Celanese Ateva® ExtruBond™ EVA and LDPE Resins: Improved Adhesion Strength for Flexible Packaging & Thermal Lamination Applications

Nagarjuna Palyam, Scott Weber, Jeffrey C. Haley
Celanese EVA Polymers
Celanese: A Global Technology & Specialty Materials Company

2018 Net Sales: $7.2 B
Employees: 7,684
Manufacturing Locations: 40

Materials Solutions
$3.2 BILLION NET SALES

- Specialty thermoplastics used in automotive, electronics, medical devices, and aesthetic applications.
- Cellulose derivatives like acetate tow for filters and diacetate films.
- Food ingredients including sweeteners and preservatives.

Acetyl Chain
$4.0 BILLION NET SALES

- Acetic acid, vinyl acetate monomer, and additional intermediate chemistries.
- Emulsion polymers for paint, adhesives, waterproofing.
- EVA polymers for flexible packaging, medical solutions.
Celanese has one of the broadest portfolios spanning all thermoplastic classes

Celanese’s Materials Solutions Portfolio

High-Performance Polymers (HPP)
(TI1 > 150 °C)

Engineering Polymers (ETP)
(TI1 90 – 150 °C)

Specialty Polymers
(TI1 <90 °C)

Semi-Crystalline Polymers
Celapex™ PEEK
Vectra®, Zenite® LCP
Fortron® PPS
Thermx® PCT
Impet® PET
Ecomid®, Friany®, Nilamid®, Nylfor®, Nivionplast®,
Litepol® B, and MetaLX® PA
Nilamid® XS Partially Aromatic PA
Friany® XT, Nilamid® XT PPA
Celanex®, Pibifor®, Pibiter®, and Vandar® PBT
Celcon®, Hostaform® POM
GUR® UHMWPE
Polifor®, Carboprene®, Litepol®, Talcoprene®, and Tecnoprene® PP
Ateva®, VitalDose® EVA

Specialized Functionality
Holo®, Forgrin®, Terra® Turf Infill TPE
Pavprene® SBS for Paving
CoolPoly® with Matrix Polymers TPE Thermally Conductive Polymers

Fiber-Reinforced
Celtran® with Matrix Polymers PP, PA, PPS, PBT, and POM Long Fiber Reinforced Polymers
Celtran® Continuous Fiber Reinforced Tapes

Specialized Functionality
CoolPoly® with Matrix Polymers PP, PC, PA, PPS, and LCP Thermally Conductive Polymers

Amorphous Polymers
Cabofor® PC
Norfor® PPE
Blendfor®, Reblend® PC/ABS
Abistir®, Retelan® ABS
Clarifoil® CA film
Sanfor® SAN
Styrofor® HI-PS

Thermoplastic Elastomers
Gumfit®, Pibiflex®, Riteflex® TPC
Sofpur® Elastomer-modified TPU
Forprene® TPU
Laprene® SEBS
Sofprene®, Sofprene® T SBS
Forflex® TPO
Ateva®-EVA

Celanese Corporation
EVA Polymers Overview

Ethylene Vinyl Acetate (EVA) polymers are a copolymer of Ethylene and Vinyl Acetate

- Addition Polymerization
- High Pressure (> 1,000 atm / > 100 MPa)
- High Temperature (150 – 250°C)

Ethylene Vinyl Acetate (EVA)

- %VA can vary from >0% to 40%
- 20% EVA: 75 of every 1000 units are VA

EVA Polymer Applications

Controlled Release
Medical
Packaging
Thermal Lamination
Automotive
Wire & Cable
Adhesives
Solar Cells
Foam
Effect of Vinyl Acetate Level on EVA Properties

Increasing VA content:
- Reduces modulus
- Reduces melting temperature
- Increases filler acceptance
- Increases transparency
- Increases polarity

To overcome low melting temperatures, EVA can be blended with other materials (ex. LLDPE) or crosslinked with peroxide or radiation.
Celanese Ateva® EVA in Flexible Packaging

Celanese Ateva® EVA polymers provide excellent heat sealing properties, organoleptics, optical properties, inter-layer adhesion, and compatibility for multi-layer films.

**Applications**

- Multi-layer Food Packaging
- Tubing & Packaging
- Multi-layer Industrial Films
- Decorative Label Films
- Personal Care Films
- Batch Compounding Additives Packaging
- Greenhouse and Agricultural Films
Improving Adhesion to Substrates During Extrusion Coating & Thermal Lamination

The low melting temperature, high clarity, and favorable rheological characteristics makes EVA a material of choice in many extrusion coating, extrusion lamination, and thermal lamination applications.

The extrusion coating process plays a central role in assembling the structures used in these applications.

The strength of adhesion between EVA and the substrate is a critical parameter in this application.

Celanese is developing extrusion coating products with improved adhesion to substrates.
Celanese Ateva® & ExtruBond™ EVA Extrusion Coating Grades

Property Ranges
- VA 16-28%
- MI 6-30
- Additives
- Antioxidant
- Slip
- Antiblock
- Chill Roll
- Release
- UV Stabilizer

- Ateva® EVA 1615 16% VA, 15 MI
- Ateva® EVA XB1615 16% VA, 15MI
- Ateva® EVA 1941 19% VA, 30 MI
- Ateva® EVA 1943SB 19% VA, 30 MI
- Ateva® EVA 2020 20% VA, 20 MI
- Ateva® EVA XB2020 20% VA, 20MI
- Ateva® EVA 2861A 28% VA, 6 MI
- Ateva® EVA 2821A 28% VA, 25 MI
- Ateva® EVA XB2821 28% VA, 25 MI
Ateva® EVA Resins for Blown and Cast Films

Property Ranges

► 9-28% VA
► 0.8-10 MI

Additive options:

► Antioxidant
► Slip
► Antiblock
► Others as needed

Will formulate to meet your custom needs

- Ateva® EVA 1081 9% VA, 1.1 MI
- Ateva® EVA 1020 9% VA, 2.0 MI
- Ateva® EVA 1070 9% VA, 2.8 MI
- Ateva® EVA 1221 12% VA, 0.8 MI
- Ateva® EVA 1231 12% VA, 3.0 MI
- Ateva® EVA 1241 12% VA, 10 MI
- Ateva® EVA 1609 16.3% VA, 8.4 MI
- Ateva® EVA 1807A 18% VA, 0.7 MI
- Ateva® EVA 1811 18% VA, 1.6 MI
- Ateva® EVA 1821A 18% VA, 3.0 MI
- Ateva® EVA 2861A 28% VA, 6.0 MI
Experimental Approach

- Performed lab studies to evaluate if the new technology will increase adhesion to PET substrates
- Produce simulated extrusion coated samples for adhesion testing
- Measure adhesion force of samples
- Completed extrusion coating trials on off-site production line
T-Peel adhesion results from laboratory model for extrusion coating onto corona-treated PET films.

**EVA: 16% VA, MI = 15 g/10 min**
- Standard EVA = 60 g/in
- ExtruBond™ EVA = 370 g/in

**EVA: 28% VA, MI = 25 g/10 min**
- Standard EVA = 70 g/in
- ExtruBond™ EVA = 520 g/in

**LDPE: Density = 0.916 g/cm³, MI = 12.7 g/10 min**
- Standard LDPE = 7 g/in
- ExtruBond™ LDPE = 50 g/in

- Runs at standard EVA Processing temperatures
- No changes in extrusion conditions
  - Neck-in
  - Drawdown
  - Temperatures
- Heat Seal & Hot Tack Performance
- No change to FDA and food contact status
## ExtruBond™ EVA: Commercial-Scale Results
(16% VA, MI = 15 g/10 min)

All results for extrusion-coated polyester film.

<table>
<thead>
<tr>
<th>Adhesion Force (g/in)</th>
<th>Ateva® EVA</th>
<th>ExtruBond™ EVA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Untreated film</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>350 ft/min</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>700 ft/min</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td><strong>Corona treated</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>350 ft/min</td>
<td>40</td>
<td>140</td>
</tr>
<tr>
<td>700 ft/min</td>
<td>60</td>
<td>160</td>
</tr>
<tr>
<td><strong>Corona/primer/Ozone</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>350 ft/min</td>
<td>280</td>
<td>440</td>
</tr>
<tr>
<td>700 ft/min</td>
<td>270</td>
<td>440</td>
</tr>
</tbody>
</table>
Low Temperature Adhesion Results

Data from corona-treated polyester films

- ExtruBond™ EVA XB2020
  - T = 23°C

- ExtruBond™ EVA XB2020
  - T = -20°C

- Standard 2020
  - T = 23°C

  - T = -20°C

peel force (g/in)
Thermal lamination

A process by which two films are laminated together using heat.

Blown film, cast film, and extrusion coating can all be used to make films for lamination, depending on the structure and objectives.

We have customer requests and inquiries about applying ExtruBond materials in films used in this process to different substrates.

Lamination is easy to do in the lab, and is also potentially a screening tool that works around some of the limitations of the film line we use to simulate extrusion coating.
ExtruBond™ EVA: Lamination data (16% VA, MI = 15)

Extrusion-coated polyester films were thermally laminated to several substrates t-peel adhesion test.

<table>
<thead>
<tr>
<th>Lamination to Paper</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Standard EVA = 60 g/in</td>
<td></td>
</tr>
<tr>
<td>• ExtruBond™ EVA = 100 g/in</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lamination to corona-treated PET</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Standard EVA = 45 g/in</td>
<td></td>
</tr>
<tr>
<td>• ExtruBond™ EVA = 110 g/in</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lamination to untreated PET</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Standard EVA = 25 g/in</td>
<td></td>
</tr>
<tr>
<td>• ExtruBond™ EVA = 25 g/in</td>
<td></td>
</tr>
</tbody>
</table>

*Samples laminated at nominal temperature of 200°F (93°C).

- Runs at standard EVA Processing temperatures
- No changes in extrusion conditions
  - Neck-in
  - Drawdown
  - Temperatures
- Heat Seal & Hot Tack Performance
- No change to FDA and food contact status
ExtruBond™ EVA: Lamination to Untreated PET

- Lamination to untreated PET sheets for graphics applications (customer currently uses 28% VA copolymer, but film is tacky and difficult to handle)
- Lidding stock for thermoformed PET trays

![Graph showing peel force comparison between AT2821A and AT2020 with XB2020 Untreated PET. Laminated at 200°F (93°C).]
ExtruBond™ EVA: Lamination to Corona-treated Nylon Film

- Adhesion when extrusion coating of nylon films is challenging

Laminated at 200°F (93°C)
ExtruBond™ XB2020 EVA Lamination to Aluminum foil

- EVA and LDPE generally show poor adhesion to aluminum foil and metalized films. Much more expensive acid copolymers and ionomers are typically used.
- Currently developing data for LDPE
- High variability in test result; working to refine.

Laminated at 200°F (93°C)
Translating ExtruBond™ EVA Technology into LDPE

- The North American LDPE extrusion coating market consumes on the order of 1 billion lbs of material.

- Applications include paperboard coating (ex. orange juice cartons or paper cups) and flexible packaging.

- We cannot support the sort of LDPE volumes that customers consume in this market.

- Instead, we have decided to develop a masterbatch that we can sell to customers.

**LDPE results coated onto corona-treated PET**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Median Peel Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>418 Control</td>
<td>7 g/in</td>
</tr>
<tr>
<td>418+5% XBLDPE</td>
<td>49 g/in</td>
</tr>
</tbody>
</table>
ExtruBond™ EVA LDPE: Preliminary Results

Lab tests have demonstrated LDPE adhesion improvements with similar gains to the EVA results

- ~2x increase on untreated film
- ~10x increase on corona treated film

<table>
<thead>
<tr>
<th>Substrate</th>
<th>LDPE</th>
<th>ExtruBond LDPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated PET Film</td>
<td>11 g/in</td>
<td>20 g/in</td>
</tr>
<tr>
<td>Corona Treated PET Film</td>
<td>15 g/in</td>
<td>130 g/in</td>
</tr>
</tbody>
</table>

- Runs at standard LDPE processing conditions
- ExtruBond™ EVA LDPE Masterbatch is customizable to customer blending requirements
- No changes in extrusion conditions
  - Neck-in
  - Drawdown
  - Temperatures
- No change to FDA and food contact status
ExtruBond™ EVA LDPE MB Lamination to Aluminum Foil

• EVA and LDPE generally show poor adhesion to aluminum foil and metalized films. Much more expensive acid copolymers and ionomers are typically used.

• Currently developing data for LDPE
• High variability in test result; working to refine.

Laminated at 240 °F (115 °C)
Celanese Extrusion Coating Development Project

Anticipated Benefits of ExtruBond™ Technology

► Increased adhesion to substrates

► Increased line speeds
  - Greater utilization of existing equipment and machinery

► Reduced air-gaps which could lead to improved neck-in

► Reduced melt temperatures

► Lower coating weights
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