Why “green” monopropellants?

- Monopropellants are typically used for applications in which simplicity and compact form factor are more highly valued than performance.
- Hydrazine (N₂H₄) is the most ubiquitous of present-day monopropellants.
- Hydrazine is highly toxic and dangerously unstable.
- Acute exposure can be lethal, and it is a suspected carcinogen.
- Use of hydrazine requires expensive precautions.
- “Green” monopropellants such as Hydroxylammonium Nitrate (HAN) hold the promise of decreasing the cost and safety risk of monopropellants.

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HAN vs. Hydrazine

**Hydroxylammonium Nitrate (HAN)**

- In its crystalline form it is potentially explosive, and thus is mixed in aqueous solution.
- Unfortunately, the high water content makes HAN solutions exceeding difficult to ignite.
- Traditional catalyst bed ignition for HAN requires a pre-heat of up to >350°C. This is problematic on spacecraft where power budgets are tight.
- Micro-hybrid igniter technology being developed at USU presents a high enthalpy, low power, and multiple use solution.

Molecular structure of HAN

Hydrocarbon Seeded Micro-Hybrid Igniter

- Simulation was used to obtain propellant dwell time and reactor volume (225 cm³).
- Operating pressure is between 1,000 kPa (145 psia) and 2,000 kPa (290 psia), yielding thrusts of roughly 12.5-25 N (2.8-5.6 lbf)
- HAN enters reactor via a coaxial impinging plate injector to improve atomization
- Igniter is an electrically ignited GOX/ABS hybrid rocket motor
  - Electrical power for the ignition of the hybrid is moderately low
  - Quartz glass windows were included in the design to allow view ports for early testing

Preliminary Test Results

- The igniter underwent a significant testing and redesign phase to reduce latency and improve reliability
- Also performed some testing to determine the minimum spark time necessary for ignition
  - Ignition of the hybrid was achieved with a spark duration of 0.25 seconds
  - Total energy required for this ignition was less than 1 Joule
- Injected propellant jets impinge on each other directly past the igniter outlet
- Chamber brought to pressure firing the igniter and flowing water through the injector
  - Additional work with water to determine proper operating procedures will be completed prior to hot fire tests

Experimental Objectives

- Primary objective: demonstrate the feasibility of using the hydrocarbon seeded micro-hybrid igniter to induce thermal decomposition of HAN.
- Secondary objectives:
  - Quantify the degree to which aqueous HAN is decomposed.
  - Demonstrate self-sustaining operation (i.e. sustained thrust after micro-hybrid deactivation)
  - Demonstrate operation with HAN-fuel component ternary blends

Simulation Results

The following figures summarize simulation results for a 25-Newton thruster operating at 2,000 kPa. 90% HAN decomposition efficiency is assumed.

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