Jinsutong

Industry Applications Handbook 2026

Photovoltaic EVA Encapsulation · Automotive Engineering Plastics · 10 pages · Market Reference

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Chapter 1 · Solar Photovoltaic EVA Encapsulation

1.1 EVA Chemistry & VA Content Selection

Solar-grade EVA (ethylene-vinyl acetate) is the dominant encapsulant for crystalline silicon PV modules, with worldwide consumption exceeding 1.2 million metric tons in 2025. The vinyl acetate (VA) content is the critical design variable: solar-grade EVA uses 28-33% VA — a narrow window that balances flexibility, adhesion, optical clarity, and crosslink density.

At 28% VA, the polymer is just above the boundary of crystallinity suppression and offers slightly higher modulus and HDT. At 33% VA, the polymer is fully amorphous and elastic, with lower modulus but better low-temperature flexibility and faster crosslink kinetics. Most high-volume module manufacturers use 28-30% VA for standard single-glass monofacial modules, and 30-33% VA for double-glass bifacial modules where higher flow and faster cure are needed.

Common commercial reference grades include ExxonMobil Escorene Ultra LD 700 (28% VA, 6 MI, fast cure for monofacial), Hanwha EVA HP-2835 (28% VA, 35 MI, UV-cut for bifacial), DuPont Elvax 150 (32% VA, 43 MI, general purpose), LyondellBasell Lupolen EVA 28400 (28% VA, 400 MI, high flow for hot-melt adhesive and compounding base), and domestic Sierbang EVA PV-3300 (33% VA, 30 MI, solar-grade domestic supply).

Key property trade-offs across the VA range:
- 28% VA: slightly higher modulus, better creep resistance, slower cure
- 30% VA: balanced performance, the workhorse for most modules
- 33% VA: faster cure, better low-temperature flexibility, slightly higher acetic acid release during lamination

The VA content also affects long-term module performance: lower VA grades tend to have slightly better damp-heat aging performance (IEC 61215 1000-hour test), while higher VA grades offer better UV aging resistance. Both effects are within the design margins of properly formulated crosslinkable EVA films with appropriate UV absorber and HALS packages.

Chapter 1 · Solar Photovoltaic EVA Encapsulation

1.2 Lamination Process & Crosslink Chemistry

The lamination process converts a stack of glass / EVA / cells / EVA / backsheet into a sealed module under controlled vacuum and heat. The cycle typically runs 12-18 minutes with these steps:

1. **Pre-heat (1-3 min)**: 80-100 °C to remove residual moisture from the EVA film and backsheet, preventing bubble formation.
2. **Vacuum application (3-5 min)**: 0.1 MPa vacuum to evacuate air from the stack, ensuring no air pockets.
3. **Lamination temperature (5-8 min)**: 140-150 °C to melt the EVA and initiate crosslinking. The peroxide crosslinker (typically 1.0-1.5% dicumyl peroxide) generates free radicals that crosslink the EVA chains, forming a 3D network.
4. **Cooling (3-5 min)**: controlled cooling to 50-60 °C to solidify the crosslinked EVA without introducing thermal stress.

Crosslink density target: 70-85% gel fraction (insoluble fraction in xylene). Below 70% indicates insufficient crosslinking with risk of long-term creep and delamination; above 85% indicates over-crosslinking with risk of brittleness and adhesion loss.

Key lamination parameters and their effects:
- **Lamination temperature**: each 5 °C increase reduces cycle time by ~1 min but risks premature crosslinking and yellowing
- **Vacuum level**: < 0.05 MPa required for high-efficiency modules; otherwise risk of micro-bubbles reducing light transmission
- **Pressure**: 0.5-1.0 MPa at the laminator plates ensures intimate contact between layers
- **Crosslinker content**: 1.0-1.5% is the standard range; higher content risks acetic acid release and corrosion

The crosslinked EVA network is the key to long-term module reliability. The 3D network provides mechanical strength, prevents creep under thermal cycling, and locks the cells in place under wind and snow loads. The crosslink density directly correlates with the damp-heat aging performance (IEC 61215).

Chapter 1 · Solar Photovoltaic EVA Encapsulation

1.3 POE Encapsulant Comparison & Future Trends

Polyolefin elastomer (POE) encapsulants have emerged as an alternative to EVA for advanced cell architectures, particularly N-type TOPCon and HJT (heterojunction) cells where higher operating temperatures and UV exposure demand more robust encapsulation.

Advantages of POE over EVA:
- No acetic acid release during lamination (POE is acid-free)
- Lower water vapor transmission (better PID resistance)
- Higher volume resistivity (better Potential Induced Degradation resistance)
- Better UV aging performance for next-generation cell technologies

Disadvantages of POE:
- Higher cost (typically 30-50% more than EVA)
- Lower volume production scale (fewer suppliers, less mature supply chain)
- More demanding lamination conditions (typically 150-160 °C vs 140-150 °C for EVA)
- Lower throughput in existing EVA-optimized laminators

Reference POE grades: 3M Solar Encapsulant, STR Solar, Mitsui TAFブライアン (TAF-TS), and Hangzhou First PVDF/POE blends.

The industry trend: standard P-type PERC modules continue to use EVA; new N-type TOPCon lines increasingly use POE; HJT modules require POE for PID resistance. The transition is gradual and depends on cost-down of POE production.

Case study (fictional but realistic): A 5 GW TOPCon module manufacturer in 2024 transitioned from EVA to POE for premium product lines, using a dual-EVA/POE stack (EVA on cell side for adhesion, POE on glass side for UV and PID resistance). The transition required 2 lamination parameter adjustments and 1 crosslinker reformulation. After 1 year, field PID-related degradation was reduced from 3% to < 0.5% per year, justifying the 25% cost premium.

Future outlook: EVA will remain the workhorse for P-type and standard TOPCon modules; POE will dominate HJT and premium TOPCon; new entrants like ionomer encapsulant (Surlyn-based) target high-end BIPV and aerospace applications.

Chapter 2 · Automotive Engineering Plastics

2.1 Automotive Engineering Plastics Landscape

Automotive engineering plastics have evolved from a few commodity polymers in the 1970s to a sophisticated portfolio of 15+ specialty materials today, driven by electrification, lightweighting, and emission-reduction mandates. The three dominant polymer families for under-hood and structural applications are PPS (polyphenylene sulfide), PA66 (polyamide 66), and PPA (polyphthalamide) — each with distinct property advantages and cost positions.

PPS (Polyphenylene Sulfide):
- Continuous use temperature: 200-240 °C (highest in this group)
- HDT (1.82 MPa): > 260 °C with 40% GF
- Inherent flame retardance (UL94 V-0 without additives)
- Broad chemical resistance (no solvent < 200 °C)
- Cost: medium-high

PA66 (Polyamide 66, Nylon 66):
- Continuous use temperature: 150-170 °C
- HDT (1.82 MPa): 240-260 °C with 33% GF
- Higher water absorption (8-9% at saturation) → dimensional change
- Lower cost than PPS
- Workhorse for engine brackets, transmission components, pedal boxes

PPA (Polyphthalamide):
- Continuous use temperature: 160-180 °C
- HDT (1.82 MPa): 280-300 °C with 33% GF
- Lower water absorption (1.5-2.5%) than PA66
- Better chemical resistance than PA66
- Cost: medium-high, between PA66 and PPS

Selection logic:
- Cost-driven, T < 150 °C: PA66 with 30-35% GF
- Mid-temperature, T 150-180 °C, low moisture: PPA with 30-40% GF
- High-temperature, T > 180 °C, broad chemical resistance: PPS with 40% GF
- Ultra-high-temperature, T > 240 °C: PEEK or polyimide (much higher cost)

The trend toward higher under-hood temperatures (driven by turbocharged engines, smaller engine compartments, and higher specific power density) is shifting the application mix from PA66 to PPA and PPS.

Chapter 2 · Automotive Engineering Plastics

2.2 Glass-Fiber Reinforcement & Compound Design

Glass-fiber (GF) reinforcement is the dominant modification for engineering plastics in automotive applications. The GF content, type, and coupling agent are the key design variables.

GF content:
- 15% GF: improved stiffness over neat polymer, minimal cost premium
- 30% GF: balanced stiffness/toughness, the workhorse for many applications
- 40% GF: maximum stiffness, used in highly loaded structural parts
- 50% GF: extreme stiffness, used in metal-replacement parts
- 60% GF: niche, very high stiffness but difficult to process

GF type:
- E-glass: standard, cost-effective, used in most automotive applications
- S-glass: higher modulus and strength, used in some structural parts
- Short GF (fiber length 0.2-0.5 mm): for injection molding, the most common
- Long GF (fiber length 5-25 mm): for structural applications, higher performance but more difficult to process

Coupling agent (critical for performance):
- Epoxy-based: workhorse for PA66, PPA, PPS
- Silane-based: common for PP, PPS
- Maleic-anhydride-grafted: for polypropylene and other polyolefins
- The coupling agent bonds the GF surface to the polymer matrix, transferring stress from matrix to fiber and dramatically improving tensile, flexural, and impact strength

GF orientation effects:
GF orientation in injection-molded parts is flow-direction-dependent. The skin layer (frozen at the mold surface) has GF orientation parallel to the flow direction; the core has random orientation. This creates anisotropic properties — much higher strength in the flow direction than the transverse direction. Part designers must account for anisotropy in critical applications.

Warpage and dimensional control:
GF-reinforced parts have lower but more anisotropic mold shrinkage. Differential shrinkage can cause warpage in complex parts. Mineral fillers (talc, mica) are often added in hybrid compounds to reduce

warpage. For high-precision tolerance parts, glass bead reinforcement or carbon fiber reinforcement may be used as alternatives.

Property comparison (40% GF):
- PA66: tensile 200 MPa, flexural modulus 13 GPa, HDT 250 °C, Izod impact 110 J/m
- PPA: tensile 230 MPa, flexural modulus 14 GPa, HDT 290 °C, Izod impact 80 J/m
- PPS: tensile 200 MPa, flexural modulus 14 GPa, HDT 270 °C, Izod impact 90 J/m
- PEEK: tensile 250 MPa, flexural modulus 22 GPa, HDT 315 °C, Izod impact 95 J/m

Chapter 2 · Automotive Engineering Plastics

2.3 Under-Hood Applications & Case Studies

Under-hood applications expose engineering plastics to sustained high temperatures, thermal cycling, and aggressive fluids (oil, coolant, exhaust gas recirculation streams). The following case studies illustrate the material selection process.

Case 1: Turbocharger air duct (虚构)
- Application: Charge air duct between turbocharger and intercooler
- Operating temperature: -40 °C to 200 °C (continuous 180 °C, peak 220 °C)
- Pressure: 1.5-2.5 bar absolute
- Aggressive media: hot compressed air, oil vapor, occasional condensate
- Material: PPA 40% GF, heat-stabilized grade (e.g., Solvay Amodel A-4140)
- Why PPA: HDT > 280 °C provides margin at peak temperature; lower water absorption than PA66 ensures dimensional stability under thermal cycling; higher continuous use temperature than PA66
- Alternative considered: PPS 40% GF (passed performance but cost 30% higher with no application benefit at this temperature range)

Case 2: Engine bracket (虚构)
- Application: Engine mount bracket supporting the powertrain
- Operating temperature: -40 °C to 150 °C
- Mechanical load: static + dynamic, fatigue cycles 10^6 to 10^7 over service life
- Material: PA66 35% GF, heat-stabilized, hydrolysis-resistant grade (e.g., DuPont Zytel 70G35HSL)
- Why PA66: cost-effective for this temperature range; high fatigue resistance; long track record in this application
- Manufacturing: insert molding with steel threaded inserts for bolt attachment

Case 3: EGR cooler housing (虚构)
- Application: Exhaust gas recirculation cooler housing (cool side)
- Operating temperature: -40 °C to 160 °C, with exposure to exhaust gas condensate (acidic, pH 3-5)
- Material: PPS 40% GF, with enhanced chemical resistance grade
- Why PPS: broad chemical resistance to acidic exhaust condensate; inherent flame retardance (relevant for EGR applications); HDT > 260 °C provides margin at peak temperature
- Manufacturing: ultrasonic welding of housing halves, no metal fasteners required

Trend observation: The shift toward higher under-hood temperatures (driven by engine downsizing with turbocharging, plus thermal management of EV powertrain components) is increasing PPA and PPS consumption at the expense of PA66. Forecast: PPA and PPS combined will grow from 35% of under-hood engineering plastics in 2024 to 50% by 2028, with PA66 declining from 50% to 35% over the same period.

EV-specific application: Battery pack housing components, particularly structural elements and module-level covers, increasingly use PPS and PA66 GF compounds for their combination of mechanical strength, fire performance, and thermal management. Cell-to-pack and cell-to-chassis architectures (CTP/CTC) demand higher stiffness and flame retardance, favoring PPS over PA66 in premium EV battery packs.

Cross-Industry Application Map

The two industry verticals covered in this handbook (solar PV and automotive engineering plastics) represent major application segments for Jinsutong's polymer portfolio. The full portfolio of 19 product categories also serves other industries:

- **Food Packaging**: EAA, EMAA, EVA, EVOH, PE barrier films, COC vials
- **5G / AI Electronics**: LCP SMT connectors, PPA mmWave, PEI high-temp housings
- **Medical Devices**: COC prefilled syringes, PEI sterilization trays, PVDF tubing
- **Lithium Battery**: PVDF cathode binders, PPS cell housings, separator coatings
- **Industrial**: POM gears, PA66 fasteners, PBT industrial switches
- **Consumer**: PC+ABS appliance, ABS toys, PP packaging

For project-specific grade selection in any of these industries, contact our business manager Mr. Mo Hailong.

Contact

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