

Development of the Dragonfly Mass Spectrometer (DraMS) and Cryogenic Sample Testing in Laser Desorption Mass Spectrometry (LDMS) Mode

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NASA's Dragonfly New Frontiers mission features a rotorcraft lander that will perform wide-ranging in situ exploration of Saturn's moon Titan by flying to different geologic settings up to ~180 km apart. The goal of Dragonfly is to explore prebiotic chemical processes and habitability on this ocean world by studying its complex carbon-rich chemistry, interior ocean, and past presence of liquid water on the surface. The Dragonfly Mass Spectrometer (DraMS) onboard the rotorcraft will perform molecular analysis of surface samples acquired and delivered by a cryogenic surface sampling drill. The mass spectral data collected by DraMS will help the mission to achieve its two primary science objectives including identifying chemical components and processes at work that may produce biologically relevant compounds, and searching for potential molecular biosignatures. DraMS is a linear ion trap mass spectrometer, with strong heritage from the Mars Organic Molecule Analyzer (MOMA) on ExoMars and the Sample Analysis at Mars (SAM) instrument on the Curiosity rover. 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 quantification of enantiomers. LDMS further supports structural analysis via ion isolation and tandem mass spectrometry (LDMS/MS). GCMS uses pyrolysis or derivatization to volatilize, separate, and identify molecules of interest. DraMS will analyze powdered cryogenic surface materials, obtained from Titan's 94 K surface, that may comprise a water ice or water-ammonia ice matrix. DraMS maintains collected samples below 170K to minimize any thermal alteration prior to analysis, particularly for the unsealed LDMS mode. To model and verify this requirement in advance of the final flight model build, we developed a cryogenic sample preparation protocol and prototype instrument setup, providing highly useful results. We present here the overall DraMS development and additional details on the LDMS analysis of powdered Titan analog samples maintained at cryogenic temperatures.