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HYPERGOLIC IGNITION CHARACTERIZATION OF LESS-TOXIC BIPROPELLANTS USING HYDROCARBON FUEL BLEND AND HYDROGEN PEROXIDE

Abstract

Mono Methyl Hydrazine (MMH) as fuel and Mixed Oxides of Nitrogen (MON-3) as oxidizer are extensively used in bipropellant thrusters of spacecrafts. This hypergolic propellant combination is primarily used for its multiple restart capabilities and good storability characteristics. However, MMH is highly toxic and MON-3 is highly corrosive in nature. Rocket grade Kerosene (called as Isrosene) as fuel and concentrated Hydrogen peroxide as oxidizer can serve as a potential replacement for the conventional toxic hypergolic bipropellants. This combination comes under the class of propellants termed as "Green Propellants" which have low toxicity, lesser environmental impact and low cost of operation. The reason for this propellant combination not used in spacecrafts yet is due to its non-hypergolic nature. Fuel blend with suitable reactive additive that can decompose Hydrogen peroxide upon contact is one of the techniques of inducing hypergolicity to the system. Subsequent to the decomposition of Hydrogen peroxide, Isrosene fuel blend will react with the decomposition products causing ignition of the mixture. Sodium borohydride was finalized as the reactive additive to be added to the fuel. Since Sodium Borohydride is insoluble in Isrosene due to non-polar nature of hydrocarbon fuel, a suitable polar solvent is identified to prepare the homogeneous fuel blend. This polar solvent dissolves Sodium borohydride and improves the miscibility of fuel blend with Hydrogen peroxide during mixing inside the combustion chamber thereby reducing the Ignition Delay Time (IDT). Suitable dispersion medium is also need to be added to the fuel compound based on Hydrophilic-Lipophilic Balance (HLB) value of the system for making a homogenous mixture of fuel blend containing both polar and non-polar compounds. IDT of the propellant combination was evaluated through drop contact test using high speed camera with 1 ms resolution. Various solvents were studied by adding to Isrosene-Sodium borohydride system in order to finalize an optimized fuel blend which aims to achieve the minimum ignition delay time. The effect of concentration of Sodium borohydride in the fuel blend and composition of additives (Sodium borohydride & solvent) in the fuel blend were also studied during the process. Drop contact test was carried out by varying the O/F ratio and it was found that shorter IDT can be achieved under fuel rich condition. IDT as low as 5 ms is achieved for the optimized Isrosene fuel blend with Hydrogen Peroxide compared to 3 ms for MMH and MON-3 evaluated through the same experimental setup.