



UNSATURATED POLYESTER RESINS (UPR)

The Hidden Hero of the Composite World

INTRODUCTION

Unsaturated polyester resins form the backbone of today's composite materials industry.

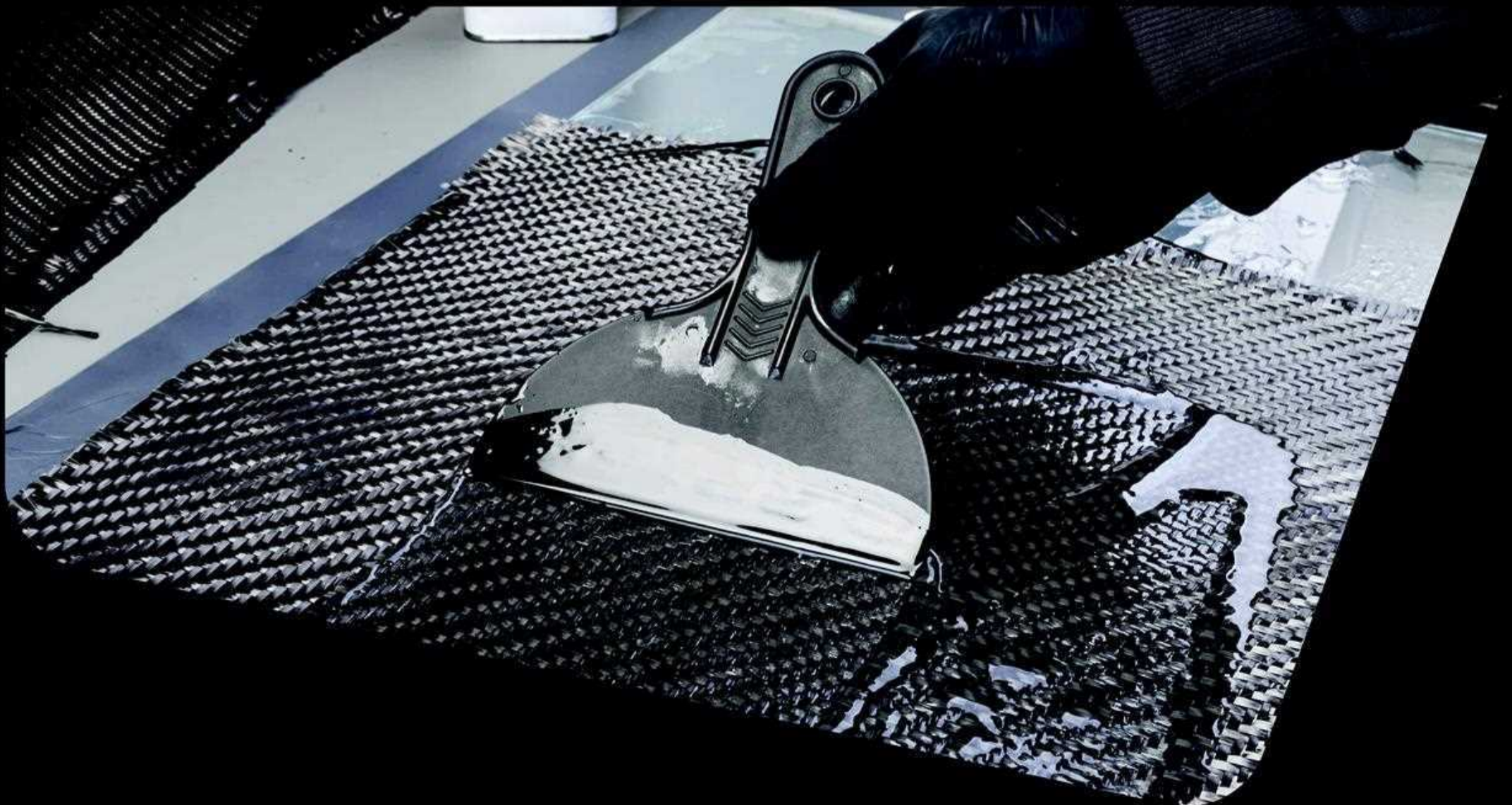
First commercialized in the 1930s, these thermoset plastics combine low cost with high mechanical strength.

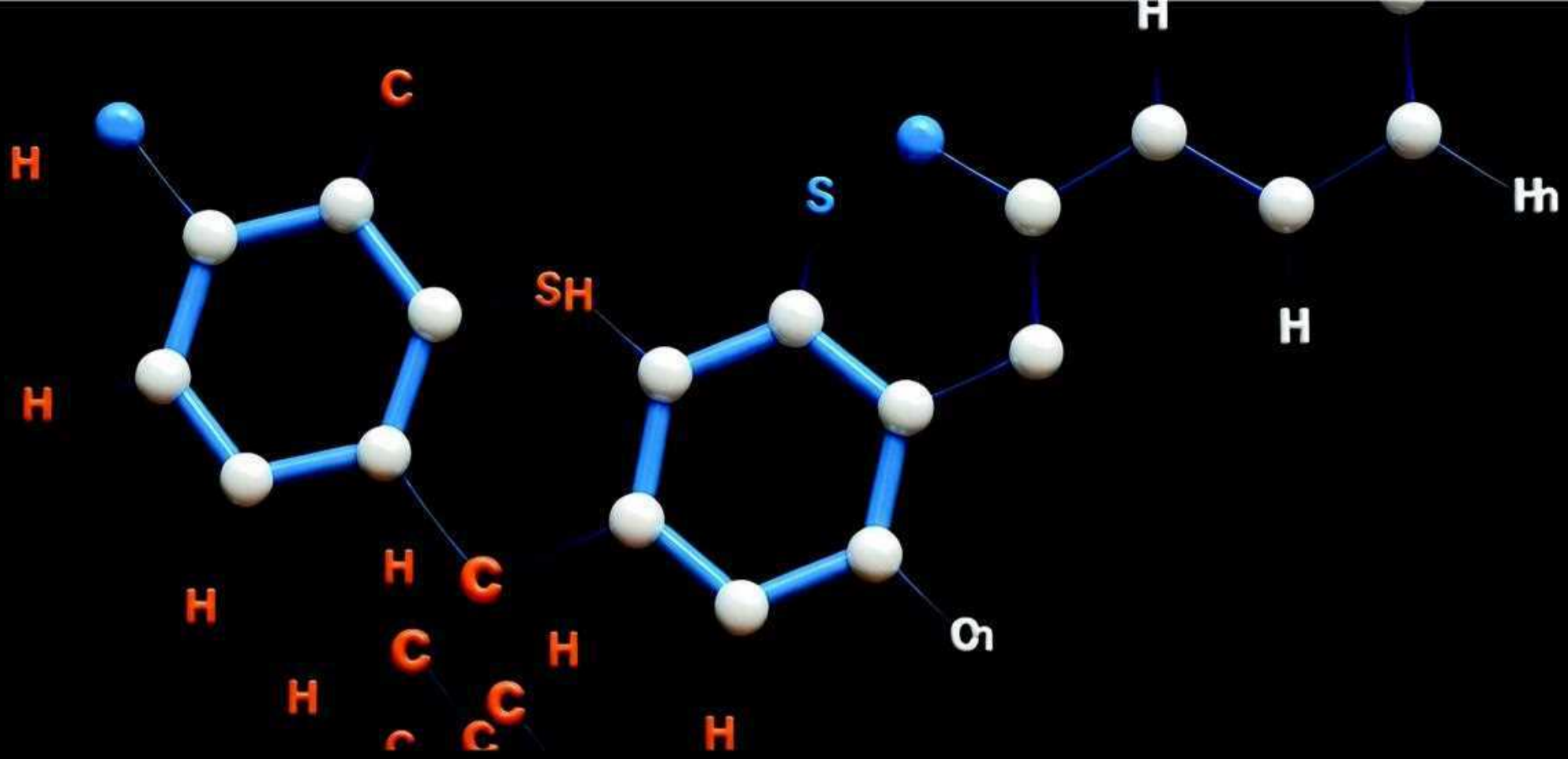
Their biggest advantage: They cure at room temperature

Every day we touch dozens of products made with UPR without realizing it:

- Boat hulls
- Automotive body panels
- Wind turbine blades
- Construction profiles

How does this material work and why is it so widespread?





CHEMICAL STRUCTURE & COMPONENTS

KEY RAW MATERIALS:

Unsaturated Acid (Maleic Anhydride)
 → Provides reactive double bonds

Saturated Acid (Phthalic Anhydride)
 → Controls chain stiffness

Glycol (Propylene Glycol)
 → Forms ester linkages

Styrene Monomer
 → Crosslinking agent and diluent

The term "unsaturated" refers to carbon-carbon double bonds deliberately built into the polymer backbone. These bonds act as "chemical hooks."

Styrene monomer grabs these hooks, bridging polymer chains together. The result: a three-dimensional, rigid, and durable network.

Styrene makes up 35-45% of the resin. This ratio controls both viscosity and final hardness.

THE CURING PROCESS

STAGE 1 — GEL TIME

The resin transforms from liquid to a soft gel. Polymer chains begin forming a three-dimensional network.

Typical time: 10-30 minutes

Tip: Gel time can be adjusted by cobalt accelerator amount.

STAGE 2 — HARDENING

The exothermic reaction accelerates. Temperature can reach 150-180°C. Thick sections risk overheating and thermal degradation.

STAGE 3 — POST-CURE

Full mechanical strength develops over days. Complete cure at ambient temperature takes 7-14 days.





FIBER REINFORCEMENT

UPR alone is brittle. But combined with glass fiber, a perfect material emerges.

Just like the concrete-steel relationship:

Resin = Concrete

Fiber = Rebar

Silane coupling agents build molecular bridges between the two materials.

Fiberglass is the dominant reinforcement with 90% market share.

Glass fiber + UPR = 5x lighter than steel, 3x stronger than concrete.

Main production methods:

- Hand lay-up — open mold
- Filament winding — pipes/tanks
- Pultrusion — constant profiles
- SMC/BMC — automotive press molding

Critical factor: Fiber-resin interface quality. Silane coupling agents act as "molecular glue."

KEY APPLICATION AREAS

MARINE

The largest UPR consumer. Boat hulls, decks, bulkheads manufactured with glass-reinforced UPR. Gel coats provide glossy waterproof exterior.

WIND ENERGY

Massive turbine blades (80m+) produced via vacuum infusion. High fatigue resistance is essential.

AUTOMOTIVE

SMC/BMC compounds enable Class A surface finishes for body panels. Lightweighting improves fuel efficiency.

CONSTRUCTION

Corrosion-resistant pipes, tanks, FRP rebar. Translucent roofing sheets for greenhouses.



BIO-BASED INNOVATIONS



Petroleum-based raw materials are being replaced by plant-derived alternatives.

- Carbon footprint reduced by 40-60%
- Less fossil fuel dependency
- Agricultural waste enters the economy

Corn stover, sugarcane bagasse, soybean oil, and lignin are now used in UPR production.

Bio-based chemicals like furans and isosorbide form the resin skeleton.

Result: Same mechanical strength, much lower environmental impact. Life cycle analyses show up to 90% carbon reduction.

NEXT: COBALT-FREE & RECYCLABLE

ENZYME TECHNOLOGY

Researchers at RWTH Aachen University developed a peroxygenase enzyme that replaces cobalt, curing the resin safely. Performance improved by 250%.

User benefit: Safer production, no carcinogenic risk.

VITRIMER CHEMISTRY

The rule "once cured, forever solid" is breaking.

Vitrimers contain dynamic covalent bonds. When heated, bonds dissolve; when cooled, they re-form.

This enables:

- Reshaping
- Self-healing
- End-of-life recycling



FUTURE & SUSTAINABILITY

The UPR industry is focused on three major goals:

- **CIRCULAR ECONOMY:** Zero waste, infinite reuse.
- **GREEN CHEMISTRY:** Plant-based sources, low VOC, carbon neutral.
- **WORKER SAFETY:** Cobalt-free, odor-free, safe production.

This transformation is not a burden, it's an opportunity. It offers cleaner production, smarter materials, and new market advantages.



CONCLUSION & REFERENCES

UPR is not a material of the past — it's the material of the future.

- Low cost and high performance
- Room temperature processability
- Bio-based and recyclable next generation
- Wide applications from marine to wind energy



REFERENCES

- Mallick, "Fiber-Reinforced Composites," CRC Press, 2007
- Grand View Research, Synthetic Polymer Market, 2024
- European Coatings Journal, "Cobalt-Free Accelerators," 2023
- Montarnal et al., "Silica-Like Malleable Materials," Science, 2011
- RWTH Aachen, "Enzymatic Curing of UPR," ACS Publications, 2024

www.polrespolyester.com.tr | info@polrespolyester.com.tr