Using Primers in Combination With Adhesive Tie-Layer Resins, or Their Blends, to Make Structures with Unique Performance

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Objectives

- *In co-extruded structures*: primers can significantly enhance performance.

- *In mono-layer extrusions with primers*: low levels of tie-layers blended into conventional extrusion resins can produce structures with outstanding properties.
Previous Work

- **Tie Layer:**

- **Coextruded Tie Layer + Primer:**
What is an Adhesive Tie-Layer?

• Functionalized polymer designed to adhere to two different surfaces
• Usually co-extruded with a commodity resin.

LDPE
Co-extruded ethylene acrylic acid copolymer (Tie Layer)
Aluminum
Tie-Layer Compositions

- Backbone is usually a typical extrusion resin:
  - Polyethylene
  - Ethylene copolymers
  - Polypropylene
- Functional groups are often:
  - acrylic acid
  - methacrylic acid
  - glycidyl ether (epoxy)
  - maleic anhydride
What is a Primer?

- Surface modifying coating applied to substrate.
- Bonds well to both substrate and extrudate.
With PE, Oxidized Surface Required for Good Bond Strength

Polyethylene extruded at 260°C.
No oxidation, poor adhesion.

Polyethylene extruded at 315°C.
Surface oxidation, good adhesion.

Covalently bonds with primer.

\[ \text{OH} \quad \text{CHO} \quad \text{CO}_2\text{H} \]
Effect of Primer and Extrusion Temperature on Bond Strength of LDPE/PET Structure.
Tie-Layers Have Built-in Functional Groups.

...So no oxidation is needed with tie-layers to form strong bonds with primers.
### Tie-Layers Used in This Study

<table>
<thead>
<tr>
<th>Code</th>
<th>Supplier</th>
<th>Grade</th>
<th>Composition</th>
<th>Tm (°C)</th>
<th>MI or MFR (g/10 min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TL-L1</td>
<td>Arkema (Atofina)</td>
<td>Lotader 3410</td>
<td>Ethylene-vinyl acetate (18%) – maleic anhydride (3%)</td>
<td>95</td>
<td>5 MI</td>
</tr>
<tr>
<td>TL-L2</td>
<td>Arkema</td>
<td>Lotader 3210</td>
<td>Ethylene-vinyl acetate (6%) – maleic anhydride (3%)</td>
<td>107</td>
<td>5 MI</td>
</tr>
<tr>
<td>TL-B1</td>
<td>DuPont</td>
<td>Bynel 50E803</td>
<td>Polypropylene-g-maleic anhydride (MAH = “high”)</td>
<td>135</td>
<td>450* MFR</td>
</tr>
<tr>
<td>TL-B2</td>
<td>DuPont</td>
<td>Bynel 50E739</td>
<td>Polypropylene-g-maleic anhydride (MAH = “low”)</td>
<td>142</td>
<td>6 MFR</td>
</tr>
</tbody>
</table>

* Calculated
Tie-Layer L1 and L2 in Polyethylene
Extruded Polyethylene

- Requires extrusion at high temperature (>315°C) for oxidation.
- May extrude better at lower temperatures.
- May affect taste and odor.
Effect of Primer on Adhesion to Aluminum of TL-L2 and its LDPE Blend.

Extruded at low temperature, 260°C
Water Resistance

100% TL-L1/primer/aluminum

Bond Strength (N/15mm) vs. Time in Water (hrs.)
Water Resistance

**Blend of 30% TL-L1 in LDPE/primer/aluminum**

![Graph showing bond strength over time in water for a blend of 30% TL-L1 in LDPE/primer/aluminum.](image)
Effect of Primer on Adhesion to PET of TL-L1 (Extruded at 260°C)
Effect of %TL-L2 in LDPE on Adhesion to PET (Extruded at 260°C)

Only about 10% TL-L2 needed for film tear at LOW extrusion temperature!
Water Resistance:
Blend of 30% TL-L1 in LDPE to PET

![Graph showing bond strength vs. time in water](image-url)
Possible Utility

- Low temperature extrusion of PE
  - Lower taste and odor?
  - Melt viscosity matching in coextrusion
- Enhanced Performance.
- Cost savings?
Tie-Layer L1 in Ethylene Vinyl Acetate
Extruded EVA

- Can generate acetic acid.
- For good bonds with primers, must extruded in presence of ozone.
Coating Thickness vs. Adhesion. Blend of 8% TL-L1 in EVA to PET

Extruded at 230°C with no ozone.
Typical Bond Strength of Various EVA / primer / PET Structures.
Water Resistance of a blend of 8% TL-L1 in EVA (45m) to PET

With Primer

All are EVA Destruct
Bond Strength of EVA/primer/PET Structure After Exposure to 5 days at 70°C and 95%RH.

- EVA + Ozone
- EVA with 8% TL-L1 with no Ozone

Extrudate

Bond Strength (N/15mm)
Water Resistance of a Blend of 8% TL-L1 in EVA (45m) to Aluminum
Possible Utility

- More robust lamination stock.
- EVA extrusions without ozone.
- Enhanced bonding to substrate in lidding.
Tie-Layer B1 and B2 in Polypropylene
Extruded Polypropylene

- Does not oxidize at high temperatures.
- VERY difficult to bond, particularly to plastic film or aluminum foil.
- Limited use in extrusion coating despite excellent properties:
  - Low cost
  - High use temperature
  - High gloss, clarity
  - Grease and chemical resistance
Effect of Primer on Adhesion of 100% TL-B2 to Various Substrates

- Aluminum, Primer G
- PET, Primer A
- Printed Paper, Primer A
- No Primer

Bond Strength (N/15mm)

Tie Layer for Coextrusion:
- Low MAH
- Low MFR
Effect of Primer on Adhesion of 15% TL-B1 in Polypropylene to Various Substrates.

Tie Layer for blending:
- High MAH
- High MFR
Possible Utility

- Clear, glossy, abrasion resistant, grease resistant coating.
  - Ream wrap
  - Pet food bags
- Possible clear steam sterilizable structures made by monolayer extrusion.
Conclusions

Unique, superior or lower cost structures can be made by using primers and:

- Tie-layers in coextrusion.
- Tie-layers / commodity resin blends in mono-layer extrusion.