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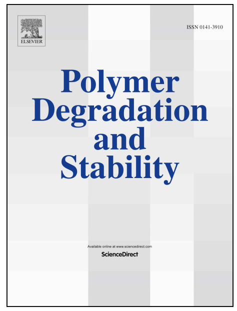

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SCREENING FLAME RETARDANTS USING MILLIGRAM-SCALE FLAME CALORIMETRY

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Abstract

A variety of flame retardants and synergistic additives have been developed over the years in order to address the inherent flammability of polymeric materials. Environmental and economic concerns have recently driven industry to replace some of these flame retardants and synergists. Screening for potential replacements can be costly due to a variety of reasons. While some methods have been developed to screen flame retardants in a cost-effective manner, there is currently a need for a method that can also produce high quality data that provide insight into the physics behind the observed behavior during screening. This work proposes the use of Milligram-scale Flame Calorimetry (MFC) as a method to screen flame retardants in a highly quantitative, cost-effective manner. A methodology based on MFC measurements is presented and subsequently implemented using poly(butylene terephthalate) (PBT) as the base polymer and poly(pentabromobenzyl acrylate) (FR-1025) as the base flame retardant. This combination was chosen due to its well-understood behavior and compatibility. Using this polymer and flame retardant as a base, the flame retardant activity of antimony trioxide (ATO), aluminum hypophosphite (AL-HYPO) and a combination of melamine polyphosphate (MPP) and a proprietary formula (SOL-DP) as additives was explored with the proposed methodology. The fact that these measurements were performed with dry-blending of relatively small amounts per composition, as well as the milligram-scale nature of the measurements should represent a significant reduction in testing times and cost with respect to other available screening methods. The results show the outstanding performance of ATO, as measured by reduction in the heat of combustion. ATO performance is shown to be highly synergistic. For AL-HYPO, and MPP+SOL-DP, the performance is lower with respect to ATO. AL-HYPO does not exhibit synergistic behavior, although certain loadings can lead to lower heats of combustion. The