Laser Desorption Ionisation Mass Spectrometry for in situ Molecular Biosignature Detection

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Humanity has long been wondering about the presence of extinct or extant life elsewhere in the Solar System and beyond. Currently, searching for signs of past or present life on other planetary objects has become feasible by means of spacecraft landing and the application of novel measurement technologies. Therefore, the detection of signatures of life, so-called biosignatures, has become a high priority topic for future space exploration missions.

Several groups of compounds are marked as potential targets in the search for signs of life, including but not limited to lipids (e.g. prenols), amino acids and nucleobases. Reliable in situ detection and identification of these molecules poses a challenge for instrumentation. The instruments should be flight-capable, imposing restrictions on size, weight and energy consumption; i.e., laboratory size instruments cannot be flown. Also, the detection capabilities should not be limited to one specific compound or compound group, but ideally several different compounds should be able to be detected simultaneously. Lastly, a high sensitivity and broad dynamic range coverage are required to detect trace abundances, as well as the highly abundant compounds.

A space prototype Laser Ionisation Mass Spectrometer (LIMS) operated in laser desorption mode was designed and constructed at the University of Bern [1]. The instrument, named ORIGIN (ORganics Information Gathering INstrument), was designed for the detection and identification of biomolecules on future space exploration missions to e.g., Mars or the icy moons of Jupiter and Saturn. ORIGIN's compact and simple design makes it a robust and lightweight system, which complies with the requirements for space instrumentation [1]. Currently, the system consists of a nanosecond pulsed laser system (λ = 266 nm, 20 Hz, τ ~ 3 ns) and a compact reflectron-type time-of-flight (R-TOF) mass analyser (160 mm x Ø 60 mm) [2].

Measurements are performed on a solid sample film (residue), which is obtained by drop-casting 1 µL of solution and subsequent solvent evaporation. Thereafter, a laser desorption measurements are performed on a single sample by rastering over the sample surface. Molecules are desorbed and ionised by the laser pulse, where after the positive ions are separated based on their mass-to-charge ratio by the mass analyser. For each laser shot, a single mass spectrum is obtained.

Several studies were conducted to investigate the current measurement capabilities of ORIGIN regarding molecular biosignature detection, as well as laser desorption conditions and the influence of the sample substrate [1,3,4]. In our contribution, the ORIGIN setup and measurement procedures will be discussed in detail, including sensitivity and dynamic range. In addition, we will show the latest results regarding sample substrate influence and the detection of nucleobases.

[1] N.F.W. Ligterink, et al., *Sci. Rep*., **2020**, *10*, 9641.
[2] A. Riedo, et al., J. *Mass Spectrom*., **2013**, *48*, 1-15.
[3] K. A. Kipfer, et al., *Planet. Sci. J*., **2022**, *3*, 43.
[4] N.J. Boeren et al., *Planet. Sci. J*., **2022**, *3*, 241.