Development of the Dragonfly Mass Spectrometer (DraMS) for Titan

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Abstract

Titan's abundant complex carbon-rich chemistry, interior ocean, and past presence of liquid water on the surface make it an ideal destination to study prebiotic chemical processes and habitability of an extraterrestrial environment. NASA's *Dragonfly* New Frontiers mission is a rotorcraft lander designed to perform wide-ranging *in situ* exploration on this moon of Saturn by flying to different geologic settings 10s of km apart. Multidisciplinary science measurements at each landing site will reveal the compositions of the solid materials on Titan's surface, which are still essentially unknown.

Two primary science goals of the *Dragonfly* mission are to identify chemical components and processes at work that may produce biologically relevant compounds, and to search for potential molecular biosignatures. These objectives are addressed by the *Dragonfly* Mass Spectrometer (DraMS), which performs molecular analysis on surface samples that are acquired and delivered by the Drill for Acquisition of Complex Organics (DrACO).

DraMS is a linear ion trap mass spectrometer, most closely related to the Mars Organic Molecule Analyzer (MOMA) [8], part of the ExoMars *Rosalind Franklin* Rover set to launch in the late 2020's. For solid sample analysis, DraMS features two modes: Laser Desorption Mass Spectrometry (LDMS) for the broad compositional survey of surface materials including refractory organics, and Gas Chromatography Mass Spectrometry (GCMS) for the separation and identification of key prebiotic molecules and measurement of enantiomeric excesses (if present). LDMS mode allows for structural disambiguation of surface molecules using ion isolation and tandem mass spectrometry (MS/MS). GCMS mode uses pyrolysis or derivatization to volatilize, separate, and identify molecules of interest using electron impact ionization mass spectrometry. Much of the gas processing system (valves, pyrolysis oven, etc.) and electronics are also inherited from the Sample Analysis at Mars (SAM) instrument onboard *Curiosity.*

The DraMS instrument completed Critical Design Review (CDR) in February, 2025, followed by *Dragonfly* Mission CDR in April 2025. DraMS is now beginning the fabrication, assembly, and integration of the flight model. Much of the novel development effort has focused on areas in which the unique aspects of the *Dragonfly* mission differed from the heritage investigations. These differences range from those imposed by the Titan environment (e.g., atmospheric

pressure, temperature), those imposed by the spacecraft (e.g., rotorcraft vibration environment), and those related to the Dragonfly science investigation (e.g., abundant organics, ice bedrock).

Here we will present the design and current status of the DraMS investigation and instrument development. We will focus on the science goals of the DraMS instrument and how the design is tailored to meet these goals.

Biography - Desmond Kaplan

Desmond Kaplan earned his B.S. in Chemistry from Towson University (2001) and Ph.D. in Analytical Chemistry from the University of North Carolina at Chapel Hill. He spent over a decade in R&D at a mass spectrometry company, advancing ion trap isolation, quadrupole hybrid analyzers, trapped ion mobility spectrometry, ion-ion reaction cell chemistry, and ruggedized nano-ESI triple quadrupoles. In 2017, he joined NASA Goddard's Planetary Environments Laboratory. His research centers on miniature linear ion trap mass spectrometers for spaceflight and field use. He contributes to the **MOMA and DraMS** flight instrument teams as well as several other projects at NASA.

Keywords

Ion Trap, Spaceflight, NASA, Titan