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Press Release

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Loctite Benzoxazine Composites

Elevating Aerospace Prepreg Performance

Henkel has developed and brought to market Loctite Benzoxazine (BZ) composites family that includes prepregs, infusion resins, film adhesives and tooling materials. Developed specifically for the aerospace industry, Henkel's Loctite BZ offers a comprehensive solution over commonly used epoxies, phenolics and BMIs, in areas including product performance, storage, processing and health and safety.

As a result, qualifications for benzoxazines prepregs are currently in progress for both the Airbus A380 and Comac C919, with the material fully tested according to major OEM programs and material systems baselines. Benzoxazines can compete in all ranges of service temperatures and toughness for both primary and secondary structure applications. Formulated and supplied in prepreg format, all BZ prepreg systems are produced using hotmelt, meaning no solvent is needed.

Great chemical stability

The fact that BZ is a ring opening molecule means it has excellent latency at low temperature. It can be stored at room temperature without cross-linking or chain reactions occurring, removing the need for refrigerated shipping and storage.

It also has excellent storage life stability. When subject to thermal analysis over one year, BZ prepreg formulas demonstrate minimal change in differential scanning calorimetry (DSC) characteristics at room temperature. They also maintain their interlaminate shear strength (ILSS) after 12 months with just a slight drop in the flow characteristics of the resin. Similarly, in its high Tg, high toughness iteration, BZ demonstrates minimal change of chemical reactivity for up to 9 months, while maintaining adequate tack and drape for lay-up even if left out on work station for up to 30 days.

The material retains 90% of properties for up to 6 months with minimal effect seen on compression, and shows no change in compression after impact (CAI) properties and only a slight decrease in Tg after 10 months. Additionally, the heat of reaction of BZ only changes by approximately 10 joules/gram over one year. While more tests need to be conducted, it is anticipated that some BZ prepreg laminates will last up to 2 years in refrigerated storage.

Stability is also evident in the fact that BZ demonstrates only a miniscule difference in its dry/wet Tg and CAI strength at +/- 10°F of the recommended cure temperature. It also shows robust wet/dry Tg and CAI strength at differing temperature ramp rates, although CAI values are slightly lower with a slower ramp-up of temperature.

Superior qualities over comparable technologies

BZ provides superior stiffness and strength to weight ratios compared to metals, enabling for flexible design and delivering weight savings of up to 30%. When compared to epoxies, BZ shows outstanding fire and smoke performance and excels still further with regards to non-flaming and flaming toxicity, typically emitting 2% or less of the parts per million limit for each toxin. Unlike phenolic technologies, BZ demonstrates no microcracking and no water generated during cure, with the added benefit of improved durability. While BMI does hold a small advantage over BZ in terms of service temperature, BZ holds a significant advantage with regards to cost and processing, demonstrating a total autoclave cure cycle of just 6 hours.

Another advantage is the low cure shrinkage. After measuring density before and after cure, BZ demonstrates a shrinkage of only 1.06%, compared to equivalent epoxy shrinkage of between 4-5%.[1] This has the potential for lower residual stress in the application, with better parts tolerance and less spring back. Indeed, after 3,000 hours of thermal aging, some BZ prepreg formulas lose less than 0.3% of their weight while retaining 100% of their ILSS with no degradation.

In addition, the lower heat of cure of the BZ system offers a lower exotherm potential. The material can demonstrate a heat of cure of only 106 Jules/Gram, compared to 210 joules/gram in a typical epoxy prepreg system. The lower heat of reaction allows for a potentially faster cure cycle and consistency of quality between thick and thin parts.

BZ systems also have a moisture pick-up rate of only 0.7-0.9%, compared to a typical toughened epoxy system’s rate of up to 3%. This means the material will pick up less weight over time, and demonstrate an improved hot/wet performance.

BZ's big advantage over primary and secondary structure epoxy applications is its excellent performance in terms of CAI and open hole compression (OHC). In every iteration of the material, it is possible to push the hot/wet compression further while maintaining good toughness. OHC shows good retention of properties from room temperature up to 415°F Wet, as well as very good CAI. Shear performance is linear up to 400°F / 204ºC wet, with a slight change in behavior afterwards. The materials also meet aerospace in-plane shear fluid resistance requirements, showing over 90% retention in both modulus and strength. Similarly, BZ shows over 90% ILSS retention during fluid soaks when tested at 302ºF / 150°C. Cured Loctite BZ resin also has superb UV resistance compared to a typical epoxy, showing no discoloration, chalking or degradation up to 95 days in outdoor exposure.

Not only does BZ compare favorably to primary structure epoxies, but it also has the potential for cost-saving Out of Autoclave, vacuum bag only cure. The material meets or exceeds all primary structure requirements with OOA cure at less than 1% porosity.

Loctite BZ prepregs are optimized for automated processing, with its high service temperature iteration performing very well with both automated fiber placement (AFP) and automated tape-laying (ATL) even on the first round, and demonstrating good tack and drape. Machines used to prove AFP capability include trials at MTorres, Ingersoll and Electro-Impact, with no change in processing necessary compared to standard prepreg, apart from an adjustment to the correct size.

Conclusion

Loctite BZ prepreg resins eliminate the need for refrigerated shipping and storage, enable increased service temperatures, lead to improved safety and lower residual stress, contribute to better thermal stability and save at least 30% of weight compared to conventional metal structures.

They demonstrate high hot/wet mechanical properties, ambient stability, excellent FST performance and low cure exotherm and shrinkage. In addition, the resins have proven highly successful in both automated processing and OOA, allowing for multiple systems capable of providing a balance of service temperature, toughness and processing.

Henkel recognizes the importance of having full confidence in supply of the materials, which is why the company has direct control of a fully established supply chain for BZ monomers. Some BZ products are already fully commercialized and available in unidirectional tape and fabric reinforcement formats, with others in immediate pre-commercialization status. Of course, being new to market, BZ requires a larger initial outlay in terms of cost, but its inherent benefits mean its cost in-use is significantly lower than comparable technologies.

Reference:

[1] Composites Part A: Applied Science and Manufacturing Volume 38, Issue 12, December 2007, Pages 2517–2526.

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Photo material is available at http://www.henkel.com/press

Contact	Lisa Kretzberg	Holger Elfes
Phone	+49 211 797-56 72	+49 211 797-99 33
Email	lisa.kretzberg@henkel.com	holger.elfes@henkel.com

Henkel AG & Co. KGaA

The following material is available:

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