High-Performance Polymers for Automotive
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Solvay offers the industry’s broadest portfolio of high-performance polymers, fluids and elastomers. These materials are designed to meet the critical requirements that engineers face every day when designing components for Automotive, Aerospace, Healthcare, Batteries, Smart Devices, Consumer, Industrial, and Energy Production and Storage.

Our production and Research & Innovation (R&I) sites are located strategically around the world to provide you with responsive technical support and customer service.

**Specialty Polymers at a Glance**

**Multiple End Markets**

- **Aircraft**
- **Alternative Energy**
- **Automotive**
- **Construction**
- **Consumer Goods**
- **Electrical/Electronics**
- **Healthcare**
- **Industrial**
- **Membranes**
- **Oil & Gas**
- **Smart Devices**

**Business Strengths**

- 50+ Proprietary technologies
- 340+ Commercial employees
- 550+ R&I specialists
- 1,500+ Products
- 3,000+ Employees worldwide
- 3,300+ Patents in force
- 4,000+ Customers
Specialty Polymers Portfolio

Polymer Performance Pyramid

Ultra Performance

High Performance

Mid Range

Commodity

Elastomers & Fluids

Amorphous

Semi-Crystalline

Solvay's specialty polymers are designated in bold type

<table>
<thead>
<tr>
<th>Aromatic Polymers</th>
<th>Fluoropolymers</th>
<th>High Barrier Polymers</th>
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<td>PPA</td>
<td>PEEK</td>
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● Currently produced in Asia  ● On-going investments in Asia  ● Not produced in Asia

4 \ High-Performance Polymers for Automotive
Advanced Lightweighting Solutions
• TegraLite™ Lightweighting Solutions
  – TegraCore™ PPSU Structural Foam
  – 3D Foams
  – Films
  – Composites
  – Solef® 80 000 e-PVDF
  – Virantage® PESU Tougheners

Biomaterials for Implantable Devices
• Solviva® Biomaterials
  – Eviva® PSU
  – Proniva® SRP
  – Veriva® PPSU
  – Zeniva® PEEK

Films
• Ajedium™ Films

Fluorinated Elastomers
• Tecnoflon® FKM & PFR FFKM
  – Base Resistant
  – Ionic Curable
  – Low Temperature
  – Peroxide Curable
  – PFR FFKM perfluoroelastomers

Fluorinated Fluids
• Fomblin® HC PFPE
• Fomblin® PFPE Lubricants
• Galden® PFPE
• Solvera® PFPE

Fluoropolymers
• Algoflon® PTFE
  – Dispersions
  – Fine Coagulated Powders
  – Granulars
  – Micronized Powders
• Halar® ECTFE
• Hyflon® PFA & MFA®
• Polymist® PTFE Micronized Powders
• Solef® PVDF

Fluoropolymer Coatings
• Halar® ECTFE
• Hyflon® PFA & MFA®
• Hylar® PVDF
• Hylar® 5000 for Architectural Coatings

Functional Fluids
• Fluorolink® PFPE
• Fomblin® PFPE Functional

Liquid Crystal Polymers
• Xydar® LCP

Polyamide-Imides
• Torlon® PAI

Polyamides, Aromatic
• Amodel® PPA
• Ixef® PARA
• Kalix® HPPA
• Omnix® HPPA

Polyesters, High-Performance
• Lavanta® HPP

Polyketones, Aromatic
• AvaSpire® PAEK
• KetaSpire® PEEK

Polymer Processing Aids
• Solef® 11010 PVDF
• Tecnoflon® NM FKM

Polyphenylene
• PrimoSpire® SRP

Polyphenylene Sulfide
• Ryton® PPS

Polyvinylidene Chloride
• Diofan® PVDC
• Ixan® PVDC Extrusion Resins
• Ixan® PVDC Soluble Powders

Specialty Materials
• Aquivion® PFSA
• EpiSpire® HTS
• Hyflon® AD
• Long Fiber Compounds
• Solvene® EAP
• Torlon® AI for Coatings

Sulfone Polymers
• Acudel® modified PPSU
• Radel® PPSU
• Udel® PSU
• Veradel® PESU
High-Performance Polymers for Automotive

Global automotive OEMs face the challenge of meeting upcoming CO₂ and tailpipe emissions standards. In order to address these challenges, OEMs are focused on improving powertrain efficiency through engine downsizing and transmission down-speeding, increasing the electrification of their vehicles, lightweighting, and reducing fuel consumption.

Specialty Polymers is focused on these CO₂ and emissions reduction technologies by offering high-performance polymers that offer heat and chemical resistance as well as dimensional stability.

Application Matrix

<table>
<thead>
<tr>
<th>Application</th>
<th>Ixef® PARA</th>
<th>Amodel® PPA</th>
<th>Ryton® PPS</th>
<th>Veradel® PESU</th>
<th>KetaSpire® PEEK</th>
<th>Torlon® PAI</th>
<th>Solef® PVDF</th>
<th>Hyflon® PFA</th>
<th>Tecnoflon® FKM</th>
<th>Fomblin® PFPE</th>
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<td>Transmission and launch devices</td>
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<td>Traction motors and power electronics</td>
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</table>

Our products are widely considered for the following solutions:

- Thermal and air management
- Transmission and launch devices
- Electronics and lighting
- Traction motors and power electronics
- Fuel and SCR systems
- Structural and semi-structural, lightweighting
- Chassis, braking and steering
Thermal Management Systems

Amodel® PPA and Ryton® PPS have replaced die-cast aluminum in engine cooling systems for over 20 years. Both materials are routinely used in under-the-hood applications where resistance to heat, humidity and automotive fluids are major considerations.

Performance Advantages

• Long-term retention of mechanical properties in high heat
• Exceptional resistance to coolant (glycols)
• Low moisture absorption for dimensional stability
• No parting-line design possible

Typical Applications

• Thermostat housings
• Water inlet/outlet valves
• E-water pumps
• Water pump impellers
• Heater cores and end caps

<table>
<thead>
<tr>
<th>Application</th>
<th>Amodel® PPA</th>
<th>Ryton® PPS</th>
<th>Veradel® PESU</th>
<th>KetaSpire® PEEK</th>
<th>Solef® PVDF</th>
<th>Fomblin® PFPE</th>
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</table>

Amodel® PPA (polyphthalamide)

Amodel® PPA offers excellent dimensional stability in corrosive, high-temperature environments along with better fatigue and impact resistance compared to standard polyamide, superior strength at 130°C (266°F) after prolonged exposure to engine coolants, and faster molding cycle times.

KetaSpire® PEEK (polyetheretherketone)

KetaSpire® PEEK combines exceptional strength, stiffness, chemical resistance and fatigue resistance with continuous-use up to 240°C (464°F), enabling it to replace metal in some of the most severe end-use environments.

Ryton® PPS (polyphenylene sulfide)

Ryton® PPS offer a unique combination of properties and an excellent cost-performance balance. Key properties include thermal stability, dimensional stability, chemical resistance and inherent flame retardancy.

Fomblin® PFPE (perfluoropolyether)

Fomblin® PFPE is the ideal lubrication solution for the automotive industry, meeting lubrication challenges by providing the best possible performance for demanding applications. It is used as neat oil, formulated into greases, or deposited on the part through suitable carriers.
Retention of Mechanical Properties

**Tensile strength**
*After 5,000 hours exposure at 120 °C (248 °F) in 50/50 glycol/ether*

- Prestone
- Valvoline
- Texaco

<table>
<thead>
<tr>
<th>30% GR PA 6.6</th>
<th>AS-1933 HS</th>
<th>AS-1945 HS</th>
<th>R-4</th>
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<tbody>
<tr>
<td>0</td>
<td>50</td>
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<td>70</td>
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</tbody>
</table>

**Flexural modulus**
*After 5,000 hours exposure at 120 °C (248 °F) in 50/50 glycol/water*

- Prestone
- Valvoline
- Texaco

<table>
<thead>
<tr>
<th>30% GR PA 6.6</th>
<th>AS-1933 HS</th>
<th>AS-1945 HS</th>
<th>R-4</th>
</tr>
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<tbody>
<tr>
<td>0</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
</tbody>
</table>

Typical Applications

**Thermostat Housing**
- High retention of mechanical properties at 130 °C (266 °F) in engine coolant
- No parting-line to prevent leakage risk
- High weldline strength

**Impeller**
- Dimensional stability
- High retention of mechanical properties > 130 °C (266 °F) in engine coolant
- Excellent resistance to glycol

**E-water Pump**
- Better dimensional stability than PA 6.6
- Continuous-use temperature 130 °C (266 °F) in glycol/water
- Fatigue resistance
- Easy welding
**Amodel® PPA**

Amodel® PPA offers excellent dimensional stability in corrosive, high temperature environments along with better fatigue and impact resistance, superior strength at 130°C (266°F) after prolonged exposure to engine coolants, and faster molding cycle times.

**Key Features**
- Retains mechanical properties in high heat
- Excellent resistance to coolants
- Dimensional stability
- Corrosion protection for metal inserts
- Under-cut designs possible

**Undercut Designs**

Amodel® AS grades are unique among high-performance plastics in their ability to mold undercut designs. Simplified mold designs can reduce tooling costs associated with parting lines.

**Undercut design and processing**

1. **Part is molded and cooled**
2. **ID core is pulled first**
3. **OD sleeve/slide is pulled second**
4. **Barb/undercut recovers**

**Weld-line strength after prolonged exposure to long-life coolant**

<table>
<thead>
<tr>
<th>Exposure (hours)</th>
<th>Amodel® AS-1945 HS</th>
<th>Amodel® AS-1933 HS</th>
<th>R-4</th>
<th>PA 6.6 33% GF</th>
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<tr>
<td>0</td>
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<td>100</td>
<td>80</td>
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<td>200</td>
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<td>500</td>
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<td>1,000</td>
<td>20</td>
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<tr>
<td>2,500</td>
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<tr>
<td>5,000</td>
<td>0</td>
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**Glycol-resistant Amodel® PPA grades**

**High Elongation**
- AS-1933 HS
- AS-1945 HS

**Thermal Stability**
- A-8930 HS
- A-8940 HS
- A-8950 HS

**Electrical Friendly**
- AE-8930
- AE-8935
- AE-8940

*High heat resistance, high strength, anti-corrosion to metal insert*
Air Management Systems

Engine downsizing driven by emission legislations has placed high-temperature demands on air induction components. Solvay’s broad range of specialty polymers can help you meet next-generation requirements of hot-side air induction components.

### Performance Advantages
- Light weight for improved fuel efficiency
- Excellent dimensional stability
- High-temperature resistance
- Highly resistant to all automotive fluids

### Typical Applications
- Turbocharger actuators
- Turbocharger by-pass valves
- Turbocharger hoses
- CAC housings
- Exhaust gas recirculation systems
- Electronic controlled throttle valves
- Hot air ducts

<table>
<thead>
<tr>
<th>Applications</th>
<th>Amodel® PPA</th>
<th>Ryton® PPS</th>
<th>KetaSpire® PEEK</th>
<th>Torlon® PAI</th>
<th>Tecnoflon® FKM</th>
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<tr>
<td>Turbocharger actuators</td>
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<tr>
<td>Turbocharger by-pass valves</td>
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<td>Turbocharger hoses</td>
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<td>CAC housings</td>
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<td>Exhaust gas recirculation systems</td>
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<td>Hot air ducts</td>
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</table>

**Amodel® PPA**
Amodel® PPA retains its high mechanical properties up to 230 °C (446 °F) and offers excellent chemical resistance to acidic condensates to meet the requirement of next generation air induction system.

**Ryton® PPS**
Ryton® PPS offer a unique combination of properties. Key properties include thermal stability, dimensional stability, chemical resistance and inherent flame retardancy.

**KetaSpire® PEEK**
KetaSpire® PEEK combines exceptional strength, stiffness, chemical resistance and fatigue resistance with continuous-use up to 240 °C (464 °F), enabling it to replace metal in some of the most severe end-use environments.

**Tecnoflon® FKM (fluoroelastomers)**
Tecnoflon® FKM offers a broad range of temperature resistance capabilities from −40 to 250 °C (−40 to 482 °F) at air section. Through our unique production technology, Tecnoflon® FKM eliminates costly processing steps, produces higher yields and increases cost efficiency.

![Temperature Chart](image-url)
Typical Properties for Air Induction Polymers

<table>
<thead>
<tr>
<th>Grade</th>
<th>Tensile Strength [GPa]</th>
<th>Elongation [%]</th>
<th>Impact Strength [kJ/m²]</th>
<th>HDT [°C]</th>
<th>Density</th>
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<tr>
<td>Amodel® PPA</td>
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<tr>
<td>A-1133 HS</td>
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<tr>
<td>VMQ</td>
<td>–</td>
<td>++</td>
<td>–</td>
<td>++</td>
<td>+</td>
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</tbody>
</table>

+++ Excellent, ++ Very good, + Good, – Poor

Typical Applications

CAC Housing
- High heat resistance
- >50% retention of mechanical strength after heat aging
- Chemical resistance to acidic condensates
- Weld-line strength (before/after heat aging)

EGR Valve
- Dimensional stability
- Low CLTE
- Heat resistance
- Chemical resistance

Turbocharger Hose
- Chemical resistance to acidic condensates
- High heat resistance
- High tear strength
- Fatigue resistance
- Silicone bonding
- Good processability
**High Heat Amodel® PPA**

Amodel® PPA offers excellent dimensional stability in corrosive, high temperature environments along with better fatigue and impact resistance, superior strength up to 230 °C (446 °F) exposure to hot air.

**Key Features**
- Retains mechanical properties in high heat
- Excellent resistance to acidic condensates
- Dimensional stability
- Good fatigue resistance

**Typical Applications**
- CAC housings
- Throttle bodies
- EGR valves
- Hot air ducts

**Structural Strength**

| A-4145 HH | High heat resistance, high mechanical strength, dimensional stability |

**Tensile bar cross section**

*after 2,000 hours aging at 230 °C (446 °F)*

---

**Retention of tensile strength at 230 °C (446 °F)**

- A-4133 HH BK
- AS-4133 HS BK
- A-4145 HH BK
- PA 4.6

---

**Retention of weld-line strength at 230 °C (446 °F)**

- A-4133 HH
- AS-4133 HS
**Tecnoflon® FKM**

Tecnoflon® FKM’s unique polymerization technology makes it possible to meet requirements for excellent resistance to heat and chemicals. Only fluorinated elastomers can deliver this high level of performance.

**Key Features**

- Resistance to conventional and bio fuels
- Engine and gear box oil resistance
- Resistance to engine coolants
- Outstanding range of thermal properties, from –45 to 250°C (–49 to 482°F)
- Long-term sealing, very low compression set

**Typical Applications**

- Gaskets
- Seals
- O-rings
- Fuel line hoses
- Turbocharger hoses

**Tecnoflon® FKM grades**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOR 5312K</td>
<td>Medium-high viscosity copolymer, superior mold flow and release, high elongation and excellent hot tear strength. Suitable for compression molding of metal bonded and complicated shapes.</td>
</tr>
<tr>
<td>FOR 7380K</td>
<td>Medium-low viscosity molded goods terpolymer with superior rubber to metal bonding, good scorch safety and excellent hot tear strength.</td>
</tr>
<tr>
<td>P 459/P 959</td>
<td>Low and medium viscosity peroxide curable polymers with 70% fluorine. Best-in-class for chemical and fuel resistance.</td>
</tr>
<tr>
<td>PL 455/PL 855</td>
<td>Low and medium viscosity peroxide curable polymers with 64% fluorine with TR10 of –30°C (–22°F).</td>
</tr>
<tr>
<td>VPL 55540/VPL 85540</td>
<td>Low and medium-low viscosity peroxide curable grades with outstanding low temperature behavior (TR10 = –40°C (–40°F)) and chemical resistance. Easy processing and low fuel permeability.</td>
</tr>
</tbody>
</table>
Fuel and SCR Systems

The race to reduce evaporative emissions along with changes in fuel formulations have sparked a strong interest in higher performing plastics for use in automotive and other fuel burning engines.

Performance Advantages
- Ultra-low permeation
- Biodiesel and flex fuel compatibility
- Long-term fuel resistance from –40 to 125 °C (–40 to 257 °F)
- Continuous use from 120–175 °C (248–347 °F)
- Electrostatic dissipation
- Resistance to automotive fluids, cleaners and road salts

Typical Applications
- SCR module housings and connectors
- Fuel flanges
- Rollover valves
- Quick connects
- Filter housings
- Fuel rails
- Fuel delivery modules
- Fuel hoses
- Fuel pumps

<table>
<thead>
<tr>
<th>Application</th>
<th>Amodel® PPA</th>
<th>Ryton® PPS</th>
<th>KetaSpire® PEEK</th>
<th>Tecnoflon® FKM</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCR modules</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel flanges</td>
<td>●</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quick connects</td>
<td>●</td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>Fuel rails</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel hoses</td>
<td>●</td>
<td>●</td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>Fuel pumps</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>

Amodel® PPA
Amodel® PPA is compatible with a wide variety of fuel blends and thrives in the hotter, confined and stressed environments of today’s down-sized engines.

Ryton® PPS
The chemical resistance of Ryton® PPS is exceptional, even at elevated temperatures. There are no known solvents below 200 °C (392 °F).

Tecnoflon® FKM
Tecnoflon® FKM’s unique polymerization technology makes it possible to meet requirements for excellent resistance to heat and chemicals. Only fluorinated elastomers can deliver this high level of performance.
**Superior Compatibility**

The compatibility of Amodel® PPA with many current and potential future fuel blends was evaluated in extensive laboratory testing. This included exposure to bio-diesel, diesel, and diesel with aggressive water for 6,000 hours at 125 °C (257 °F) (to simulate under-the-hood conditions) and exposure to fuel C, flex fuels, and auto-oxidized fuels for 5,000 hours at 60 °C (140 °F) (to simulate fuel tank conditions).

Amodel® PPA showed low weight gain, little dimensional change, and excellent retention of mechanical properties over the range of fuels and temperatures evaluated.

### Average permeability rates over 28 days

CE10 Fuel (90% Fuel C, 10% Ethanol) at 60 °C (140 °F)

<table>
<thead>
<tr>
<th>Material</th>
<th>Permeability [g · mm/m²/day]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amodel® A-1004</td>
<td>0.03</td>
</tr>
<tr>
<td>Amodel® AT-1002</td>
<td>0.4</td>
</tr>
<tr>
<td>PVDF</td>
<td>2.5</td>
</tr>
<tr>
<td>PBT</td>
<td>11</td>
</tr>
<tr>
<td>PA 6</td>
<td>15</td>
</tr>
<tr>
<td>POM</td>
<td>18</td>
</tr>
<tr>
<td>PA 12</td>
<td>98</td>
</tr>
</tbody>
</table>

### Chemical resistance

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Test Conditions</th>
<th>Amodel® AT-1002</th>
<th>POM</th>
<th>PA 6.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrochloric acid, 5–10 %</td>
<td>23 °C (74 °F), 1,000 hrs</td>
<td>Excellent</td>
<td>Poor</td>
<td>Poor</td>
</tr>
<tr>
<td>Hydrofluoric acid, 1–5 %</td>
<td>23 °C (74 °F), 1,000 hrs</td>
<td>Good</td>
<td>Poor</td>
<td>Poor</td>
</tr>
<tr>
<td>Nitric acid, 5–10 %</td>
<td>23 °C (74 °F), 1,000 hrs</td>
<td>Excellent</td>
<td>Poor</td>
<td>Poor</td>
</tr>
<tr>
<td>Sulfuric acid, 5–10 %</td>
<td>23 °C (74 °F), 1,000 hrs</td>
<td>Excellent</td>
<td>Poor</td>
<td>Good</td>
</tr>
<tr>
<td>Sulfuric acid, 30–36 %</td>
<td>23 °C (74 °F), 1,000 hrs</td>
<td>Excellent</td>
<td>Poor</td>
<td>Poor</td>
</tr>
<tr>
<td>Sulfuric acid, 30–36 %</td>
<td>40 °C (104 °F), 200 hrs</td>
<td>Excellent</td>
<td>Poor</td>
<td>Poor</td>
</tr>
<tr>
<td>Zinc chloride, 50 %</td>
<td>23 °C (74 °F), 200 hrs</td>
<td>Excellent</td>
<td>Poor</td>
<td>Poor</td>
</tr>
</tbody>
</table>

**Excellent:** >85% retention of tensile strength, no chemical attack and no stress cracking  
**Good:** >50% retention of tensile strength, no chemical attack and no stress cracking  
**Poor:** chemical attack and stress cracking

### Grade

<table>
<thead>
<tr>
<th>Grade</th>
<th>Mechanical Strength</th>
<th>Heat Resistance</th>
<th>Fuel Resistance</th>
<th>Fuel Permeability</th>
<th>Fatigue Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tecnoflon® FKM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P 459/P 959</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>–</td>
</tr>
<tr>
<td>FOR 4391</td>
<td>++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>–</td>
</tr>
<tr>
<td>VPL 85540</td>
<td>++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>PL 855</td>
<td>+++</td>
<td>+++</td>
<td>++</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>AEM</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>N/A</td>
<td>++</td>
</tr>
<tr>
<td>VMQ</td>
<td>–</td>
<td>++</td>
<td>–</td>
<td>–</td>
<td>+++</td>
</tr>
</tbody>
</table>

+++ Excellent, ++ Very good, + Good, – Poor, N/A Not applicable
Typical Applications

Fuel Injector O-rings
- Excellent low temperature resistance
- Outstanding chemical resistance
- Excellent C-set and sealing force retention
- Outstanding processability
- Excellent tear strength at high temperature

Fuel Hose
- Excellent fuel/bio-fuel resistance
- Lowest fuel permeation rate
- Extrusion processing
- Fatigue resistance
- ECO bonding
- Good mechanical properties

Available Grades

<table>
<thead>
<tr>
<th>Grade</th>
<th>TR_{10} - Temp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>VPL 85730/VPL 45730</td>
<td>–30 °C (–22 °F)</td>
</tr>
<tr>
<td>VPL 45535</td>
<td>–35 °C (–31 °F)</td>
</tr>
<tr>
<td>VPL 85540/VPL 55540</td>
<td>–40 °C (–40 °F)</td>
</tr>
</tbody>
</table>

Available Grades

<table>
<thead>
<tr>
<th>Grade</th>
<th>Properties</th>
</tr>
</thead>
</table>
| P 959/P 459 | 70 % fluorine
Best fuel/bio-fuel resistance |
Ryton® PPS compounds offer an unique combination of properties and a cost/performance balance unmatched by other engineering thermoplastics. Key properties include thermal stability, dimensional stability, chemical resistance and inherent flame retardancy.

**Performance Advantages**
- Long term heat resistance up to 200 °C
- Mold complex parts with tight tolerances
- Low to no moisture absorption
- Broad chemical resistance
- Inherent flame retardancy

**Performance at high temperature**

<table>
<thead>
<tr>
<th>Temperature [°C]</th>
<th>20</th>
<th>40</th>
<th>60</th>
<th>80</th>
<th>100</th>
<th>120</th>
<th>140</th>
<th>160</th>
<th>180</th>
<th>200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ryton® PPS</td>
<td>100</td>
<td>80</td>
<td>60</td>
<td>40</td>
<td>20</td>
<td>0</td>
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</tr>
<tr>
<td>PCT</td>
<td>100</td>
<td>80</td>
<td>60</td>
<td>40</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>PPA</td>
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<td>80</td>
<td>60</td>
<td>40</td>
<td>20</td>
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<tr>
<td>LCP</td>
<td>100</td>
<td>80</td>
<td>60</td>
<td>40</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Ryton® PPS melt-processable grades**

**Glass Fiber and Mineral Filled Compounds**
- **BR111/BR111BL**: Creep resistance, high modulus, dimensional stability
- **R-7-120BL/R-7-120NA**: Arc resistance, dimensional stability
- **R-7-220BL**: Hydrolytic stability, creep resistance, high modulus, dimensional stability

**40% Glass Fiber Reinforced Compounds**
- **BR42B**: Low friction, high wear resistance
- **R-4-200BL/R-4-200NA**: Enhanced strength and toughness
- **R-4-220BL/R-4-220NA**: Exceptional resistance to hot water and engine coolants
- **R-4-230BL/R-4-230NA**: Low flash, high flow, good strength

**Alloy Compounds**
- **XE4050BL**: High impact strength, good thermal stability
- **XE5030BL**: High impact strength, high flow, good thermal stability
- **XE5515BL**: Blow molding and extrusion
- **XK2340**: High strength, exceptionally high flow, precision molding

**Immersion in M30 fuel at 60 °C (140 °F), 2,000 h (M30: 30 % methanol fuel)**
Increased system complexity, higher operating and processing temperatures, reduced weight allowances, and over-crowded engines have made material selection a critical factor. Solvay’s broad selection of high-performance plastics can help you meet these challenges.

Performance Advantages
• High strength and stiffness for good pin retention
• Withstands SMT processing up to 280 °C (536 °F)
• Low moisture absorption prevents blistering
• High flow for thin-wall designs
• Continuous use from –40 to 240 °C (–40 to 464 °F) for 5,000 hours
• Excellent electrical insulating properties
• Excellent dimensional stability

Typical Applications
• Motor end caps
• Sensors
• ECU housings
• Bobbins and solenoids
• Connectors
• Circuit protection/relays
• Actuator housings
• Li-Ion battery systems
• Fuse boxes

<table>
<thead>
<tr>
<th>Application</th>
<th>Ixef® PARA</th>
<th>Amodel® PPA</th>
<th>Ryton® PPS</th>
<th>Veradel® PESU</th>
<th>Udel® PSU</th>
<th>KetaSpire® PEEK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor end caps</td>
<td></td>
<td>●</td>
<td>●</td>
<td></td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>Sensors</td>
<td></td>
<td>●</td>
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<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>ECU housings</td>
<td></td>
<td>●</td>
<td>●</td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>Bobbins and solenoids</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Connectors</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Actuator housings</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>Li-Ion battery systems</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuse boxes</td>
<td></td>
<td>●</td>
<td>●</td>
<td>●</td>
<td></td>
<td>●</td>
</tr>
</tbody>
</table>

Amodel® PPA
Amodel® PPA is compatible with lead-free surface-mount technology (SMT) processing and highly resistant to many commonly used electronic cleaning agents, fuels and automotive fluids. Grades with high strength and high elongation are well-suited for snap-fit designs.

Ryton® PPS
Due to the inherent thermal stability of PPS, the dielectric properties of Ryton® PPS compounds remain stable over a wide range of temperatures and frequencies.

Udel® PSU and Veradel® PESU (polysulfone and polyethersulfone)
Sulfone polymers retain their mechanical strength in some of the toughest environments. Unfilled grades offer excellent ductility and are available in a range of transparent colors. Udel® PSU has an HDT of 174 °C (345 °F) and provides excellent dimensional and hydrolytic stability. Veradel® PESU has an HDT of 204 °C (399 °F) and offers better chemical resistance than Udel® PSU resins.
Lower Moisture Prevents Blistering
Blistering is primarily caused by water vaporizing during SMT processing. Amodel® PPA absorbs significantly less moisture than standard polyamides, making it an excellent candidate for SMT processing up to 280 °C (536 °F).

Better Mechanical Properties and Faster Cycle Times
Amodel® PPA delivers strength, toughness and impact resistance along with low moisture absorption, high HDT and faster injection molding cycle times.

One-minute solder dip test

<table>
<thead>
<tr>
<th>Polymer</th>
<th>250 °C (482 °F)</th>
<th>260 °C (500 °F)</th>
<th>270 °C (518 °F)</th>
<th>280 °C (536 °F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amodel® PPA</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
</tr>
<tr>
<td>Xydar® LCP</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
</tr>
<tr>
<td>Ryton® PPS</td>
<td>OK</td>
<td>Blisters</td>
<td>Blisters</td>
<td>Blisters</td>
</tr>
<tr>
<td>PA 4.6</td>
<td>OK</td>
<td>Blisters</td>
<td>Blisters</td>
<td>Blisters</td>
</tr>
</tbody>
</table>
| Test bars conditioned at 23 °C (74 °F) in 50% relative humidity for 48 hours.

Heat deflection temperature

Veradel® has better thermal performance in lower thickness.

Typical Applications

Motor End Cap
- Flatness
- Dimensional stability
- Thermal cycling from −40 to 150 °C (−40 to 302 °F)
- 1,000 hrs/180 °C (356 °F) heat aging
- Resistant to road salt
- Creep resistant
- 30% weight reduction

ECU Housing
- USCAR PF1 Class 4
- Balance of strength and toughness
- High dielectric strength
- High comparative tracking index
- Excellent insulating capability
- Compatible with lead-free soldering reflow
- High temperature resistant to 190 °C (374 °F)

Lighting
- High heat resistance
- Class A surface finish
- Inherently flame retardant
- Platable
**Amodel® AE Grades**

**Eliminates Corrosion of Metal Inserts**

Sensors, solenoids and connectors use molded components that are in direct contact with conductive metal inserts. Traditional CuI/KI heat stabilizers in polyamides can sensitize an application to galvanic corrosion and ionic migration which can cause the failure mode of intermittent, erratic or loss of component electrical function. AE grades eliminate this sensitivity.

Components made from products in the Amodel® AE-8900 series provide high-voltage resistance and retain dielectric properties at elevated temperatures. They also extend the performance envelope beyond the Amodel® AE-1100 and AE-4100 series by delivering greater resistance to automotive fluids, enhanced thermal properties, higher mechanical strength and lower moisture absorption.

**Reduces Ionic Migration**

Ionic migration is an electrochemical process where metal on an insulating material in high humidity and under an applied electric field leaves its initial location in ionic form and re-deposits somewhere else. Such migration can reduce isolation gaps and ultimately lead to an electrical short circuit.

**Solves Galvanic Corrosion**

Galvanic corrosion is an electrochemical process in which one metal corrodes preferentially to another when both metals are in electrical contact, in the presence of an electrolyte. It is similar to ionic migration without needing an electrical field. This type of corrosion can lead to loss of electrical performance.

**Performance Advantages**

- Solution for miniaturization and high pin densities
- Water moldable to “Green” option
- Excellent dielectric performance of 600V CTI at 150 °C (302 °F)
- Suitable for lead-free soldering
- High HDT, blister free, dimensional stability

**Amodel® AE Grades**

**AE-4133**

- Hot-water moldable
- Fast cycling
- High HDT for soldering process

**AE-89xx series**

- Highest retention of mechanical properties
- Best retention of dielectric properties at 150 °C (302 °F)
Transmissions and Launch Devices

Smaller, more complex transmissions must deliver higher performance and better fuel economy, yet cost less to manufacture. Solvay’s broad selection of high-performance plastics can help you meet these challenges.

Better than Metal
• Light weight for improved fuel efficiency
• Parts consolidation for lower manufacturing and assembly costs
• Noise and vibration dampening
• Compatible with transmission fluids
• Abrasion and corrosion resistance
• High-temperature wear resistance in dry and lubricated environments

Transmission & Launch Devices
• Dual clutch (DCT)
• Automated manual (AMT)
• Continuously variable (CVT)
• Automatic (AT)
• Torque converter
• Dual mass flywheel
• Power takeoff
• Clutch cylinder

<table>
<thead>
<tr>
<th>Application</th>
<th>Ixef&lt;sup&gt;®&lt;/sup&gt; PARA</th>
<th>Amodel&lt;sup&gt;®&lt;/sup&gt; PPA</th>
<th>Ryton&lt;sup&gt;®&lt;/sup&gt; PPS</th>
<th>KetaSpire&lt;sup&gt;®&lt;/sup&gt; PEEK</th>
<th>AvaSpire&lt;sup&gt;®&lt;/sup&gt; PAEK</th>
<th>Torlon&lt;sup&gt;®&lt;/sup&gt; PAI</th>
<th>Tecnoflon&lt;sup&gt;®&lt;/sup&gt; FKM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thrust washers</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Seal rings</td>
<td>●</td>
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<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Check balls</td>
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<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Shift forks</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
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<td>●</td>
</tr>
<tr>
<td>Bearing cages</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Hydraulic pistons</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
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<tr>
<td>Shaft seals</td>
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<td>●</td>
</tr>
<tr>
<td>Bonded pistons</td>
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<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Clutch cylinders</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>

Torlon<sup>®</sup> PAI (polyamide-imide)
Torlon<sup>®</sup> PAI provides exceptional wear resistance in both dry and lubricated environments and retains its toughness, high strength and high stiffness up to 275°C (525°F). It exhibits outstanding creep and chemical resistance – including strong acids and most organics – and is ideally suited for harsh environments.

KetaSpire<sup>®</sup> PEEK
KetaSpire<sup>®</sup> PEEK combines exceptional strength, stiffness, chemical resistance and fatigue resistance with continuous-use up to 240°C (464°F), enabling it to replace metal in some of the most severe end-use environments.

Tecnoflon<sup>®</sup> FKM
Tecnoflon<sup>®</sup> FKM offers a broad range of temperature resistance capabilities from –40 to 250°C (–40 to 482°F) at air section. Through our unique production technology, Tecnoflon<sup>®</sup> FKM eliminates costly processing steps, produces higher yields and increases cost efficiency.

Amodel<sup>®</sup> PPA
Amodel<sup>®</sup> PPA is stronger, stiffer and has higher thermal capabilities than standard nylons. It is less sensitive to moisture and retains excellent mechanical properties – including fatigue and creep resistance – when exposed to a wide range of operating temperatures, high humidity and aggressive chemicals.
### Wear-resistant Polymers for Transmissions and Launch Devices

<table>
<thead>
<tr>
<th>Torlon® PAI</th>
<th>Dry</th>
<th>Lubricated</th>
<th>Seal Rings</th>
<th>Thrust Washers</th>
<th>Check Balls</th>
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<td>Small rings, high elongation</td>
<td>High lubrication</td>
<td>Compressive properties</td>
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<td>KetaSpire® PEEK</td>
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<td>KT-820 SL31</td>
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<td>AvaSpire® PAEK</td>
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<td>AV-755 SL45</td>
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<td>Large rings</td>
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<td>Amodel® PPA</td>
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</tbody>
</table>

### Typical Applications

- **Seal Rings**
  - Excellent sealing and conformability
  - High ductility for easier installation of small rings
  - Molded-in joint geometries provide cost savings
  - Excellent wear properties in dry and lubricated environments

- **Thrust Washers, Thrust Bearings, Needle Bearing Replacements**
  - Low creep
  - High compressive strength
  - Low coefficient of friction
  - Excellent wear properties in dry and lubricated environments
  - Suitable for very high pressures and velocities
  - Molded-in oil grooves eliminate secondary machining costs

- **Check Balls**
  - Excellent sealing and conformability
  - High compressive strength
  - Low creep
  - Lighter than metal for quicker response
  - Non-destructive to metal seat
  - Noise reduction
**Torlon® PAI**

Torlon® PAI offers the highest strength and stiffness of any thermoplastic up to 275 °C (527 °F). Its outstanding wear, creep and chemical resistance make it ideal for severe service environments.

**Key Features**

- Very high strength and stiffness to 275 °C (527 °F)
- Superior toughness from cryogenic to 275 °C (527 °F)
- Exceptional wear resistance
- Resistant to strong acids and most organics
- Inherent flame resistance
- Low CLTE

High-strength grades deliver metal-like performance and are routinely specified for precision components used in repetitive-use, load-bearing operations. Glass fiber and carbon fiber filled grades retain their strength and stiffness at high temperatures with the added benefit of low creep and excellent fatigue resistance.

Wear-resistant grades offer select combinations of mechanical and tribological properties. Their inherent heat and chemical resistance, makes them an effective alternative to metal in high-temperature friction and wear applications – even when lubrication is marginal or non-existent. Select grades can perform in lubricated environments at exceptionally high pressures and velocities (PV).

**Mechanical performance at high temperature**

[Graph showing shear modulus vs. temperature for Torlon® PAI, TPI, PEEK, and PI.]

(1) Data generated by Dynamic Mechanical Thermal Analysis (DMTA).
Traction Motors and Power Electronics

Hybrids, Plug in Hybrids, Battery Electric Vehicle, Fuel Cell Vehicles

As the most critical component of electrified powertrain in electric vehicles, lithium-ion batteries are the key for the xEV performance. A safe, robust battery (module) pack can help ensure the safety and durability of the xEv.

Improved Battery Performance
- Higher energy density for better mileage
- Higher power density to achieve excellent drivability and fast charge
- Longer lasting to extend vehicle’s service life
- Safer under critical operation conditions

Durable and Safe Battery packs
- Outstanding mechanical properties
- High safety under extreme conditions
- Efficient cooling system of packs
- Light weight

<table>
<thead>
<tr>
<th>Application</th>
<th>Amodel® PPA</th>
<th>Solef® PVDF</th>
<th>Galden® PFPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Binders for electrodes</td>
<td>●</td>
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<tr>
<td>Separator coatings</td>
<td>●</td>
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<tr>
<td>Battery pack casings</td>
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<tr>
<td>Battery pack cooling systems</td>
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</tbody>
</table>

Solef® PVDF (polyvinylidene fluoride)

Binders for Electrodes
Solef® PVDF provides the outstanding binding function among the electrode active materials as well as with the current collecting substrate, which can be realized by only very low usage amount. Very high electrochemical stability up to 5V due to its exceptional chemical stability.

Separator Coatings
Both suspension and emulsion grades of Solef® PVDF provide excellent adhesion and pore forming properties with or without ceramic on various separator substrate. It also provides remarkable chemical resistance in electrolytes and high electrochemical stability at high voltage.

Amodel® PPA
Amodel® PPA is stronger, stiffer and has higher thermal capabilities than standard nylons. It is less sensitive to moisture and retains excellent mechanical properties – including fatigue and creep resistance – when exposed to wide range of operating temperatures, high humidity and aggressive chemicals.

Galden® PFPE (perfluoropolyether)
Galden® PFPE is an inert, dielectric, high-performance heat transfer fluid that allows precise control of the battery pack temperature.
**Solef® PVDF Binders for Durable, High Performance Batteries**

Adding a small amount of Solef® PVDF can significantly improve battery pack performance while reducing cost. A reduction of binder concentration that corresponds to higher amount of active material will reduce cost at the cell level which translates to a significant savings on the EV battery pack. Cost savings are realized by both battery relative capacity and increased lifetime. Solvay is using its in-depth knowledge of fluoromaterials to increase the stability and lifetime of these polymeric binders to the Li-ion cells.

Solef® 5130 and Solef® 5120 are third generation binders that combine high adhesion and good processability for increased battery performance.

Solvay is the only PVDF supplier that uses both emulsion and suspension polymerization technologies, thereby producing a broader PVDF portfolio for anode, cathode and separator applications in Li-ion batteries.

**PVDF grades for binder**

<table>
<thead>
<tr>
<th>Solef® 6010</th>
<th>PVDF standard homopolymer</th>
<th>Standard for cathode and anode</th>
<th>1st Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solef® 6020</td>
<td>PVDF homopolymer with high MW</td>
<td>Improved binder for cathode and anode</td>
<td>2nd Generation</td>
</tr>
<tr>
<td>Solef® 5130</td>
<td>Modified PVDF, high viscosity</td>
<td>New grade for cathode and anode with highest performances</td>
<td>3rd Generation</td>
</tr>
<tr>
<td>Solef® 21216</td>
<td>PVDF-HFP flexible copolymer</td>
<td>Acetone-based processing, high thickness electrodes</td>
<td>Flexible Binder</td>
</tr>
<tr>
<td>Solef® Flex PVDF</td>
<td>Experimental PVDF-based material</td>
<td>Flexible electrodes, conformable (shaped) cells</td>
<td>Flexible Binder, High Adhesion</td>
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<tr>
<td>Solef® 5120</td>
<td>Modified PVDF, medium viscosity</td>
<td>New grade for cathode and anode with high performance</td>
<td></td>
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</tbody>
</table>
Solef® PVDF for High-Performance, Safe Separators

To reinforce the safety and the performance of the Li-Ion batteries, surface coatings with ceramics have become more popular in the industry, especially for xEVs.

Solvay provides various grades of Solef® PVDF based on our expertise in fluorinated polymers and in-depth knowledge of separator coatings.

Solef® PVDF’s intrinsic chemical/electrochemical stability combined with Solvay’s cutting edge technology ensures the excellent adhesion and cohesion among ceramic particles and separator substrates. The coated layers containing ceramic particles promote battery safety in critical conditions, especially at high temperatures. They also improve overall power performance and extend product life thanks to the laminating effects with electrodes.

Both suspension and emulsion grades of Solef® PVDF can be supplied to the customers to comply with different processing conditions, technologies and specific requirements.

Amodel® PPA and Galden® PFPE for Electric Vehicle Battery Packs

Amodel® PPA is a lightweight alternative to metal that withstands the harsh operating conditions of xEV battery packs. The material’s high thermal stability makes it particularly suited for thermal insulation between inside and outside the packs. Its broad chemical resistance provides extra protection in extreme conditions, such as leakage of carbonate-based electrolytes.

Thermal management is a critical requirement for battery packs, enabling them to work safely and efficiently in confined, high heat conditions. Liquid cooling systems, which are today’s most efficient battery pack cooling systems, benefit from Galden® PFPE’s high thermal conductivity, low electrical conductivity, low viscosity and broad chemical resistance. PFPE also enables OEMs to precisely control the operating temperature within the battery pack.
**Structural and Semi-Structural Lightweighting**

Solvay’s Long Fiber Thermoplastics (LFT) products target challenging metal replacement applications and semi-structural applications, opening new opportunities in terms of weight reduction, function integration and per part costs.

Exceptional performances of LFT products result from the creation of a unique 3-D entangled long glass fiber skeleton inside the molded part. Solvay’s LFT compounds differ by the type of polymer resin used as well as the quantity of fiber reinforcement. They are available under the brands Omnix® LF, Amodel® LF, Ixef® LF and Ryton® LF.

**Performance Advantages**
- Combination of high stiffness and outstanding impact strength
- Excellent retention of mechanical performance at high temperature
- Extremely low tendency to creep under high permanent loading
- Outstanding fatigue resistance
- Isotropic mold shrinkage
- High dimensional stability/low warpage
- High shear strength and high burst pressure
- Excellent surface finish

**Typical Applications**
- Gears and bearings
- Sunroofs
- Brackets and mounts
- Electrical battery housings
- Thermal management components
- Braking system elements
- Pump and EGR systems

<table>
<thead>
<tr>
<th>Application</th>
<th>Ixef® LF PARA</th>
<th>Amodel® LF PPA</th>
<th>Ryton® LF PPS</th>
<th>Omnix® LF HPPA</th>
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</thead>
<tbody>
<tr>
<td>Gears &amp; bearings</td>
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<td>Sunroofs</td>
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<td>Electrical battery housings</td>
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<td>Thermal management</td>
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<td>Pump and EGR systems</td>
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</table>

**Typical Applications**

**Gear**
- Isotropic behavior and dimensional stability
- Wear performance
- Low noise generation
- High stiffness in a wide T range
- Fatigue performance

**Sunroof**
- High strength and stiffness
- Dimensional stability
- Fatigue resistance

**BMW M4 GTS Hood**
- Rapid cure thermoset resin system SolvaLite™ 760
- DMA E’ onset T_g of 135 °C
- Superior toughness
- Successful head impact crash and functional tests
- 40 % weight reduction over traditional materials
- Class-A finish
- Compatible with existing metal stamping assets for composite production
Safety Data Sheets (SDS) are available by emailing us or contacting your sales representative. Always consult the appropriate SDS before using any of our products.

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