Title

Using metal oxides to reduce pyrolysis difficulty for getting weaken-bond HTPB-based hybrid rocket fuels

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Abstract

The hybrid rocket propulsion is wisely investigated for its safety, reliability, environment friendliness, and low cost, hence regarded as a promising candidate in suborbital flight, space tourism, and small satellite orbital injection. The hydroxyl-terminated polybutadiene (HTPB)-based fuels are extensively used in hybrid rocket propulsion originating from its superior mechanical properties. Nevertheless, the low regression rate which is induced by high pyrolysis difficulty has limited its practical application. The weaken bond HTPB-based fuels, developed from the concept of self-disintegration fuel, have been demonstrated to have a higher regression rate relative to traditional HTPB fuels by reducing the pyrolysis difficulty of polymer matrix. In several studies of this innovative fuel, the transition acetylacetone complexes exhibit the effect of catalyzing the pyrolysis of the HTPB matrix. And the formed metal oxides during combustion may have the same effects, which can increase the regression rate of HTPB-based fuels.

In this paper, the transition metal oxides including NiO, Fe_2O_3, CuO, and MnO_2 are added into the HTPB-based fuels with 5 wt%, for reducing its pyrolysis difficulty and hence increasing the regress rete. The presented experimental results show these metal oxides can intensely decrease the thermal stability of the HTPB matrix, and this catalytic effect is mainly reflected in the middle and final pyrolysis stages of polybutadiene components. For example, the end temperature of the metal oxides doped fuels is reduced by - 91 °C (CuO), - 53 °C (Fe_2O_3), - 31 °C (MnO_2), and - 29 °C (NiO) in the thermal test. The regression rate of HTPB-based fuels is increased obviously. The enhancement effects of these four transition metal oxides on the regression rate of the HTPB-based fuels are as follows: CuO ≥ MnO_2 ＞ NiO ＞ Fe_2O_3, and the differences are mainly originated from the differences in the catalytic performance of the oxides, and in the agglomeration of the oxides on the fuel surface.