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Poly(lactic acid)-starch/Expandable Graphite (PLA-starch/EG) Flame Retardant Composites

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Abstract

This work reports on the effect of commercial expandable graphite (EG) on the flammability and thermal decomposition properties of PLA-starch blend. The PLA-starch/EG composites were prepared by melt-mixing and their thermal stability, volatile pyrolysis products and flammability characteristics were investigated. The char residues of the composites, after combustion in a cone calorimeter, were analyzed with environmental scanning electron microscopy (ESEM). The thermal decomposition stability of the composites improved in the presence of EG. However, the char content was less than expected as per the combination of the wt% EG added into PLA-starch and the % residue of PLA-starch. The flammability performance of the PLA-starch/EG composites improved, especially at 15 wt% EG content, due to a thick and strong worm-like char structure. The peak heat release rate (PHRR) improved by 74%, the total smoke production (TSP) by 40% and the specific extinction area (SEA) by 55%. The improvements are attributed to the ability of EG to exfoliate at increased temperatures during which time three effects occurred: i) cooling due to an endothermic exfoliation process, ii) dilution due to release of H₂O, SO₂ and CO₂ gases, and iii) formation of a protective intumescent char layer. However, the CO and CO₂ yields were found to be unfavorably high due to the presence of EG.