In situ mass spectrometry on current and future space exploration missions for the detection of signatures of life

A. Riedo[1,2], N.J. Boeren[1,2], K.A. Kipfer[1,2], N.F.W. Ligterink[1,2], P. Keresztes Schmidt[1], C.P. de Koning[1], M. Tulej, and P. Wurz[1,2]

[1]Physics Institute, Space Research and Planetary Sciences, University of Bern, Sidlerstrasse 5, 3012 Bern, Switzerland
[2]NCCR PlanetS, University of Bern, 3012 Bern, Switzerland

andreas.riedo@unibe.ch

For decades, the detection and identification of signatures of life, past or present, has been one of the key topics in space research and planetary exploration. Its detection is, however, extremely challenging, involving highly demanding aspects ranging from the operation of sophisticated instruments on Solar System bodies other than Earth to the definition of which bio-signature(s) the instruments should be looked for [1]. Since the first Viking mission in the 1970s on Mars, which represents one of the most promising targets in our Solar System, space agencies aim to find traces of life. Unfortunately, no conclusive answer has been found as of yet. Since the detection of liquid oceans underneath a several km thick ice crust, the icy moons of Jupiter and Saturn, e.g., Europa and Enceladus, are considered as high priority targets in current space exploration. Their liquid oceans might harbour life since the basic requirements for life are supported there. Consequently, space agencies, foremost ESA and NASA, are planning to explore these moons.

In this contribution, the most promising classes of signatures of life and the payload of the first Viking lander are briefly presented. This discussion is followed by an introduction of the Sample Analysis for Mars (SAM) instrument, part of the analytical payload of NASAs Curiosity rover, which represents the most sophisticated GC-MS system designed to find biologically relevant organic molecules to this date. Laser Ablation Ionisation Mass Spectrometry, operated in ablation or desorption mode, represents the next generation instrumentation for the detection and identification of traces of life on future missions. This measurement technique allows the detection of several classes of bio-signatures, using one instrument only. The performance of this measurement technique will be demonstrated based on recent studies conducted in laboratories of the University of Bern using a miniature space-prototype LIMS system. These studies cover microbes inoculated in Martian mudstone analogues [2], amino acids [3], and lipids [4].

[1] L.E. Hays, H.V. Graham, D.J.D. Marais, E.M. Hausrath, B. Horgan, T.M. McCollom, M.N. Parenteau, S.L. Potter-McIntyre, A.J. Williams, K.L. Lynch, *Astrobiol.*, **2017**, 17, 363-400.
[2] A. Riedo, C. de Koning, A.H. Stevens, C.S. Cockell, A. McDonald, A. Cedeño López, V. Grimaudo, M. Tulej, P. Wurz and P. Ehrenfreund, *Astrobiol.*, **2020**, 20, 1224-1235.
[3] N.F.W. Ligterink, V. Grimaudo, P. Moreno-García, R. Lukmanov, M. Tulej, I. Leya, R. Lindner, P. Wurz, C.S. Cockell, P. Ehrenfreund, A. Riedo, *Nature Sci. Rep.*, **2020**, *10*, 9641.
[4] N.J. Boeren, S. Gruchola, C.P. de Koning, P. Keresztes Schmidt, K.A. Kipfer, N.F.W. Ligterink, M. Tulej, P. Wurz, Andreas Riedo, *Planet. Sci. J.*, **2022**, *3*, 1-12.