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A STUDY ON THE CONDENSED PRIMARY COMBUSTION PRODUCTS OF BORON-BASED FUEL-RICH PROPELLANT

Abstract

Extensive work has been done on boron combustion in ducted rocket which concentrated mainly on secondary combustion, since most boron particles must ignite and burn in the secondary combustor. However, the practical species composition of the combustion products of boron-based propellant at the primary nozzle exit, called primary combustion product, is not well known so far. To clarify the properties of the condensed primary combustion products of boron-based fuel-rich propellants, the elemental, species composition and morphology of the products were studied by using energy dispersive (EDS), X-ray photoelectron spectroscopy (XPS) and scanning electron microscopy with energy dispersive (SEM-EDS) individually. The thermal oxidation characteristics were also studied by thermogravimetry–differential scanning calorimetry. Analysis shows the elemental compositions of the product are mainly B, C, O, because the average content of B, C, O contributes more than 90 wt%. These elements correspond to elementary boron, B2O3, elementary carbon, and boron carbide. The surface of boron in the condensed primary combustion products has been severely oxidized. The products are composed of irregular boron lumps and spherical carbon particles with a diameter of about 100 nm in microstructure. Boron lumps are partially or almost fully covered with carbon particles on the surface. The thermal oxidation process of the condensed primary combustion products includes six consecutive reactions: H2O evaporation, decomposition of NH4Cl, oxidation of elementary carbon, oxidation of boron carbides, oxidation of elementary boron, melting of KCl. Given that there are lots of carbon particles in the products, the effect of carbon on boron ignition, was also investigated by a laser ignition system. The result shows that the existence of carbon prolongs the ignition delay time of boron. This work could provide important information about both the primary combustion and secondary combustion mechanisms of boron-based propellants in a ducted rocket.