Phase 2 Project Summary

Firm: Orbital Technologies Corporation
Contract Number: NNX11CA72C
Project Title: Non-Toxic Ionic Liquid Fuels II

Identification and Significance of Innovation:
Vintage hypergols such as MMH are hazardous, and the necessary safety measures add considerable cost to NASA missions. In response to this need, ORBITEC is developing and testing new, safer hypergolic rocket fuels. These new, ionic liquid fuels are non-volatile, dense, and energetic. The non-volatility removes the main avenue of exposure to humans and reduces fire hazards. The density and high energy enable smaller systems. Together these attributes will simultaneously increase performance and safety of storable liquid bi-propellant propulsion systems.

Technical Objectives and Work Plan:
The objective of this program was to synthesize new, safer, high-performing fuels, test them, and bring the technology to TRL 4 to allow for quick implementation in NASA's propulsion systems. The work plan included the following tasks:

- Synthesize Ionic Liquid Fuel Candidates
- Conduct Material Property Testing
- Verify Structures of Fuels
- Conduct Ignition Tests
- Investigate Liquid Phase Reactions
- Select Fuels for Combustion Work
- Scale Up Synthesis
- Design Hardware
- Conduct Small Scale Ignition and Engine Tests

Technical Accomplishments:
In the Phase II work, ORBITEC synthesized new ionic liquid fuels, characterized their properties, and demonstrated their performance in small thrusters. The work is unique not only in its development of new chemistry but also in the reactions using a microreactor and specially-designed rocket hardware. Specific technical accomplishments include:

- Synthesis produced ~ 15 ionic liquid fuel candidates.
- Tests measured viscosity, density, surface tension, thermal stability, impact sensitivity, and ESD sensitivity.
- Calculations predicted ideal performance of all conceived fuel candidates.
- Droplet ignition tests measured the hypergolic ignition delay of several candidates and identified 3 fuels that ignited with nitric acid in < 10 ms.
- Microreactor tests investigated the liquid phase reactions between four ionic liquid fuels and nitric acid.
- Iterative design produced injectors and chambers to facilitate combustion of the new fuels.
- Three sets of hot-fire tests demonstrated the use of these fuels in thrusters.

NASA and Non-NASA Commercial Application(s):
Designed for NASA's propulsion needs, these hypergolic fuels would be useful in storable bi-propellant systems in applications ranging from boost to in-space maneuvering. Therefore these fuels would also find use by the military in a range of tactical and missile defense applications and by civilian companies involved in satellite launching. The market for the non-volatile ionic liquid fuels is very large.

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