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Editorial corner – a personal view

Fibers and safety in fire retarded polymer systems: Are we just at the beginning of the road?

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Fibres promote safety in living nature, including the adaptable reinforcing effect of cellulose fibres in trees, sensory nerve fibres that encircle the composite structure of bones, and actin fibres in cells that transmit alarm information from cell surface receptors to the cell nucleus. These examples show the potential of fibrous structures to assist safety in materials. Fibres play, however, an ambivalent role in flame retardant (FR) polymer systems, in which the fibres can be classified into three groups: inert inorganic fibres, organic char-forming fibres and non-char forming fibres.

Inorganic fibres and fabrics in polymer composites accelerate the heat flow back (due to increased heat conductivity) and feed the fuel from the pyrolysis zone to the flame (by capillary action), making it decompose and burn faster. Furthermore, hindered protecting mechanism of intumescent FRs was identified in carbon fibre-reinforced composites (https://doi.org/10.1016/j.polymdegradstab.2010.03.021). In contrast, carbon nanofibers and nanotubes in well-designed FR composites contribute to flame resistance synergistically.

Organic fibres or textiles of high specific surface area enhance the rate of volatile fuel formation and transfer the flammable mass to the burning area according to the so-called 'candlewick effect', making the natural fibre-reinforced composites more flammable. In contrast, integrated fibrous-intumescent char structure formed by the assistance of char-forming fibres has a physical integrity superior to those of components of FR biocomposites alone (https://doi.org/10.1016/j.polymdegradstab.2018.04.021). It was found that the formation and the structure of the fire-protecting char are influenced by the length of the cellulose fibres (https://doi.org/10.3390/fire6030097). A balanced distribution of P-containing additives between the phases improves the performance of the biocomposites significantly (https://doi.org/10.3144/expresspolymlett.2020.50). The multifunctional activity of a novel phosphorous-silane, applied as a surface-treating agent of the reinforcing biofibres, demonstrates that the cooperative action of fibres and flame retardants improves both the mechanical and FR characteristics in well-designed biocomposites (https://doi.org/10.1016/j.polymdegradstab.2013.10.025). The advantage of the fibrous structure over the powder form of additive was highlighted in polylactic acid (PLA) composites by comparing the effect of the same amount of conventional (2-Hydroxypropyl)-beta-cyclodextrin (HPBCD) powder additive and electrospun microfibrous HPBCD (https://doi.org/10.1016/j.polymdegradstab.2021.109655). The fibrous form resulted in improved flame retarding efficacy accompanied by significantly increased mechanical performance.

Non-char forming fibres, *e.g.* made of polyolefins (even when flame retarded), exhibit melt dripping, contributing thus to the spreading of fire. Surprisingly, in multilayer self-reinforced polypropylene composites fire retarded with APP-based intumescent systems, good fire retardancy combined with excellent mechanical properties could be realized at low additive levels (https://doi.org/10.1016/j.polymdegradstab.2012.10.029). Physical cooperation between the

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expansion process, caused by intumescent fire retardants, and the shrinking of the reinforcing fibres is the reason behind the observed novel synergism. This concept, combined with embedded fibrous sensors, can be utilized to produce smart fire protection helmets.

Coating objects with carbon nanotubes, nanofibers or flexible graphene layers of smoke-detecting gas sensor capability can provide high sensitivity and short response time at a low cost. Pyroelectric polyvinylidene fluoride nanofibers acting as temperature sensors and piezoelectric PLA nanofibers as strain sensors, built into FR composite, can provide multiple fire-specific data to be processed, after data fusion, with *e.g.* artificial neural network (ANN). Core-shell fibres filled with FR compound and melting at a triggering temperature can also be a useful part of such a highly intelligent system that integrates sensor and extinguishing function.

Continuing this line of thought, we can see an almost endless perspective for the 'symbiosis' of fibres and flame retardant systems.