Paper ID: 36690
student

SPACE PROPULSION SYMPOSIUM (C4)
Propulsion Technology (3) (10)

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HYPERGOLIC IONIC LIQUIDS AS GREEN PROPELLANTS

Abstract

With the recent push for a more sustainable and economic space transportation infrastructure, it is a goal of NASA and other aerospace entities to target areas of potential cost reduction to promote space exploration, and to do so in a self-sustaining way. Current in-space propulsion using bipropellant thrusters employ toxic hypergolic propellants including hydrazine and its derivatives as a fuel and nitrogen tetroxide (NTO), mixed oxides of nitrogen (MON), and nitric acid mixtures as oxidizers. Due to the toxicity of hydrazine and its derivatives, SCAPE fueling procedures are in place for propellant loading, which aim to prevent any chance of human or environmental exposure to the fuel. For satellites and in-space vehicles where hydrazine is employed, these procedures drive up the cost of the given mission.

An ionic liquid (IL), composed of a cation and anion, is liquid under 100C. Various ionic liquids (ILs) have demonstrated energetic properties with select oxidizers. They also have low vapor pressures and can be hydrolytically stable with a high calculated specific impulse, which are very valuable qualities in a fuel and provide a great improvement over hydrazine in those respects. For application to in-space propulsion, those that are liquid at room temperature and show energetic properties are considered.

In an attempt to better understand the hypergolicity of ILs, the roles that the cation and anion play in the reactivity and fluidic properties have been a focus for those interested in this alternative. Schneider et al. have shown the use of fuel-rich anions, such as dicyanamide, to improve the reactivity of the fuel also reduce the viscosity of the liquid. It has also been shown that imidazolium-based ILs improve thermal stability and have demonstrated improved hypergolicity due to having unsaturated side chains. These combinations are a starting point for this study. It is with these concepts and iterations that various ILs may be formulated and tested for performance. Each IL is tested in a droplet combustion chamber at various pressure set points. A high speed camera and spectrometer are used for data collection to extract ignition delay times and determine chemical reaction mechanisms, that, when coupled with computational results, provide insight into the key hypergolic chemical mechanisms of ILs. These experiments are currently being conducted and results will be analyzed in March, 2016.