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Title

Ionic liquids performance for externally wetted electrospray propulsion system

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Abstract

Among the electric propulsion systems, electrosprays propulsion systems have gradually attracted the researcher's attention due to their small size, high specific impulse, and low power consumption, becoming more suitable for micro and nano satellites compared to ion thrusters or hall thrusters, since they retain higher efficiencies in the low power range (<100 W) [1]. Electrospray propulsion systems are based on the extraction and acceleration of charge particles from a conductive liquid, known as Ionic Liquid (IL). ILs are room temperature molten salts composed of chemically stable mixtures of positive and negative molecular ions. One of the key advantages of ionic liquids is their negligible vapor pressure which makes them suitable for space applications. Additionally, the emission of both positive and negative ions allows for net neutral emission without the need of a neutralizer.

The operation principle of electrospray is as follows: the propellant wets a substrate, called emitter, located close to an extractor grid. An electric potential difference is established between the liquid and extractor grid. At sufficiently high values of the electric field, ions are extracted from the emitter tip and accelerated to a high-speed jet, producing thrust. Depending on the molecules found in the plume, three different emission regimes have been reported in the literature for electrospray thrusters: pure ionic, where only ions are sprayed; droplet, where clusters of ions are emitted; and mixed, containing both ions and droplets in the plume [2]. From the propulsive point of view, ionic regime produces higher specific impulse and lower thrust, and droplet regime yields lower specific impulse and higher thrust. The properties of the ionic liquid (i.e. conductivity, surface tension and viscosity) have a direct impact on the operating regime. Therefore, propellant choice becomes extremely relevant to achieve the desired performance of the thruster.

In this paper, we investigate and gain insight on how the propulsive performance of an externally wetted electrospray thruster changes under different propellants by using a time-of-flight mass spectrometer diagnostic. From the different propellants tested in this study, we highlight: EMI-BF_4, most widely known IL for electrospray; EMI-Im, flight heritage under LISA Pathfinder mission [3]; and EMI-SCN, a hypergolic IL which could be potentially used in a hybrid propulsion system (chemical + electrical). We also analyze time-of-flight data of ionic liquids that to the best of our knowledge have not been reported in the literature before.

References

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