Availability in North America
North American autoclave start up year

1954
1960
1965
1966
1968
NA LDPE Balances (‘14 to ’19)

2014 LDPE Balances

- Tubular: 57%
- Autoclave: 43%

Projected 2019 LDPE Balances

- Tubular: 68%
- Autoclave: 32%

6.8 B lbs

9 B lbs

Data source: Townsend Solutions, Global PE Demand 2014
LDPE: *Advanced Tubular vs Traditional Autoclave Performance*
Autoclave vs Tubular LDPE

Molecular weight distribution of autoclave produced LDPE vs one produced on a conventional tubular asset and one on an advanced tubular asset.
## Comparative Examples

<table>
<thead>
<tr>
<th>LDPE</th>
<th>Type</th>
<th>MI (g/ 10min)</th>
<th>Density (g/ cc)</th>
<th>Notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dow LDPE 722</td>
<td>Autoclave</td>
<td>8.0</td>
<td>0.918</td>
<td>AC918</td>
</tr>
<tr>
<td>Dow LDPE 5004I</td>
<td>Autoclave</td>
<td>4.2</td>
<td>0.924</td>
<td>AC924</td>
</tr>
<tr>
<td>Dow LDPE 5005</td>
<td>Autoclave</td>
<td>5.7</td>
<td>0.922</td>
<td>AC922</td>
</tr>
<tr>
<td>AGILITY ™ EC 7000</td>
<td>Adv. Tubular</td>
<td>3.9</td>
<td>0.919</td>
<td>EC919</td>
</tr>
<tr>
<td>Competitive 1</td>
<td>Adv. Tubular</td>
<td>5.0</td>
<td>0.918</td>
<td>CT918</td>
</tr>
<tr>
<td>Competitive 2</td>
<td>Adv. Tubular</td>
<td>5.0</td>
<td>0.919</td>
<td>CT919</td>
</tr>
<tr>
<td>Dow LDPE PG 7008</td>
<td>Autoclave</td>
<td>7.7</td>
<td>0.918</td>
<td>EU918</td>
</tr>
</tbody>
</table>
Calculated Rheology curves, 320°C

- EC919 (Adv. Tubular)
- AC924
- AC918

Viscosity (Pa·sec) vs. Shear Rate (1/sec)
Processability Comparison

Advanced tubular LDPE will process similarly to autoclave grades.

**Back Pressure (psi)**

- AC918: 1200 psi
- AC924: 1000 psi
- EC919 (Adv. Tubular): 800 psi
- AC922: 600 psi

**Horsepower**

- AC918: 30 horsepower
- AC924: 25 horsepower
- EC919 (Adv. Tubular): 20 horsepower
- AC922: 15 horsepower

**Amps**

- AC918: 140 amps
- AC924: 120 amps
- EC919 (Adv. Tubular): 100 amps
- AC922: 80 amps
Neck-In Comparison

Similar Neck-In performance of advanced tubular LDPE to traditional autoclave resins.

Neck-In (inches)\(^1\)

\[\text{Neck-In} = x - y\]
Lower is better

1 Set temp 600°F, 1 mil 440 fpm

\(^1\) Set temp 600°F, 1 mil 440 fpm
Drawdown Comparison

**Drawdown (fpm)**

- **AC918**
- **AC924**
- **EC919** (Adv. Tubular)
- **AC922**

- **Polymer Curtain Breaks**
- **Substrate**

- Draw down = tearing speed
  - Higher is better

1 Ramping with frozen output until web breaks
Minimum coat weights

Improvement in drawdown ability of Adv. Tubular (EC919) over conventional autoclave grades, could allow for a wider process window and/or use less material.
Several more Advanced Tubular Grades vs Standard Autoclave Performance
Comparison of Tubular Grades Available in Europe

**Neck-In (mm)**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Neck-In (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EC919</td>
<td>0</td>
</tr>
<tr>
<td>CT918</td>
<td>100</td>
</tr>
<tr>
<td>CT919</td>
<td>150</td>
</tr>
<tr>
<td>EU918</td>
<td>200</td>
</tr>
</tbody>
</table>

1. Set temp 320°C with 15 g/m² & 100 m/min.

**Drawdown (mpm)**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Drawdown (mpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EC919</td>
<td>500</td>
</tr>
<tr>
<td>CT918</td>
<td>400</td>
</tr>
<tr>
<td>CT919</td>
<td>300</td>
</tr>
<tr>
<td>EU918</td>
<td>600</td>
</tr>
</tbody>
</table>

2. Ramping until instability or break with frozen output at 15 g/m² and 100 m/min.

Data source: Dow Europe GmbH – Technical Center Horgen
Conclusions

New advanced tubular extrusion coating LDPEs are capable of meeting and exceeding the performance targets of conventional autoclave LDPEs

Dow AGILITY™ technology delivers a sustainable tubular LDPE solution to the aging autoclave LDPE asset base while enabling higher coating speeds at lighter coating weights

Be on the look out for an extended portfolio of AGILITY™ grades to meet your additional LDPE needs, including: Ultra high speed extrusion processing, and high melt strength blends particularly with mLLDPE
Acknowledgement

Jim Cooper (Co-Author) – Development Leader
Bernard Fehr – Principal Scientist
Heather Turner – Market Development Manager
Gabe Ayala – Sr. Research Technologist
Garrett Garcia - Technologist
THANK YOU

For more information or to discuss your application, please feel free to contact us:

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