NANO-SIZED BIMETALLIC ALUMINUM-COPPER POWDERS IN HTPB-BASED FUELS

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This work is focused on production, characterization and test of nano-sized, dual-metal Aluminum-Copper (Al-Cu) powders used as additives in solid HTPB-based fuels for hybrid propulsion.
The Al-Cu composites were produced by EEW (Electric Explosion of Wire) and passivated in a dry gaseous stream of (Ar + 1% vol. Air). Seven different powders were produced. The nano-sized Al-Cu composites differ because of the relative content of Al and Cu. Tested additives have nominal mass Al contents ranging from 100% (ALEX™) to 0% (Cu powder).
The Al-Cu composites were characterized in terms of active aluminum content and DSC/TGA (Differential Scanning Calorimetry/Thermogravimetric Analysis). Reactivity parameters for powder non-isothermal oxidation tests were identified according to [1]. While ALEX™ presents an oxidation onset temperature of 856 K, dual-metal Al-Cu powders presents a general decrease of this parameter for increasing Cu mass fraction. On the other hand, Al-Cu powders exhibit a lower heat release in the first oxidation peak with respect to ALEX™. The produced nano-sized powders were tested as additives in HTPB-based solid fuel formulations. Tests were performed in a 2D radial micro-burner; data were reduced by the SPLab proprietary time-resolved technique [2]. Operating conditions were characterized by a quasi-steady chamber pressure of 1.0 MPa and an initial oxidizer mass flux G_{ox} ~380 kg/(m^{2}s). The relative ballistic grading of the tested fuels was performed considering HTPB as baseline formulation. The HTPB-based formulations loaded with Al-Cu powders containing 74% and 15% Aluminum exhibit regression rate enhancements with respect to baseline and ALEX™ loaded fuels for 150 kg/(m^{2}s) $\leq G_{ox} \leq$ 350 kg/(m^{2}s). The percent regression rate increases with respect to ALEX™ of these fuels is higher than 15% with G_{ox} = 350 kg/(m^{2}s) and slightly increase for decreasing oxidizer mass flux, reaching 23% at 150 kg/(m^{2}s). The possible performance enhancement of these fuel formulations is higher when mass burning rate increase is considered, thanks to the higher density of Al-Cu composites with respect to standard ALEX™. In spite of this, no monotonic trend was identified between Al (or Cu) additive mass fraction and the resulting performance enhancement, though increasing powder Cu mass fraction yields a reduced sensitivity of regression rate to G_{ox}.

References

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