ABSTRACT

In microgravity combustion research, piloted ignition mixing time is of great interest because the ignition mixing time might be on the same order of magnitude as the pyrolysis time. If this can be confirmed, then the mixing time should be incorporated and cannot be neglected in modeling the ignition delay time. In order to study the piloted ignition mixing time related to micro-gravity combustion, we developed an experimental technique in normal gravity conditions. This technique is based on the investigation of degradation of a large particle size material, 0.5 mm diameter PMMA by Thermogravimetry (TG)/ Mass Spectrometry (MS)/ and Differential Thermal Analysis (DTA). The experimental results were incorporated in a numerical model previously developed for determining the piloted ignition delay time of a solid combustible impulsively exposed to an incident heat flux and prescribed forced flow. The results indicate that due to mass transport effects and a rate limiting process controlled by diffusion, the theoretical surface temperature is over-predicted compared to the measured surface temperature. Hence, the measured temperature, beginning at 285°C, is deemed the pyrolysis temperature, while the overshoot time period from the pyrolysis temperature to the ignition is deemed the mixing time. The TG/MS/DTA measurements also suggested that due to the large particle size, mass transport affects the degradation in both inert and oxidative environments. The diffusion process has inhibiting effects on the weight loss rate and the rate of production of pyrolysis products. These inhibiting effects are enhanced with the increase of oxygen content. Furthermore, diffusion is initiated at lower temperatures and shifted to higher temperatures with lowering the heating rates in an oxidative environment compared to an inert atmosphere. The MS data show abrupt changes in the rate of production of gases, which confirmed the hypothesis that degradation is impacted by mass transport effects; DTA profiles indicate that the reaction is endothermic in an inert environment and exothermic in an oxidative environment. From these findings, we confirmed that piloted ignition mixing time is of the same order to the pyrolysis time. In the mixing time zone the problem exhibits some similarity to injecting or blowing fuel vapor in laminar boundary layers. In future work, therefore, fuel vapor injection velocities in low Reynolds number flows corresponding to those typically found in micro gravity combustion should be studied in addition to the present work. Post-Doctoral research on Propanol droplet combustion in ambient and high pressure up to 10 atmospheres and Laser based diagnostics techniques development in high temperature environment (Raman Scattering/LIF) will also be discussed.