Epoxy Resin vs Vinylester vs Polyester
Use and Application Overview

Overview

This White Paper explores the differences between Epoxy Resins, Vinylester and Polyester, including their chemical underpinnings, performance, and cost, and provides a view on CRD Epoxy components.

Composites are virtually corrosion free and provide virtually maintenance free use, whilst providing good value and being extremely sustainable.[1] Resins are used often instead of their metal counterparts due to the corrosive susceptibility of metals, which is estimated to cost the US industry alone around $276 billion a year. Resins can be used to successfully replace many exotic alloys and metals while providing superior performance and zero corrosion.

This paper is a comparison of each of the resins available, but there will be considerably more focus on the use of Epoxy resin compared with Vinylester, as Polyester is not suitable for the more strenuous uses that Vinylester and Epoxy resins are more specifically designed to endure.[1] However, a brief overview of Polyester and its use and applications will also be provided.

Polyester

Polyester is often used for pipes, tanks and high performance components in the marine and automotive industries. Although it is the most commonly used resin due to the ease of manufacture which matches that of Vinylester resin, it is very cheap, but with limited structural properties it is not suitable for use when high structural properties are required, or when use is required in extreme temperature conditions.[2] Due to the unsaturated nature (lots of double bonds, specifically ester groups) of this composite the tensile strength of it is greatly reduced when compared with Vinylester or Epoxy resins.[3] Polyester also bonds with water throughout its lifetime, gaining weight within the first few days from manufacture, which is from absorption of water reacting with the double bonds on the backbone chain structure of the resin, and then losing weight slowly as the polymer is broken down, leached out of the composite, which is in turn replaced with water. This decreases the strength of the material.[4] Even with Polyester resin reacting to water in this way, for non-structural work such as coating a boat hull, many marinas use Polyester instead of Vinylester resins due to the cheap cost and a faster curing time leading to quick turnover makes Polyester much more favourable.[5]

Vinylester

Vinylester resins are designed much more specifically than Polyester resins as they are a hybrid form of Polyester resin that has been strengthened by the addition of Epoxy resin.[6] With much more aggressive chemical environments in mind for the design, they are especially useful when used in an organic solvent environment.[1] They have a higher resistance to greater vibrational loads because they are more tolerant of stretching than Polyester resins, showing less stress cracking and are

therefore able to absorb larger impacts without damage.[7] Vinylester resins bond in a similar way to Polyester resins with cross-linking of side groups along a backbone structure. Although Vinylester resins are less absorbent of water than Polyester resins due to a more tightly bonded structure of the side groups which provides fewer areas of access for the water molecules to 'attack' the backbone and solubilize the side chains, they do still have a degree of water absorption which weakens the structure.[6] This cross-linking of side chains is the reason that Vinylester resins have "outstanding thermal stability".[1]

Vinylester is not easily bonded to other structures which are dissimilar to itself (such as Kevlar or carbon fibre), or to Vinylester resin that has already cured ('maturing' of the material by the application of heat to encourage further cross-linking of side chains) which can make repair work difficult, as delamination of the repair resin can occur, although adequate preparation of the repair site can exhibit reasonable adhesion of the resin.[6] Vinylester is extremely durable when compared with Polyester, and in the marine industry is used on high quality yachts and similar boats instead of Polyester to ensure that a professional and long-lasting laminate is used, also being used as a final coating over Polyester to prevent "blistering" of the Polyester due to osmosis.[6, 8]

Both Polyester and Vinylester resins require thinning by the addition of styrene, which is a chemical that emits fumes of a harmful nature (volatile organic compounds - VOCs). These fumes are the reason that hand lay-up Polyester is banned in many parts of the US, and they also contribute to global warming which has lead to production facilities in advanced countries that use large volumes of VOCs having to ensure that emission control systems are in place.[3,9]

Epoxy

Epoxy resins have generally superior qualities compared with those of Polyester and Vinylester resins, which are due to the basic structural properties of this resin. The basic backbone structure is still present, however within this backbone the Epoxy resin contains aromatic groups (ring structures – in this case 6 carbons, also known as benzene rings) making it approximately three times stronger than Vinylester resin and therefore incredibly thermo stable and able to better absorb much larger impacts than either Vinylester or Polyester resins without damage.[1] The side groups off of the chain are also much more sheltered from attack from molecules such as water due to the "steric hindrance" provided by the benzene rings, which ensure the structure maintains its' high amount of cross-linking, further ensuring its impact resistance and thermostability.[1,11] Epoxy resins also have high resistance to environmental degradation and do not "blister" like Polyester and Vinylester resins when exposed to water. With this and the other qualities in mind, they are being used almost exclusively for aircraft components.[1]

CRD Epoxy Resin Components

Among the many reasons why CRD Epoxy resins out-perform Vinylester and Polyester resins is its' increased impermeability to water, and the bonding qualities it possess. The ability to adhere to Aramid (Kevlar), Carbon fibre and fiberglass, in addition to bonding to most materials very well

(allowing the use of it for repair work to be undertaken easily), CRD Epoxy resin is often the first choice for many situations as it forms a virtually leak-proof barrier and is extremely durable.[12] CRD Epoxy resins also do not change weight throughout its' lifetime, even in post cure. This is because no styrene is used to form CRD Epoxy resin components which means that no solvent evaporates from the formed resin.[9] Instead, an amine is used as a 'hardener' which acts more as a catalyst of the bonding and linking of the side groups of the molecules and when mixed in the correct ratios, means that a complete reaction takes place.[10]

Conclusion

Effectively, all resins are virtually non-corrosive when compared with their metal counterparts, and are an ideal substitute where corrosion or performance under high stress is needed. Polyester is suitable for work where no structural properties are desired due to being cheap and having a quick cure time, allowing high turnover for businesses such as marinas repairing boat hulls. Vinylester resins are a hybrid of Polyester and Epoxy resins, meaning that they are suitable for the majority of structural applications, and especially in aggressive chemical conditions, but are still slightly permeable to water and are not particularly suitable for repairs or layering as they bond poorly to dissimilar structures, or even themselves if the surface is not carefully prepared. Vinylesters are more expensive than Polyesters.

CRD Epoxy resins are much more suited to extremely strenuous tasks such as enduring vibrational loads, are more water resistant and environmentally stable than either Vinylester or Polyester resins, whilst providing higher tensile strength and thermal stability. They form a much more complex structure than the other resins, without the use of styrene making it more environmentally friendly and safer to manufacture. They bond very well to almost any material and do not lose their structural properties with time.

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[1] http://www.compositesworld.com/articles/vinyl-esters-make-tough-parts-for-highly-corrosive-applications
[2] http://www.ncsresins.com/unsaturated-polyester-resin
[3] http://www.scribd.com/doc/135402772/Epoxy-VinylEster
[4] http://www.multihulldesigns.com/pdf/Why%20Epoxy%20is%20Preferable%20to%20Vinylester%20and%20both%20are%20Preferable%20to%20Polyester.htm
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