Q&A TENCATE HIGH TEMPERATURE THERMOSETS

Sean Johnson, Product Manager

Sean Johnson, TenCate product manager, provides insights and opportunities for using high temperature thermosets, particularly in the ultra-high temperature product range.

Q1 What are the design motivations for using high temperature organic matrix composites (OMC) from TenCate Advanced Composites?

A1 There are many excellent reasons to use high temperature OMCs:

- **Structural weight reduction:** For example, a properly designed carbon reinforced OMC is about one-half the density and weight of an aluminum component, or one-third that of a titanium structure, and roughly one-fifth the weight of a steel or Inconel part.
- **Cost:** Especially when replacing titanium or steel, composite parts and assemblies may enable structural integration, part count reduction, and reduced material usage and waste.
- **Enabling technology:** In many cases, composite structures enable the application through weight reduction; hybridization with other composites, metals, or ceramics; or automated/additive manufacturing that reduces overall costs.
- **Dielectric structures** (antennas/radomes/embedded electronics): All TenCate high temperature resins when matched with the right reinforcement can provide electromagnetic transparency with low losses at very high temperatures.

Q2 There continues to be strong interest in the TenCate Advanced Composites high temperature product line. What applications are spurring interest in TenCate's high temperature materials?

A2 Crewed space vehicles, commercial aviation, eVTOL (air taxis), the new generation of fighter jets (F-35), missiles, hypersonic applications, and commercial applications such as oil and gas extraction and high performance automotive are driving the new interest. TenCate already has qualified materials on the Orion heat shield, F-35 engine components, a variety of missile structures (strakes, control surfaces, fuselage, antennas), and select very hot space exploration vehicles including MESSENGER and BepiColombo.

Q3 What are the main categories of high temperature resins available from TenCate and where might they be applied?

A3 There are five main categories of high temperature resins:

- **High temperature epoxies:** While epoxies are not traditionally considered to be high temperature materials, TenCate has a new generation of materials with very high wet long-term service temperatures (these include TC275-1E and TC380). These materials are finding applications in the new generation of helicopters, civil aircraft, and eVTOL applications.

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- **Cyanate esters:** Most notably TC420 (dry T_g 343°C (650°F)), used on Orion space capsule heat shields, RS-9 (T_g of ~340°C), used on the BepiColombo mission to Mercury launched this October, and RS-3 (T_g > 255°C), used on the MESSENGER mission to Mercury.
- **BMI:** RS-8HT and RS-8M (dry T_g 310°C (590°F)) and used on many missile applications, including some of those listed above.
- **Polyimides** (in conjunction with our resin partner PROOF Advanced Research™): AFRPE-4E is used for engine applications on the F-35 Lightning; TC890, with T_g as high as 454°C (850°F), is used for military hardware, Formula 1, and Hypercars like the Aston Martin Valkyrie; and non-MDA PMR15 replacement product 635LM (dry T_g 384°C (723°F)) isused in commercial aircraft engine applications.
- **Phthalonitriles** (PN): These were developed with NRL(dry T_g > 454°C (> 850°F)) and show some promise in the future for applications requiring high temperature chemical resistance and dielectric applications.

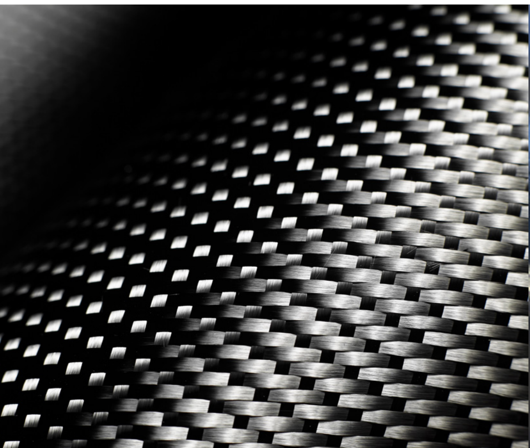
Q4 What sort of reinforcements are suitable for use with TenCate high temperature materials?

A4 A wide variety of reinforcements have been used for the various high temperature materials made by TenCate including:

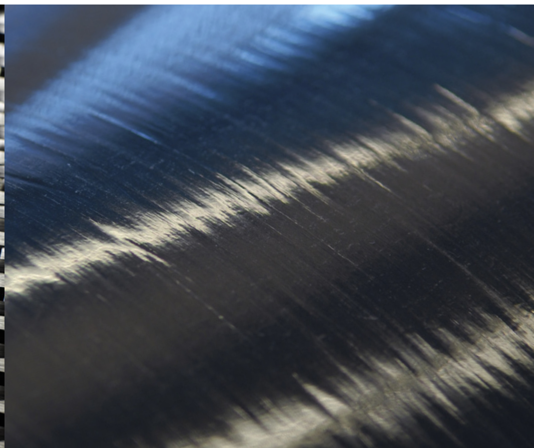
- **Carbon fabric:** Including high strength/standard modulus (such as T730), intermediate modulus (for example T830), and high modulus (such as M46J).
- **Carbon uni-directional (UD) tapes:** Including standard modulus (such as T700), intermediate modulus (for example T800), and high modulus (such as M46J).
- **Quartz/Glass (fabrics and UD):** All of TenCate's high temperature materials are available in glass and quartz with high temperature finishes offered.

Q5 Where is the next frontier for TenCate Advanced Composites in the high temperature realm?

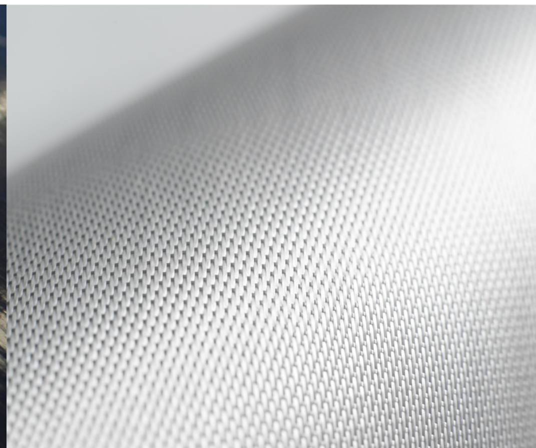
A5 There is strong interest in organic precursor ceramic matrix composite prepregs from a variety of customers. While TenCate has not yet fielded a current active product set for this class of materials, we have previous experience in this area and are actively exploring applications with customers to develop materials and applications. This class of composites could be enabling for hypersonic applications due to enormous structural and cost benefits: they initially process to shape with the same general equipment and processes that are used for standard and high temperature OMCs, their cost versus a vapor deposition process is much less, and they offer the prospect of much higher strength, stiffness, and operational life versus a standard ceramic part.



Woven carbon fabric



UD carbon



Quartz fabric

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