PHOSPHOROUS-BASED FLAME RETARDANTS FOR THERMOPLASTIC POLYESTERS AND CARBON FIBRE REINFORCED EPOXY COMPOSITES

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ABSTRACT

This work focuses on the flame retardancy of two important polymer classes particularly relevant for applications in transportation. These materials belong to the category of functional polymers because a modification with functional groups leads to flame retardance of the polymers.

Thermoplastic polyesters like poly(butylene terephthalate) (PBT) are polymers used for injection moulding applications in electrical engineering, communication and transportation. The burning behaviour in these applications plays clearly a decisive role. Regarding the second polymer class investigated in this study, there is also a growing demand for modern epoxy resins for the manufacture of high-performance fibre-reinforced composites in the aerospace and automotive industry employing liquid composite moulding processes. Again, in this case, applications in mass transport systems are sensitive to fire, smoke and toxicity (FST) aspects in a fire scenario owing to the inherently confined operating conditions. As these materials do not show inherent flame retardancy, the use of materials that delay ignition or rapidly self-extinguish after ignition and produce low toxicity upon burning is therefore required. Nevertheless, other key properties of the polymers should also be taken into consideration, and the addition of flame-retardants should not influence too severely the mechanical stability and processibility.

This study presents a common approach, namely using phosphorous-based additives, to improve the flame retardancy of these two classes of materials. On one hand, the halogen-free flame retardance of PBT could be achieved by solid additives as well as by new polymeric flame-retardants based on polycondensates with DOPO-derivatives (9,10-Dihydro-9-oxa-10-phospha-phenantrene-10-oxide). Furthermore, three different approaches were analysed to provide the required flame retardancy for carbon fibre reinforced epoxy composites. Firstly, the influence of novel non-reactive organo-phosphorous additives is discussed. Alternatively, phosphorous-containing amines are used as simultaneous hardeners and flame-retardants, and finally, a phosphorous-containing thermoplastic is used in order to simultaneously improve flame retardancy and fracture resistance.

Besides the flame retardancy and overall mechanical performance of these materials, the effect of such modifiers on the processability of the polymers and the correlation to the structure are deeply addressed in this study.