



Creating a Fibreglass (GRP) Laminate

Strategies to help generate high quality composites.

Preparation, storage and usage of unsaturated polyester resin for glass fibre-based laminates.

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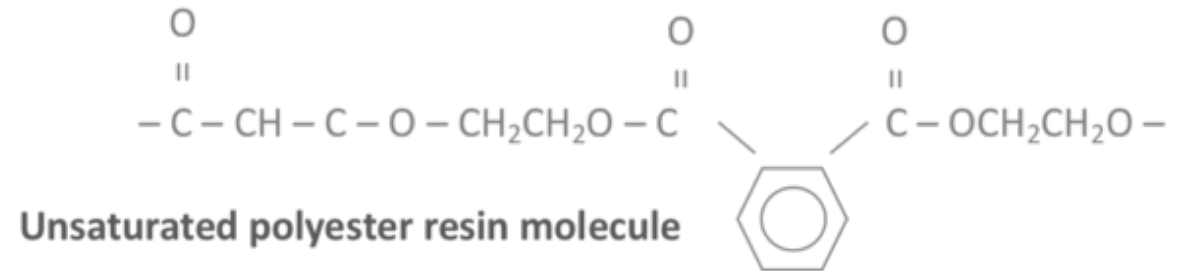
Supporting customers every step of the way

What is Polyester Resin?

[*Polyester resins*](#) are unsaturated synthetic resins formed by the reaction of dibasic organic acids and polyhydric alcohols.

There are two main types of polyester resin: saturated and [*unsaturated polyester resin*](#).

This presentation will intentionally focus on the unsaturated given its significantly greater range of applications.

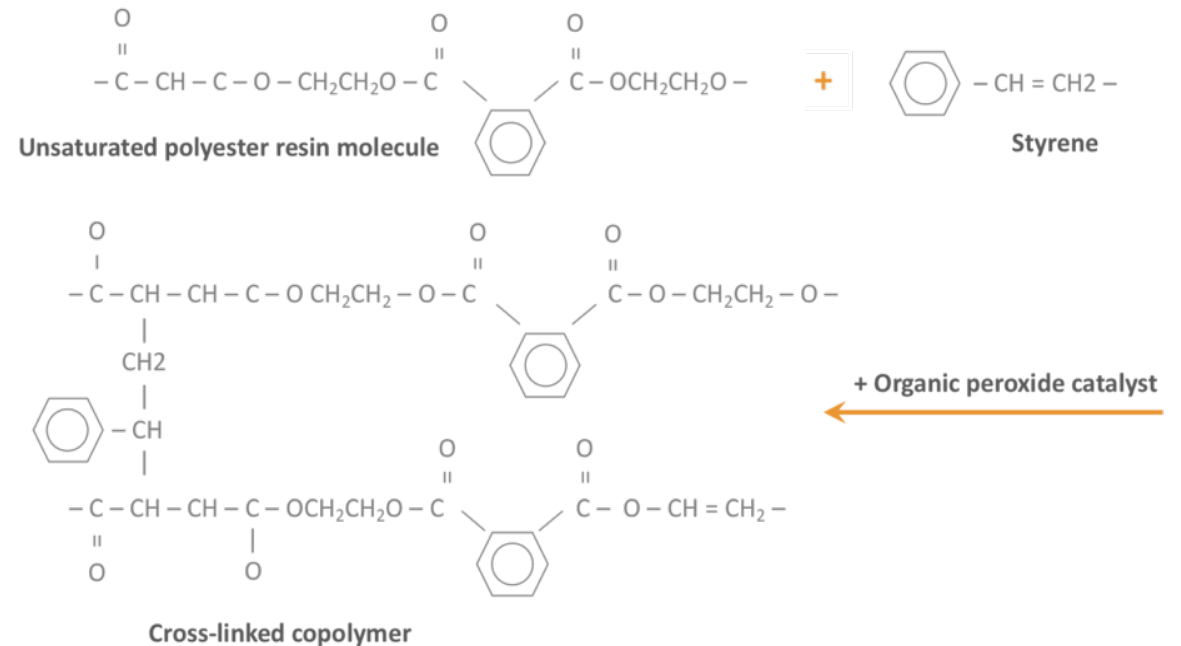


Polyester Resin Curing Chemistry

The qualities of polyester resin are realised upon curing or 'hardening'. Curing involves a combination of ingredients.

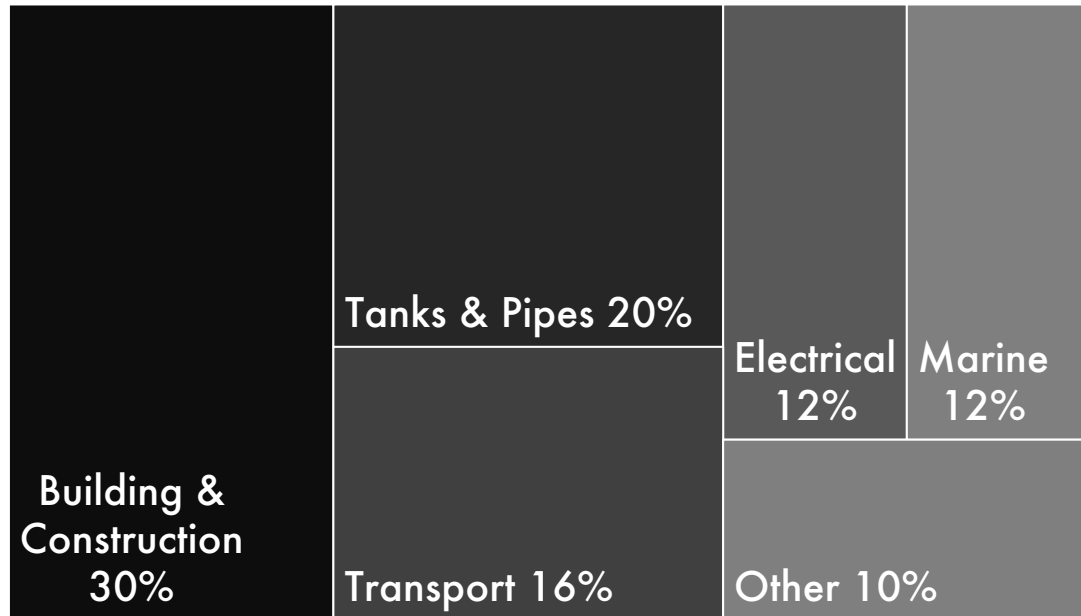
Long-chain unsaturated polyester resin molecules contain double bonds (ethylenic groups) and ester groups. Because of these double bonds they are often classified as vinyls.

Curing is facilitated by cross-linking long linear chains using vinyl monomers such as styrene and via the addition of an organic peroxide catalyst prior to use.



Applications of Polyester Resin

Polyester resin is utilised across a wide range of industrial sectors and is most common in construction.



Composite materials – namely fibreglass (also known as glass reinforced polyester (GRP)) – is at the core of these applications and ultimately range from surfboards to aircraft components.



Types of Polyester Resin: Orthophthalic vs. Isophthalic Resin

There are two types of a polyester resin utilised in standard laminates^{a, b}:

- ***Orthophthalic (ortho)***: primarily comprised of orthophthalic acid with a styrene content ranging from 35 – 45%. Used in low cost applications that do not require high temperature, high corrosion resistance, or high mechanical properties.
- ***Isophthalic (iso)***: contains 42 – 50% styrene, preferred for corrosion environments, higher temperatures and applications requiring more strength. Exhibit good performance across a wide range of applications whilst remaining economical.

^a <https://www.sciencedirect.com/book/9780081022924/mechanical-and-physical-testing-of-biocomposites-fibre-reinforced-composites-and-hybrid-composites>

^b <https://www.sciencedirect.com/science/article/abs/pii/S1359835X08000274>

Polyester Resin: a Thermoset Resin

Polyester resin is a [thermosetting](#) resin – one which will irreversibly harden via a curing process from a liquid state to a solid state in the form of a seamless, [three-dimensional structure](#).

Thermosetting resins like polyester are extremely popular because in their uncured, liquid state, they are extremely easy to work with. When combined with a reinforcement phase, such as glass fibre, the material can be easily shaped and moulded. Upon curing, the resultant composite is incredibly hard, lightweight and highly durable.

In addition to polyesters, vinylesters, epoxies, phenolics, polyamides (PA), and bismaleimides (BMI) are also popular [thermosetting resins](#).

Polyester Resin Safety Considerations

The chemical and physical properties of unsaturated polyester resin have been extensively investigated over several decades. Some of these properties are highlighted below.

Hazard Labels



Hazard statements

H315 - Causes skin irritation
H319 - Causes serious eye irritation
H335 - May cause respiratory irritation
H361d - Suspected of damaging the unborn child
H372 - Causes damage to organs through prolonged or repeated exposure if inhaled
H412 - Harmful to aquatic life with long lasting effects
H226 - Flammable liquid and vapour

[Polyester resin health hazards](#) have been well documented for several decades pertaining to the resin itself and then individual ingredients such as [styrene](#) and catalysts such as [MEKP](#). These health risks aside, it is generally considered safe provided that adequate precautions (risk assessment, are taken and PPE is worn.

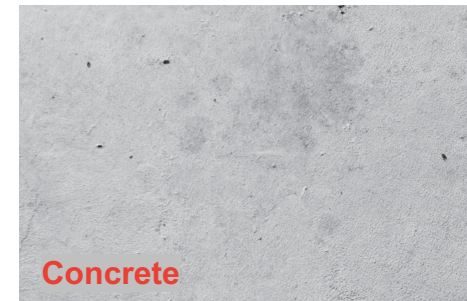
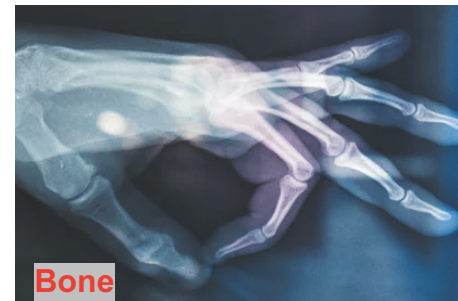
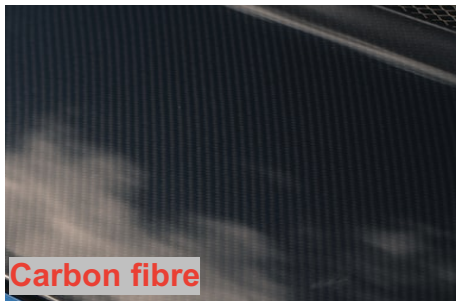
Making Composites From Polyester Resin

Polyester resin without reinforcement several limitations: it is brittle with limited strength.

However, when combined with a reinforcement material – such as glass fibre – a ‘composite’ structure is created. As such, the limitations of polyester resin alone are eliminated and the performance of the overall structure (fibreglass) is significantly increased^a.

What is a composite?

Composites are “materials made up of a matrix and a reinforcement phase. Composites take advantage of directional properties of the reinforcement phase and gluing properties of the matrix. The reinforcement phase may be any material in fibre, platelet, or aggregate form. The matrix phase must be able to flow around the reinforcement and later hardened.”



^a <https://www.semanticscholar.org/paper/Mechanical-Properties-Of-Glass-Fiber-Reinforced-EL-Wazerya-EL-Elamyb/9c4108f15ad35ca81f6c604a5d47e1c944fd9161>

Properties of polyester resin

The chemical and physical properties of unsaturated polyester resin have been extensively investigated over several decades. Some of these properties are highlighted below.

Liquid Resin^a

Parameter	Value	Unit
Appearance	Light brown viscous liquid	
Viscosity at 20oC	200 – 300	cps
Specific gravity at 25 oC	1.11 ± 0.02	
Volatile content	40 ± 2	wt.%
Acid value	25 ± 5	mg KOH/g

Note: cured (liquid) and uncured polyester resin have isolated properties. However, when combined with a reinforcement material like glass fibre CSM to create fibreglass, the properties improve significantly.

Cured Resin^a

Parameter	Value	Unit
Tensile strength	33 ± 1.5	MPa
Tensile modulus	1 ± 0.3	GPa
Elongation at break	1.5 ± 0.14	%
Flexural strength	40.6 ± 3.21	MPa
Flexural modulus	1.53 ± 0.28	GPa
Shear strength	4.1 ± 0.64	MPa
Impact strength	0.4 ± 0.05	J/cm ²
Hardness	40 ± 3	BHN

^a <https://www.sciencedirect.com/science/article/abs/pii/S0261306910006680>

Performance of polyester resin composites: Fibreglass (GRP)

Given these properties, polyester resin has limited uses alone. It is preferable to combine it with other materials – namely glass fibre matting – to create ‘composite’ structures.

[Fibreglass \(GRP\)](#) is the primary composite made from polyester resin-glass fibre matting blends. The table below details some of the key properties of a fibreglass composite material.

Fibreglass (GRP) Properties^a

Parameter	Value	Unit
Tensile strength	28.25 – 78.83	MPa
Flexural strength	44.65 – 119.23	MPa
Impact energy (@ room temperature)	3.5 – 6.5	Joules
Hardness	31.5 – 47.0	BHN

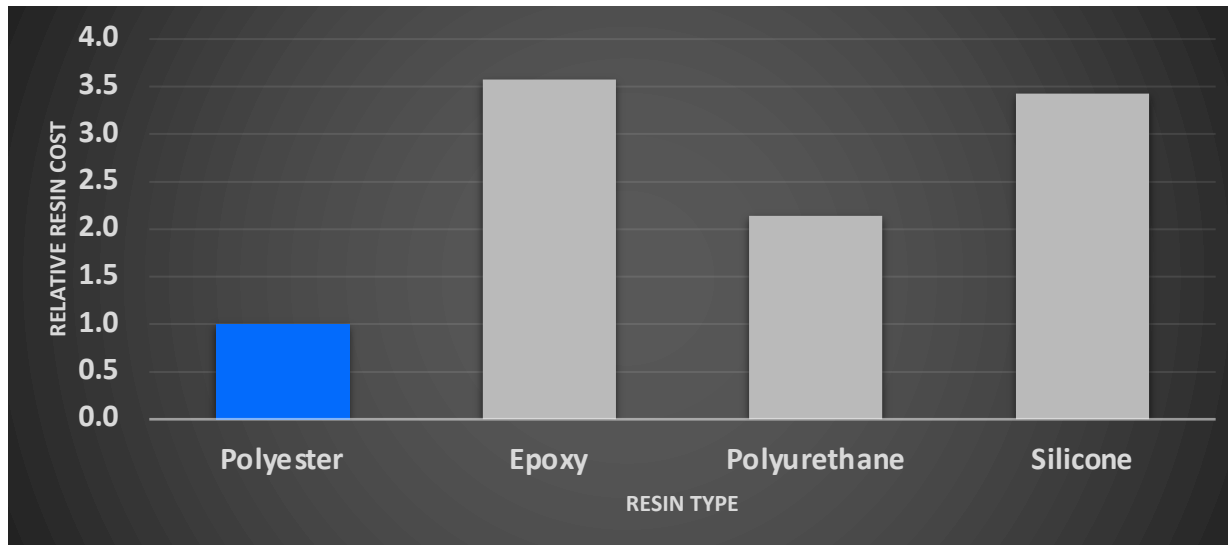
Note: these properties can vary according to a wide range of parameters, from [glass fibre type](#) (length, thickness, composition), ratio of to glass fibre to polyester resin and the number of fibreglass [laminate layers](#). Other factors such as whether or not the material was produced by [hand layup](#) or by [spray layup](#) also has a role.

^a <https://www.semanticscholar.org/paper/Mechanical-Properties-Of-Glass-Fiber-Reinforced-EL-Wazerya-EL-Elamyb/9c4108f15ad35ca81f6c604a5d47e1c944fd9161>

Cost of Polyester Resin

USP resin prices fluctuate depending on supply, demand and other financial factors like [inflation](#). The chart below shows the average price of various industrial-grade resins relative to polyester resin.

Resin Cost Relative to Polyester Resin^a



In general, polyester resin is several times cheaper versus epoxy (3.6x), polyurethane (2.1x) and silicone (3.4x).

As a standalone resin, it provides an economical choice that is further supported by its exceptional performance when combined with glass fibre reinforcement.

[Laminating polyester resin](#) is sold online.

^a Resin Library market survey conducted February 2021

Conclusions

- Polyester resin is a polymer, of which unsaturated polyester resin is most commonly utilised
- It transitions from a liquid to a solid by catalyst-driven curing.
- Polyester resin's real benefits are only fully realised when combined with a reinforcement material.
- The most common composite material made from polyester resin is fibreglass – also referred to as glass reinforced polyester.
- Fibreglass has:
 - Water resistance
 - Resistance to a broad range of chemicals
 - Exceptional strength-to-weight ratio
 - Low cost versus other composites
 - Fully customisable features with a multi-decade lifetime

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