High Performance Extrusion Coating EVA with Low Temperature Activation

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Learning Outcomes

- Introduce AT Plastics, div of Celanese
- Understand the effects of increasing %VA content in EVA resins
- Specifically compare the adhesion performance of 16% VA and 28% VA lamination films
- Troubleshoot typical difficulties encountered when extrusion coating EVA’s with very high %VA content
AT Plastics, div of Celanese

- **Celanese** ([www.celanese.com](http://www.celanese.com))
  - $6 Billion diversified chemical company with many JVs in China

- **AT Plastics’ Facility in Alberta, CANADA**
  - Five High Pressure Autoclave Reactors
    - 145 kt annual capacity (EVA & LDPE)

- **Focus on Specialty Polymers (LDPE & EVA)**
  - LDPE with melt index up to 2200
  - EVA grades from 6% VA to 40% VA

- **Excellent access to rail and ship ports**
  - Ship to Asia from Port of Vancouver

- **Technical Service Centre**
  - Located in state of the art Celanese facility in Kentucky, USA

- **Represented in China by Cahota**
Introduction

What is Thermal Lamination Film?
- Step 1: LDPE or EVA is extruded onto substrate film (nylon, PET, BOPP)
- Step 2: Film laminated to substrate stock
  - E.g. posters, school products, signs, book covers

EVA is the established adhesive resin in the thermal lamination market
- Versatile adhesion
- Good processability
- High gloss
- Typically 15-18% vinyl acetate content
The EVA Copolymer Structure

~~CH₂-CH₂-CH₂-CH-CH₂-CH₂-CH₂-CH₂-CH₂-CH₂-CH₂~~
Polymer Chain Branching in EVA’s

- Long chain branching (LCB)
- Short chain branching (SCB)

Net effect: Reduced crystallinity with increasing %VA (SCB)
Effect of Increasing % of VA

Polymer properties:
- More short chain branching
- Less crystalline
  (More amorphous)
- Lower melt temperature
- More elastic as solid
- Greater flexibility
- Higher clarity and gloss
- Higher density
  *(VA unit weighs more than Ethylene unit)*
- Increased polarity
  *(VA more polar than ethylene)*
- Increased toughness
Effect of Increasing % of VA

**Application properties:**
- Better adhesion to polar substrates
  - Aluminum Foil
- Increased tackiness (Coeff of Friction)
  - “Blocking” - Pellets may stick together in a warm environment or under a heavy load
  - Wound film blocking concerns
    - Need good tension control
    - Molten resin sticking to chill rolls

**Lower seal initiation temperature**
- Due to lower melt temperature and softening point

**Increased tendency to degrade or form gels during extrusion**
- Generates acetic acid and “vinegar” odour
- Acetic acid promotes crosslinking and gels
# Property comparison 16% & 28% VA

<table>
<thead>
<tr>
<th>EVA Property</th>
<th>16% VA</th>
<th>28% VA</th>
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</thead>
<tbody>
<tr>
<td>Density</td>
<td>936 kg/m³</td>
<td>948 kg/m³</td>
</tr>
<tr>
<td>DSC Melt Temp</td>
<td>89 °C</td>
<td>70 °C</td>
</tr>
<tr>
<td>VICAT Soften Temp</td>
<td>62 °C</td>
<td>43 °C</td>
</tr>
<tr>
<td>Tensile strength</td>
<td>9 MPa</td>
<td>8 MPa</td>
</tr>
<tr>
<td>Elongation</td>
<td>700%</td>
<td>850%</td>
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</tbody>
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Materials

Lamination Films:
- Thermal Lamination Film from two suppliers
  - EVA extrusion coated on primed PET and corona treated

Two Extrusion Coating Resins
- Ateva® 2821A = 28%VA, 25MI → call it 28
- Ateva® 1641 = 16%VA, 28MI → call it 16

Supplier “K” Structures: 0.25 mm PET/ 0.5 mm EVA
- 16K dynes=42 CoF=1.2
- 28K dynes=42 CoF=1.5

Supplier “L” Structures: 0.25 mm PET/ 1 mm EVA
- 16L dynes=44 CoF=1.1
- 28L dynes=44 CoF=2.6
Materials

**Substrates:**
- Glossy paper substrates
- Offset Ink (solid print)
- Soy-based ink (solid print)
- Prints were about 1 month old and sealed in foil pouch
Heat Seal Activation Comparison

**Method:**
- Heat seal film adhesive to adhesive
- 10 mm heat seal bars
- 138 kPa, 0.5 sec dwell
- Vary temperature from 71-127 °C
- Cut 2.5 cm strip and peel 180° on tensiometer @ 27 mm/min
Heat Seal Activation – 16% & 28% VA

Heat Seal Initiation
Average Peel Strength

Supplier K Film: 0.25 mm PET/0.5 mm EVA
Heat Seal Activation – 16% & 28% VA

Heat Seal Initiation
Average Peel Strength

Supplier L Film: 0.25 mm PET/ 1 mm EVA
**Optical Property Comparison**

**Method:**
- Heat seal film adhesive to adhesive
- Measure 45° gloss at surface of sealed structure
  - Although mainly influenced by PET gloss, adhesive resin has an effect
- Measure haze through sealed structure
- Two temperatures selected
  - Common lamination temperature for 28% EVA ~93°C and for 16% EVA ~115°C
Heat Seal Gloss Comparison

Optical Properties - Gloss

- 16K
- 28K
- 16L
- 28L

Temperature (°C)

45° Gloss

93 116

Temperature (°C)
Heat Seal Haze Comparison

Optical Properties - Haze

Temperature (°C)

Haze (%)

- 16K
- 28K
- 16L
- 28L

Heat Seal Haze Comparison
**Adhesion to Printed Substrates**

**Method:**
- Desktop pouch laminator
  - Constant speed and pressure
  - Vary temperature from 71-127 °C
- Samples then peeled 1 hour after the lamination
- Cut 25 mm strip and peel on tensiometer 127 mm/min
  - 180° Peel Configuration
  - Max. load and average load between limits recorded
  - Peel strength reported in N/25 mm

0-5 = poor, 5-10 = fair, 10-15 = good, 15+ = excellent
Results on offset ink

Supplier K Film: 0.25 mm PET/0.5 mm EVA
Results on offset ink

Offset Ink Print

Adhesion (N/25 mm)

Temperature (°C)

Supplier L Film: 0.25 mm PET/1 mm EVA
Results on soy-based ink

Soy-ink Print

Adhesion (N/25 mm) vs Temperature (°C)

Supplier K Film: 0.25 mm PET/0.5 mm EVA
Results on soy-based ink

Soy-ink Print

Temperature (°C)

Adhesion (N/25 mm)

93

16L

116

28L

Supplier L Film: 0.25 mm PET/1 mm EVA
**Processing Guidelines for 28% EVA’s**

- **Extrude 28% EVA’s at lower temperature**
  - Melt Temp for 16% EVA’s typically 225 °C
  - Melt Temp for 28% EVA’s recommended at 215 °C
    - To minimize gels after long run times

- **Minimize Chill Roll Sticking**
  - **Heat of melt** - Could reduce melt temperature. However, watch for lowered adhesion properties.
  - **Temperature of chill roll** - Reduce chill roll temperature. Watch for condensation.
  - **Efficiency of chill roll** - Should use purified water to prevent fouling. Check for fouled water system.
Minimize Chill Roll Sticking

- **Degree of wrap around chill roll** - More wrap will allow more cooling. However, if too much wrap around, chill roll water does not have time to recover, and gradually warms up. ("recovery time of chill roll")
- **Angle of pull-off** - steeper angle may help
- **Chill roll release agent in resin** - Not usually used because of adhesion. Acts like slip agent, and migrates to interface.
- **Overcoat width** - Sometimes resin is overcoated beyond edge of substrate film. Reduce if possible.

Minimize Wound Roll Blocking

- Careful control of tension
- Can use lower tension because of higher surface tack
Concluding Remarks

- Difference in melt/softening temperature: 20 °C
- Difference in heat seal activation: 8 °C
  - MI difference may play a role
  - Adhesive thickness plays a role in bond strength

Optical properties of 28% EVA superior to 16% EVA at 93 °C
  - Just above melt temperature of 16% EVA at 93°C

Optical properties similar at 115 °C
  - Optical properties depend on quench rate
  - Fast solidification of melt allows less time for crystallization
  - Less crystallinity results in better gloss and lower haze
**Concluding Remarks**

- **Adhesion to offset ink**
  - Both 16% EVA and 28% EVA adhesion improves with increasing temperature
  - 28% EVA superior to 16% EVA at each temperature

- **Adhesion to soy ink**
  - Increasing temperature improved adhesion for each film
  - 16% EVA adheres better at 115 °C
  - 28% EVA adheres better at 93 °C but no advantage over 16% EVA at 115 °C
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