Flaming Combustion Calorimetry:

A New Tool for Flammability Assessment of Mg-scale Pyrolizable Solid Samples

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Brominated flame retardants have been actively used in the polymer industry due to their high effectiveness at relatively low cost. Recent studies suggest that brominated compounds present health and environmental hazards [1]. Developing a suitable replacement flame retardant can be costly due to the required sample sizes (on the order of 100 g) for use in standard bench scale testing (cone calorimetry). To obtain adequate replacements, there are several challenges involved. It is not only important to improve the understanding of the physical mechanisms governing the action of gas phase flame retardants in order to develop new additives, but it's also critical that the screening of new flame retardant candidates can be done in a cost effective, highly repeatable manner. Furthermore, screening results should reflect actual performance during a large scale fire.

Micro Combustion Calorimetry (MCC) [2] has been recently introduced to address some of these issues. While this technique can provide excellent information regarding heat release rates and total heats of combustion of pyrolyzable solids, the extrapolation of these results to performance in a real fire can be challenging due to their different nature (MCC relies on complete combustion in a fixed temperature combustor, while a real fire consists of diffusion flames). To overcome these limitations, a Flaming Combustion Calorimeter (FCC) is proposed as an alternative testing tool.

In FCC, the pyrolysis and gas phase combustion process is uncoupled, allowing one to focus on the gas phase activity. The required samples are on the order of 30 + 5 mg. These characteristics are similar to the methodology and advantages of the MCC. However, the pyrolysis products are burned in a laminar diffusion flame under controlled and customizable atmosphere conditions, similar to the conditions of a large scale test (cone calorimeter). The system is set up for O2 concentration measurements to determine heat release information based on O2 consumption calorimetry [3]. Optical access allows for secondary flame behavior measurements (flame height, soot production). Atmosphere composition can be controlled from 0 to 100% O2, allowing for the measurement of flammability limits as a function of O2 concentration. Measurements of post-combustion char and other solid residue mass as well as mass of solid combustion products can also be obtained. The design also allows for customization and extension to more research oriented measurements such as soot thermometry for flame temperature measurements. Along with a description of the design, parametric optimization of test conditions, and overall testing methodology, results for 3 polymers of the polystyrene family with increasing brominated flame retardant concentrations are presented.

Selected Bibliography

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