Vistamaxx™ performance polymers are propylene-rich olefinic specialty elastomers produced by using ExxonMobil Chemical’s Metallocene technology.

- They are unique semi-crystalline copolymers of propylene and ethylene.
- Reduced crystallinity is obtained through introduction of amorphous regions into the polypropylene sequences via ethylene.
- Vistamaxx performance polymers elastic properties are the consequence of a predominantly amorphous ethylene-propylene (EP) matrix laced with a network of fine, well-dispersed isotactic polypropylene (PP) crystallites.

Isotactic PP Microcrystalline Region

Amorphous Region

What is Vistamaxx™ performance polymers
Compatibility of Vistamaxx and Polypropylene

- Vistamaxx performance polymers possess a strong compatibility with polypropylene (PP)

- Atomic-force microscopy (AFM) micrograph shows uniformly dispersed fine particles of 30% Vistamaxx performance polymer in 70% homopolymer (hPP)

- Vistamaxx performance polymers are particularly effective in modifying PP to enhance flexibility, soft touch, impact strength and adhesion, while maintaining clarity and reducing or eliminating stress whitening

- Vistamaxx performance polymers provide new possibilities to improve and extend the properties of PP
C3 Elastomer vs C2 Elastomer Modifier

**Vistamaxx™ performance polymers**
- Low crystallinity copolymers of propylene (>80wt%) and ethylene
- Densities from 0.855 to 0.871 g/cm³

**Strengths**
- Elasticity
- Excellent compatibility with PP
- Excellent adhesion to PP and polyethylene (PE)
- Maintain clarity of PP
- Impact performance down to -20°C

**Shared Attributes**
- Toughness
- Flexibility
- Softness
- Loadability

**Exact™ plastomers**
- Ethylene alpha olefin copolymers with butene, hexene or octene comonomer
- Densities from 0.860 to 0.905 g/cm³

**Strengths**
- Excellent low temperature ductility
- Broad polyolefin compatibility
- Impact performance down to -40°C

**Vistamaxx performance polymers** possess a unique compatibility with PP. This is illustrated in AFM micrographs where Vistamaxx elastomer blend has smaller, more uniformly dispersed particles.

**Exact plastomer** forms a dispersed elastomeric phase in continuous PP matrix, imparting excellent impact strength. Low density grades provide outstanding low temperature toughness.

**AFM Micrographs of 70:30 / PP Modifier**
- (dark areas = elastomer, light areas = PP)
## Vistamaxx™ Performance Polymers
### Grades and Key Physical Properties

<table>
<thead>
<tr>
<th>Vistamaxx™ grade</th>
<th>3000</th>
<th>6102/6102FL</th>
<th>6202/6202FL</th>
<th>6502</th>
<th>8880</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Melt Index</strong>¹ (MI), g/10min ExxonMobil Method</td>
<td>3.6</td>
<td>1.4</td>
<td>9.1</td>
<td>20</td>
<td>/</td>
</tr>
<tr>
<td><strong>Melt Mass-Flow Rate</strong> (MFR), g/10 min ASTM D1238</td>
<td>8</td>
<td>3</td>
<td>20</td>
<td>48</td>
<td>&gt;&gt;10³⁵</td>
</tr>
<tr>
<td><strong>Ethylene content, wt%</strong> ASTM D3900</td>
<td>11</td>
<td>16</td>
<td>15</td>
<td>13</td>
<td>6</td>
</tr>
<tr>
<td><strong>Density</strong>² (23°C), g/cm³ ASTM D1505 modified</td>
<td>0.873</td>
<td>0.862</td>
<td>0.863</td>
<td>0.865</td>
<td>0.879</td>
</tr>
<tr>
<td><strong>Vicat softening point, °C (°F)</strong> ASTM D1525</td>
<td>65.6 (150)</td>
<td>52.2 (126)</td>
<td>47.2 (117)</td>
<td>51.5 (125)</td>
<td></td>
</tr>
<tr>
<td><strong>Tensile strength</strong>² at break, MPa (psi) ASTM D412</td>
<td>17.1 (2,480)</td>
<td>&gt;6.9 (&gt;1,000)</td>
<td>&gt;5.5 (&gt;798)</td>
<td>&gt;9.65 (&gt;1,400)</td>
<td>6.2 (900)</td>
</tr>
<tr>
<td><strong>Elongation</strong>² at break, % ASTM D412</td>
<td>1,898</td>
<td>&gt;2,000</td>
<td>&gt;2,000</td>
<td>&gt;1,900</td>
<td>1,237</td>
</tr>
<tr>
<td><strong>Flexural modulus</strong>²,³ (1% secant), MPa (psi) ASTM D790</td>
<td>59.3 (8,610)</td>
<td>12.3 (1,790)</td>
<td>12.3 (1,790)</td>
<td>20.5 (2,980)</td>
<td></td>
</tr>
<tr>
<td><strong>Tear strength</strong>², Die C, N/mm (lbf/in) ASTM D624</td>
<td>62.3 (356)</td>
<td>34.3 (196)</td>
<td>33.3 (190)</td>
<td>38.4 (220)</td>
<td></td>
</tr>
</tbody>
</table>

¹ Value reported is an estimate based on ExxonMobil’s correlation from melt flow rate data measured at other standard conditions, based on ASTM D1238.
² All physical properties were measured on specimens cut from compression molded plaques based on ASTM D4703, Procedure A, Type I and conditioned at 23°C for a minimum of 40 hours based on ASTM D618 prior to testing.
³ 1% secant at break
Calcium Carbonate (CaCO$_3$) Dispersion Study

Vistamaxx™ 6202 as carrier polymer provides smaller particle size compared to LLDPE

- 2 different MB samples: 20% carrier polymer with 80% CaCO$_3$
- Dry blended at 2% in hPP and extruded in cast film
- Particle size measure via Optical Control System (OCS) as dispersion indicator
Better Filler Dispersion

**Vistamaxx™ Performance Polymer as a carrier polymer**

- Provides more uniform filler dispersion compared to linear low density polyethylene (LLDPE)
- Allows higher filler loadings

![Comparison of filler dispersion](image)

**Note:** Calcium carbonate raw material mean particle size < 1 µm
Vistamaxx™ in the Compounding Process
Compounding Overview

- The compounding operation inside a twin screw extruder (TSE) or Farrel Continuous Mixer (FCM) is not significantly affected when using Vistamaxx performance polymers.

- Barrel/processing temperatures typically are run lower due to the lower melting point of Vistamaxx™ Performance Polymers compared to polypropylene (PP) or polyethylene (PE).

- FCM machines are typically used for loading high weight percentages of inorganic fillers (>50%) into polymers.

- Do not get the “pulverizing” effect of the hard pellets on the filler in the conditioning zone of the TSE before the polymer begins to melt.
Compounding Overview Continued

- Vistamaxx™ Performance Polymers can be very challenging to compound because of its very slow recrystallization rate
- The primary issue centers around pelletization
- Vistamaxx tends to “chain” within the pellet water stream
  - Pellets are cut at the die with little problem, but do not crystallize quickly and form a hard surface in the pellet water stream
  - These “soft” pellets then bump into other pellets within the water stream due to turbulence and stick together forming “chains”
- The higher the ethylene content, the more difficult it is to pelletize

Easier 3980* 3020* 3000* 6102* 6202* 6502* → More Difficult

* Vistamaxx performance polymer grade numbers
Alloying

• When compounding Vistamaxx™ Performance Polymer grades or other polymers, a number of things can be done to reduce the formation of “chains”

• Very low pelletizer water temperature is required to pelletize a high concentration Vistamaxx™ Performance Polymer blends
  • Pellet water temperatures need to be maintained below 12°C and preferably around 5°C
  • Higher pelletizer water flow rates relative to extruder throughput reduces the concentration of pellets in the pelletizer water stream
  • Using the following formula, (kg/hr extruder throughput/gpm pelletizer water flow rate), you get a ratio of extruder output to water volume. When possible, 6:1 is the maximum you should target.

• The addition of calcium stearate (CaSt) to the pelletizer water is required to pelletize high Vistamaxx™ Performance Polymer concentrations
  • CaSt emulsions are the preferred method of introduction
  • Keep pellet water tank mixed as CaSt tends to separate out of water
  • CaSt coats the surface of the pellets which reduces pellet tackiness
When compounding Vistamaxx™ Performance Polymer grades or other polymers, a number of things can be done to reduce the formation of “chains”

Run extruder barrel setpoint temperatures as low as possible

- For 100% Vistamaxx™ Performance Polymer blends, barrel temperatures can be run as low as 120°C
- For Vistamaxx™ Performance Polymer blends with low concentrations, 15% or less, of polypropylene polymers, homopolymer (hPP), random co-polymer (RCP), and impact co-polymer (ICP), maximum barrel temperatures can be run between 140°C – 150°C
- Blends with higher percentages of polypropylene will require barrel temperatures in excess of 165°C
- Blends with linear low density polyethylene (LLDPE) or high density polyethylene (HDPE) will require barrel temperatures of 135°C
Alloying Continued

• Die temperatures for 100% Vistamaxx™ Performance Polymer (plastic phase) should be around 150°C

• For low percentage polypropylene / Vistamaxx™ Performance Polymer blends, die temps need to be higher, 190°C – 200°C

• Low concentration blends with other more crystalline polymers (hPP or HDPE) can greatly reduce the “chaining” tendency
  • Blends with around 15% hPP or HDPE will allow pelletizing with minimal “chaining” at higher pelletization water temperatures, between 25°C – 30°C

• Moderate/standard intensity compounding screw designs are typically effective in mixing Vistamaxx™ Performance Polymer blends
Alloying Pelletization

• Several equipment choices are critical for effective pelletization
  • Use of an underwater pelletizer
  • Use the minimum number of die holes possible
    • For 0.125” (3.18 mm) die holes, 25 kg/hr/hole is a good rule of thumb, higher rates/hole may be possible with experimentation

• Use the minimum number of cutter hubs possible
  • Use cutters with 3 or 4 hub arms/blades when possible. This reduces turbulence in the water box and limits the snag points for the Vistamaxx™ polymer to wrap around
  • Higher cutter speeds tend to perform better, this tends to throw polymer build-up off of hubs/blades

• The longer the residence time in the pellet water stream the better

• Longer pelletizer water piping loops are recommended

• Fewer, larger pellets tend to reduce “chaining” tendency compared to having more, smaller pellets
Filled Compounding

- Vistamaxx™ Performance Polymer can be loaded to very high weight percentages of inorganic fillers, calcium carbonate (CaCO₃), talc, clay, or carbon black compared to most other polymers
  - Demonstrated 80% (by weight) of 4.5 micron non-treated CaCO₃ in numerous Vistamaxx™ Performance Polymer grades using a TSE, but pellets were borderline “friable”
  - The finer the filler particle size, the lower the maximum loading due to the increased filler surface area
  - The higher the filler loading, the rougher the pellet surface is
  - The lower the Melt Flow Rate (MFR) of the Vistamaxx the worse the surface roughness
  - The rougher the surface, the higher the residual moisture content of the pellets
    - Pellets may require a secondary drying step
    - Surface treatment of the fillers or other processing additives can be used to reduce pellet roughness issues
- Compounds with >40% filler will allow pelletizing with minimal “chaining” at higher pelletization water temperatures, between 25°C – 30°C
Filled Compounding Equipment

- Run extruder barrel temperatures as low as possible, they can be run as low as 120°C

- Filler loadings of >35% require two extruder feed locations for filler addition
  - Can feed part of the filler loading at the feed throat and part downstream via a crammer at a side feed barrel but abrasive wear in the upstream barrels and screw section will be more severe in this case
  - Can feed part of the filler loading downstream via a crammer at a side feed barrel and part further downstream via a crammer at another side feed barrel
    - Typically requires longer twin screw extruder L/D
    - Lower abrasive wear on extruder barrels and screw
    - On certain types of fillers, this will improve the dispersion of the filler

- Moderate temperature pelletizer water is required to pelletize highly filled (>40%) Vistamaxx™ Performance Polymer, pellet water temperatures should be between 25°C and 30°C

- High intensity, dispersive compounding screw designs with dedicated downstream addition sections for fillers are required for high filler loading
Liquid Mixing

- Vistamaxx™ Performance Polymers can be loaded to very high weight percentages of oil / poly-alpha-olefin (PAO) compared to most other polymers.

- Have demonstrated ~50% (by weight) incorporation:
  - Injection accomplished through dual liquid injection locations.
  - Oil injection should be done under pressure directly into melted polymer, not sprayed onto pellets (leads to slippage) in the extruder feed throat.

- Level of incorporation is dependent on the specific Vistamaxx™ Performance Polymer grade and compatibility parameters.

- The higher the oil loading, the stickier and softer the pellets become:
  - Compounded pellets need to be dusted due to tackiness.
  - Require the same pellet water temperature/flow/CaSt addition as neat Vistamaxx™ Performance Polymer blends.
  - Tendencies to “chain” and smear at the die are significantly increased.

- High intensity, distributive, back-mixing screw designs with dedicated downstream injection locations for liquids are required for high oil / PAO loadings.
Summary

- Changes in extrusion equipment (TSE or FCM) are typically not necessary
- Run lower processing/barrel zone temperatures
- Use an underwater pelletizer
- Run much lower pelletizer water temperatures
- Run higher pelletizer water flow rates relative to extruder throughput
- Minimize the number of die holes
- Minimize the number of cutter hubs, maximize cutter speed
- Longer pelletizer water piping loops are recommended
- Use CaSt in the pelletizer water
- Addition of >40% inorganic filler or ~15% hPP significantly reduces “chaining” tendency
An underwater pelletizer system is being used.

If Vistamaxx performance polymer is being compounded neat or with less than 15% of a more crystalline polymer (i.e. hPP, RCP, ICP, HDPE, LLDPE) and less than 40% inorganic filler, a chiller is available to provide chilled pelletizer water (~10°C).

If Vistamaxx performance polymer is being compounded with more than 15% of a more crystalline polymer (i.e. hPP, RCP, ICP, HDPE, LLDPE) or more than 40% inorganic filler, enough cooling tower water capacity is available to maintain ~28°C pelletizer water temperature.

The MINIMUM number of die holes are being used for the compounding application.

The MINIMUM number of cutter hubs/blades are being used for the pelletization operation.

A calcium stearate emulsion is available for the pelletizer water system. A defoamer is also available for the pelletizer water system.

Higher pelletizer water flowrates (relative to extruder output) and longer residence time pelletizer water piping loops are being utilized if available.

Is an offline, secondary drying operation available for highly filled Vistamaxx performance polymer pelletized compounds or is another more crystalline polymer (i.e. hPP, RCP, ICP, HDPE, LLDPE) available to add in small percentages to the formulation to assist recrystallization of the pellets at higher pelletization water temperatures.
Vistammaxx™ Compounding Checklist

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☐ If Vistammaxx performance polymer is the only polymer in the formulation, the processing temperatures (extruder barrels or FCM mixer) are set to a MAXIMUM of 120°C. The die temperature is set to 150°C.

☐ When adding more than 35% inorganic filler or more than 20% liquid to a Vistammaxx performance polymer formulation, the addition amount of filler or liquid needs to be split into two separate addition locations within a twin screw extruder.

☐ When adding liquid to a Vistammaxx performance polymer formulation, the liquid is injected under pressure into the extruder, directly into the melted polymer, not sprayed onto packed pellets. This will reduce the possibility of slippage.

☐ When adding high percentages of an inorganic filler to a Vistammaxx performance polymer formulation, vibrators are used on all hopper locations to prevent the accumulation of the inorganic filler on the hopper walls (which could suddenly break loose and overload the extruder).
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Backup Slides
Generic Filled Compounding Extruder Configuration
Typical set up of a compounding line

- A compounding operation set up consists of the following major units:
  1. Feeding system
  2. Twin screw extruder
  3. Pelletizing unit
  4. De-watering unit
  5. Bagging unit
Core unit – the extruder

Drive System
- Main Motor
- Aux Motor
- Coupling
- Gearbox & Lube systems

Process System
- Subcomponents:
  - Co-Rotating Twin Screws
  - Screw Elements
  - Extruder Barrel
  - Barrel Heating, Cooling
  - Venting
  - From Extruder
  - Feed System

Downstream System
- Subcomponents:
  - Gear Pump
  - Melt Diverter
  - Screen Changer
  - Die
  - Pelletizer
  - Pellets to Dryer System

Feed System
- Dryer System
- Pellets to Extruder System

Subcomponents:
- Pellets to Extruder System
- From Extruder Feed System
- Gear Pump
- Melt Diverter
- Screen Changer
- Die
- Pelletizer
- Pellets to Dryer System
The underwater pelletizing system
The strand cut set up

Lab Pelletizing Line