Detection of Nucleobases and other N-Heterocycles with Laser Desorption Ionisation Mass Spectrometry for In Situ Space Exploration

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Humanity has long been wondering about the origin of life and the possible existence of extra-terrestrial life. Lately, in situ detection of molecules present on other planetary objects in our solar system has become feasible by means of spacecraft landing and the applying novel measurement technologies. This facilitates future missions with an astrobiological focus to identify the possible presence of prebiotic molecules and molecular biosignatures that could provide us with information about the origin and presence of life.
Several groups of molecular compounds (both biotic and abiotic) are of astrobiological interest to be identified on planetary surfaces by space exploration missions [1,2]. Examples are amino acids, polycyclic aromatic hydrocarbons, sugars, lipids, and N-heterocycles. Nucleobases, which are N-heterocycles, are monomeric units of RNA and DNA as well as cofactors of several enzymes in present-day life on Earth [3]. Multiple N-heterocycles, including nucleobases, have been identified in meteorites and some are thought to be directly involved in primitive biological systems [4].

Instrumentation for the reliable detection of these molecules in space research is severely hampered compared to laboratory-sized instruments, due to restrictions on size, weight, and energy consumption. Moreover, instruments have to be robust, as well as have high sensitivity and broad dynamic range coverage to detect trace abundances. A lightweight and robust instrument, which complies with the requirements for space instrumentation, was designed at the University of Bern for the detection of bio-relevant molecules for future space exploration missions [5]. Organics Information Gathering Instrument (ORIGIN) is a space prototype Laser Ionisation Mass Spectrometer (LIMS) operated in laser desorption mode. The system consists of a ns-pulsed laser system for the desorption and ionisation of molecules and a compact reflectron-type time-of-flight (R-TOF) mass analyser (160 mm x Ø 60 mm) for the separation of ions [6].
Current measurement capabilities of ORIGIN were investigated regarding biosignature detection, as well as the laser desorption conditions [5,7,8]. In our contribution, the ORIGIN measurement procedures and setup will be discussed in detail. We will show results on the feasibility of the detection and identification of nucleobases and other N-heterocycles using ORIGIN. In addition, we will discuss the sensitivity and dynamic range of the instrument and the influence of the sample substrate on the measurement performance of ORIGIN.

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