New research key to revolutionary 'green' spacecraft propellant

May 7 2013

In 2015, NASA, for the first time, will fly a space mission utilizing a radically different propellant—one which has reduced toxicity and is environmentally benign. This energetic ionic liquid, or EIL, is quite different from the historically employed hydrazine-based propellant, which was first used as a rocket fuel during World War II for the Messerschmitt Me 163B (the first rocket-powered fighter plane).

Within the U.S. space program, hydrazine was used on the 1970s Viking Mars program, and more recently in the Phoenix lander and Curiosity rover Mars missions, as well as in the Space Shuttle's auxiliary power units. Significantly, monopropellant hydrazine-fueled rocket engines are the norm in controlling the terminal descent of spacecraft. What makes hydrazine desirable as a propellant for this terminal descent role is that when combined with various catalysts, the result is an extremely exothermic reaction that releases significant heat in a very short time, producing energy in the form of large volumes of hot gas from a relatively small volume of hydrazine liquid.

Unfortunately, hydrazine has several significant drawbacks: it is very toxic when inhaled, corrosive on contact with skin, hazardously flammable, and falls short in providing the propulsive power required for future spacecraft systems. In 1998, driven by these challenges, Dr. Michael Berman, a Program Manager at the Arlington, Virginia-based Air Force Office of Scientific Research (AFOSR), the basic research arm of the Air Force Research Laboratory (AFRL), funded Dr. Tom Hawkins of the Propellants Branch, Rocket Propulsion Division at

AFRL's Aerospace Systems Directorate, to find a more benign, yet even more powerful material to replace hydrazine.

This research effort was ultimately associated with a joint government and industry development program, the Integrated High Payoff Rocket Propulsion Technology (IHPRPT) initiative, to improve U.S. rocket propulsion systems. IHPRPT challenged the Department of Defense, the National Air and Space Administration, and the rocket propulsion industry to double U.S. rocket propulsion capability (cost and performance) by 2010. Beginning in 1996, this IHPRPT challenge meant the development of propellants that would provide far greater energy density than current state-of-the-art propellants.

Dr. Hawkins' interest in EILs began early on in his career beginning at Lehigh University when he worked on advanced propellants for the Strategic Defense Initiative in the 1980s. Knowing the untapped potential of ionic liquids to provide high energy density materials, he embarked on an effort to design and characterize the EIL family. This effort was funded by AFOSR and continues to the present day.

But it was in 2002 that Dr. Hawkins, "…thought we were on the right track when we produced an ionic liquid monopropellant that incorporated an EIL that was investigated under our AFOSR program. This propellant class, known as AF-M315, has an energy density close to twice that of the state-of-the-art spacecraft monopropellant, hydrazine." With additional support from the IHPRPT program, the Missile Defense Agency (MDA) and related USAF missile programs, a full characterization of one of these new propellants, AF-M315E, was investigated for its overall safety and hazard properties. According to Dr. Hawkins, these safety properties, coupled with the performance of AF-M315E, were "…absolutely outstanding; we found the oral toxicity of AF-M315E to be less than that of caffeine, and its vapor toxicity to be negligible. The vapor flammability of AF-M315E was essentially nil, and this made it difficult to unexpectedly ignite and sustain combustion of AF-M315E—one could even put out small fires with the propellant!"

In 2005 NASA took a keen interest in this very promising alternative to hydrazine and performed further evaluations. Follow on work performed by Aerojet, Inc. brought AF-M315E engine design to a level that was very attractive for a technology transition to the commercial sector. But for that to occur, it was necessary to find a champion to sponsor the flight demonstration that would make AF-M315E spacecraft propulsion an 'off-the-shelf' choice for future propulsion systems. NASA became that champion in 2012 with their selection of Ball Aerospace & Technologies Corporation as the lead integrator for the Green Propellant Infusion Mission—a $45 million program that will produce new AF-M315E- based thrusters for NASA's 2015 spacecraft mission. Additional program team members consist of the Air force Research Laboratory, Aerojet, Inc., the Air Force Space & Missile Systems Center and the NASA/Glenn Research Center.

The field of energetic ionic liquids is the product of AFOSR-sponsored research at AFRL that is changing the landscape of work in the energetic materials community. According to Dr. Hawkins: "The AFOSR- funded program provided the synthesis and characterization work for an EIL that enabled the experimental USAF fuel, AF-M315E, to act as a high-energy density, environmentally benign, easy-to-handle replacement for spacecraft hydrazine fuel."

Hawkins also noted that twenty years is a well-recognized time period for producing such a revolutionary propellant approach and propulsion system due to the fact that the EIL approach to liquid propulsion is completely different than that of hydrazine, and, most significantly, the performance potentials of EIL-based propellants are not small incremental improvements, but significantly larger than any state-of-the-art propellant. As EIL-based propellants are developed, they will provide lower cost and safer propulsion system operations along with greater mission flexibility and faster mission response times.

Provided by Air Force

Citation: New research key to revolutionary 'green' spacecraft propellant (2013, May 7) retrieved 3 May 2024 from
https://phys.org/news/2013-05-key-revolutionary-green-spacecraft-propellant.html