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Novel routes in flame retardancy of bisphenol A polycarbonate/impact modifier/aryl phosphate blends

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The massive use of electronic engineering products accompanied by high demands on fire safety has led to increasing interest in environmentally friendly flame retardancy of bisphenol A polycarbonate (PC) based materials. In this work, novel routes for enhancing the flame retardancy of PC/Impact Modifier/Aryl phosphate were studied with respect to pyrolysis (TG, TG-FTIR, ATR-FTIR, NMR), flammability (LOI and UL 94) and fire behavior (cone calorimeter at different irradiations).

To improve charring of PC/ABS_{PTFE}+Aryl phosphate, the exchange of bisphenol A bis(diphenyl phosphate) (BDP) with novel aryl phosphates was proposed. Two novel flame retardants were synthesized: 3,3,5-trimethylcyclohexylbisphenol-bis(diphenyl phosphate) (TMC-BDP) and bisphenol A-bis(diethylphosphate) (BEP). TMC-BDP was more stable than BDP, thus gave a potential to increase the chemical reactions between the components of the PC/ABS_{PTFE}+Aryl phosphate, whereas more reactive BEP was expected to increase the cross linking activity with the polymer matrix. Nevertheless, the corresponding blends did not enhance the flame retardancy compared to PC/ABS_{PTFE}+BDP. BEP in PC/ABS_{PTFE} preferred to cross-link with itself instead of with PC, thus it showed poor fire protection performance. TMC-BDP gave as good results as BDP in PC/ABS_{PTFE} material. The results delivered evidence that BDP possesses a high degree of optimization in PC/AB_{SPTFE} system.

To provide a novel impact modifier improving not only mechanical properties but also the fire retardancy of PC/BDP material, the replacement of highly flammable acrylonitrilebutadiene-styrene (ABS) with silicon acrylate rubber (SiR) with high content of polydimethylsiloxane (PDMS) was studied. In PC/SiR_{PTFE}/BDP the replacement of ABS is beneficial, but PDMS worsened the BDP gas phase and condensed phase action. PDMS reacted also with PC during combustion. PDMS-PC and PDMS-BDP interactions led to silicon dioxide. In fact, the inorganic residue of PC/SiR_{PTFE}/BDP contributed to fire residue and greatly improved the LOI of about 10 % in comparison to PC/ABS_{PTFE}+BDP system. Thus, the use of SiR with high PDMS content is proposed as replacement of ABS in PC/Impact Modifier/BDP blend.

To enhance the fire protection, the PC/SiR_{PTFE}/BDP was combined with several adjuvants: (i) layered fillers: talc and organically modified layered silicate (LS), (ii) metal hydroxides: magnesium hydroxide (Mg(OH)₂) and boehmite (AlO(OH)), (iii) metal oxides and carbonate: magnesium oxide (MgO) and silicon dioxide (SiO₂) and calcium carbonate (CaCO₃) as well as (iiii) hydrated metal borates: zinc borate (ZnB), calcium borate (CaB) and magnesium borate (MgB). It was demonstrated that the blend PC/SiR_{PTFE}/BDP+filler is very sensitive to chemical (e.g. hydrolysis) and physical (e.g. viscosity) effects. Additionally, the large deformations of PC/SiR_{PTFE}/BDP materials make difficult to optimize the char.

Overall, the ZnB, MgB and CaB are proposed for enhancing the flame retardancy of PC/SiR/BDP with respect to flammability results, reduction of fire hazard and maximum of heat release rate. The results of this work enable the understanding of various mechanisms controlling the fire behavior and thus effective selection of the most appropriate flame retardant, impact modifier and inorganic fillers for producing fire resistant PC based polymers.