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An Optical and Mass Spectrometric Study of the Aluminum-Oxygen Flame

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Abstract: Aluminum oxide particulates are major contributors to aluminized propellant solid rocket stability and two-phase performance losses and are also chief contributors to the visible and infrared exhaust signatures. These particulates result from the combustion of elemental aluminum. A basic research program is being conducted at the Air Force Rocket Propulsion Laboratory (AFRPL) to investigate the formation mechanisms of such particles in a controlled laboratory environment. A high temperature flow reactor has been used in a series of experiments to look at overall rates and identify global mechanisms. Identification of the major aluminum oxide species has been made mass spectroscopically, while initial particle formation has been inferred from the UV/visible spectra. Identification of A1nOm species with O less than n, m less than or = 2 has been made. A mass peak at 102 Atomic Mass Units (AMU) has been ascribed to the previously unobserved gas phase A1203 molecule. The UV/visible spectra from A1(+)02 flame zone are dominated by a continuum. This emission has been attributed to incandescence of newly nucleated alumina particles. The effective temperatures (T sub p) of these particles has been found to lie in the range 1960. T sub p 2250 deg K (ambient gas temperature is 800 deg K). This temperature has been shown to be consistent with the heat flux produced by condensing A1203 species. Rates for the bi-molecular reactions leading to A1203 have been inferred from the data. Following nucleation and growth to approximately 10 nm diameter, alumina particulates are observed to grow by agglomeration into 0.3-m clusters.

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