

IAF SPACE PROPULSION SYMPOSIUM (C4)  
Propulsion Technology (2) (5)

Author: Mr. Martin Hoener  
University Duisburg-Essen, Germany, martin.hoener@uni-due.de

Prof. Tina Kasper  
University Duisburg-Essen, Germany, tina.kasper@uni-due.de

EXPERIMENTAL AND NUMERICAL CHEMICAL KINETICS INVESTIGATION OF NITROUS  
OXIDE FUEL BLENDS WITH SPECIAL EMPHASIS ON SPACE VEHICLE CONTAMINANTS**Abstract**

Despite their toxicity, hydrazine and its derivatives such as 1,1-dimethylhydrazine and blends thereof are popular upper stage, reaction control and orbital maneuvering system fuels. Their popularity arises from properties such as stability and high specific impulse. Future use however will be regulated by new environmental legislation, like the European REACH framework. Storable, environmentally friendly and safe alternative fuels have to be developed and deployed to fuel space vehicles such as satellites for station keeping and operations. In recent years as an emerging alternative to hydrazine, nitrous oxide fuel blends (NOFB) have been investigated. Still in their early development stages and an active area of research, they comprise pressurized liquified nitrous oxide (N<sub>2</sub>O) that acts as oxidizer and solvent for a hydrocarbon fuel. Those blends in principle represent storable, liquid and non-toxic high energetic materials that can be used in propulsion applications. This contribution looks at the detailed combustion kinetics of N<sub>2</sub>O/CH<sub>4</sub> and N<sub>2</sub>O/C<sub>2</sub>H<sub>4</sub> blends, respectively. Detailed measurements of two low-pressure burner-stabilized flames with equivalence ratios of 1.2 and the aforementioned fuel-oxidizer combinations were performed using photo-electron photo-ion coincidence mass spectrometry. This technique uses molecular beam sampling and vacuum ultra violet synchrotron radiation for photo ionization and detailed identification of species of interest. A gas sample containing combustion species is taken directly from the flame. The subsequent expansion through a quartz sampling probe into a high vacuum stage stops all chemical reactions and allows for measurement of stable and reactive flame constituents. The key combustion species and their concentration histories across the flame are identified. Comparative simulations are performed using chemical kinetics mechanisms for nitrogen-fuel chemistry. Special emphasis is given to possible vehicle surface and instrument contaminants that might emerge from non-equilibrium expansion of combustion gases into the vacuum of space. Especially the presence of carbon-carbon bonds in the reactants (i.e. C<sub>2</sub>H<sub>4</sub>) might pose problems that can arise from formation of carbonaceous species such as soot or aromatic and poly-aromatic hydrocarbons. With respect to classical monopropellants and fuel oxidizer combinations such as hydrazine and dinitrogen tetroxide, additional C-N-chemistry can be expected. A comparison of methane without existing carbon-carbon bonds with ethylene that contains such bonds will be an emphasis of this contribution from which additional hydrocarbon selection criteria for NOFB are derived.