

## Editorial corner – a personal view

### Cyanate ester resins – ‘old newcomers’ among high performance composite materials

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Among high performance and high temperature resistant thermosetting polymer materials, cyanate ester resins offer numerous advantages over the widely used commodity resins. Due to the high aromatic content of the monomer and the cured polymer, they possess higher glass transition temperatures ( $T_g$ ) than epoxy resins (up to 400°C), while the triazine ring formed during addition polymerization is responsible for high thermal stability, high char yield and low smoke generation. Balanced dipoles in the cured state and absence of hydrogen bonding functionality provide further important advantages as low dielectric properties and low moisture absorption. This latter is one of the most significant advantages, as high water uptake would plasticize the resins, lower the  $T_g$  value and thus limit the hot/wet service temperature of it. As for the mechanical properties, the relatively low crosslink density and high free volume is responsible for appropriate toughness. These properties can be further fine-tuned through backbone structure (using different linking groups between the aromatic rings of the monomer) or by blending them with other polymers as epoxy resins, phenolic resins, bismaleimides, benzoxazines. Further advantage of the cyanate ester resins is that they can be processed using the same composite preparation methods (resin transfer moulding (RTM), vacuum-assisted resin transfer moulding (VARTM), moulding, filament winding, prepregging) as epoxy resins. But in comparison to epoxy resins, they offer greater dimensional stability due to reduced outgassing during the addition type polymerization reaction.

Despite the listed advantages and the fact that they were commercialized already in 1976, cyanate esters are still considered as relative newcomers in the composite industry. The reason behind is not only their relatively high cost (approximately twice as high performance epoxy resins), but also lack of formulation knowledge (moisture sensitivity of the uncured resin, toughness). Moisture sensitivity of the cyanate ester curing process is a known issue: the hydrolysis of the cyanate function leads to formation of carbamates, decomposing to amine and CO<sub>2</sub> over 190°C, resulting in voids in the composite structure, decrease in mechanical properties, lower crosslink density and  $T_g$ . The use of rapidly developing process analytical technologies during composite preparation (e.g. in-line fibre-optic-coupled Raman spectrometric monitoring of the curing reaction and moisture uptake with possible feedback to process parameters itself) may offer a key to overcome these problems and facilitate the headway of cyanate esters in high-tech composite applications.



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