LIMS: A measurement technique that allows for sensitive in-situ detection of biomolecules and element and isotope signatures of life

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Various groups of signatures of life, extinct or extant, are of high astrobiological interest, ranging from biomolecules (such as amino acids and lipids) to fractionated element isotopes (e.g., metabolized sulphur isotopes) [1]. Their reliable in situ detection on surfaces of Solar System objects, however, is extremely challenging. Lessons learned from previous space exploration missions show that a sensitive and complementary suite of instruments is required for future space exploration missions devoted to the detection of life.

In our contribution, we present the current measurement capabilities of our miniature space-prototype Laser Ablation Ionization Mass Spectrometer (LIMS). The LIMS system consists of a miniature reflectron-type time-of-flight mass spectrometer that is coupled either to a femtosecond laser ablation ion source (λ = 775 nm, 1 kHz pulse repetition rate, ablation spot sizes of ~10 µm) for element and isotope analysis of solids, or to a nanosecond laser system (λ = 266 nm, 20 kHz pulse repetition rate, ablation spot sizes of ~30 µm) for the gentle desorption of biomolecules from a surface. Three scientific studies on three different sample materials were just completed that are of high relevance for a future Europa Lander mission, including i) mineral matrix that contains artificially inoculated microbes[2], ii) desorption studies on amino acids[3], and iii) recent desorption studies on polycyclic aromatic hydrocarbons (PAHs).

The measurement campaign conducted on the mineral host samples demonstrates that single microbes can be identified through their distinct element composition and that the system can differentiate between biotic and abiotic signatures. Desorption studies conducted on 20 amino acids showed amino acid unique and simple fragmentation patterns that allow their identification, even in the presence of e.g., NaCl, and quantification. A 3σ limit of detection of down to 1 femtomol mm^{-2} is achieved for the investigated amino acids, thus meeting and even exceeding the requirement for amino acid detection as defined by the Europa lander study team[4]. The same desorption measurement methodology was recently applied on a subset of PAHs and, similar to the amino acid study, simple and robust PAH fragments were identified. For this reasons, this miniature space-prototype LIMS system is well suited to serve as an organic composition analyzer on the future Europa Lander.

References

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