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Editorial corner – a personal view
Flame retardancy of carbon fibre reinforced composites

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Carbon fibre can be considered as a benchmark reinforcement in many structural composite applications, where its relatively higher price is balanced by technical advantages as high strength along with low density, durability, low moisture uptake, corrosion- and chemical resistance. Due to its high thermal stability, it can be considered a non-flammable material, which usually reduces the flammability of the incorporating matrix in polymer composites. Despite the increased inert inorganic ratio due to the inclusion of carbon fibres, the organic polymer matrix will still require flame retardancy to meet the relevant standards of more demanding industrial sectors. The flame retardancy of polymers in the presence of carbon fibres, however, raises several issues to be addressed:

The high thermal conductivity of carbon fibres facilitates the ignition of the composites (this phenomenon is known as the candlewick effect) (https://doi.org/10.1016/B978-0-08-100136-3.00005-4).

The sizing of the commercial carbon fibres is adapted to the polymer matrix, thus the use of flame retardants more polar than the polymer matrix leads to decreased fibre-matrix adhesion, and consequently, poorer mechanical properties (https://doi.org/10.3144/expresspolymlett.2009.33). As flame retardants usually have a plasticizing effect, finding a balance between fire performance, the glass transition temperature and mechanical properties presents a real challenge.

Furthermore, the incorporated carbon fibres interfere in the mode of action of flame retardants acting in the solid phase (https://doi.org/10.1016/j.polymdegradstab.2010.03.021) by hindering the formation of a protective charred layer (addressed as intumescent phenomena). Although the formation of char in the case of carbon fibre reinforced composites is only a fraction of that occurring in the matrix material without reinforcement, it is still sufficient to delaminate the layers of the carbon fibre reinforcement, leading to the loss of post-fire mechanical properties.

In the case of solid flame retardants, carbon fibre reinforcement layers may filter the solid phase additive particles during resin transfer moulding, commonly used for the production of high-performance fibre reinforced polymer composites, resulting in non-uniform distribution of the particles and uneven fire performance (https://doi.org/10.3390/ polym9070250).

A possible solution to overcome these issues is to apply a separate flame retardant coating or a multifunctional gel coat with flame retardant properties (a few such gel coats are already commercially available). In some sectors these coatings alone are not sufficient to provide appropriate fire performance, as they can be applied only in thin layers. However, with their application the amount of flame retardant to be added to the polymer can be significantly reduced. With a liquid flame retardant in the matrix, preferably acting mainly in the gas phase during combustion, and a flame retardant gel coat, a targeted solution can be elaborated for the flame retardancy of carbon fibre reinforced composites processed by injection moulding.

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