Pyrolysis-compound specific isotope analysis (Py-CSIA) of terrestrial analogue samples. Possible applications in astrobiology and geomicrobiology

Nicasio T. Jiménez-Morillo*[1,2], Ana Z. Miller*†[2,1], José M. De La Rosa[2], Layla M. San-Emeterio[2], and José A. González-Pérez[2]

[1]Laboratorio Hercules (Universidade de Évora) – Largo Marquês de Marialva, 8 Palácio do Vimioso 7000-809 Évora, Portugal

[2]IRNAS-CSIC – Avda. Reina Mercedes, 10. Sevilla, E-41012, Spain

Abstract

Astrobiology greatly relies in cutting-edge analytical techniques to explore life in extreme conditions and eventually may help recognize different biospheres to that on Earth. This, in turn may allow us to better understand the origin of life on Earth and to investigate the possibility of life on other planets.
Taking into account ongoing and upcoming planetary explorations, the detection of biosignatures in terrestrial analogue environments, such as lava tubes, hypersaline and acidic caves, appear extremely important. In this sense, the use of state-of-the-art techniques is of upmost importance for the accurate characterization of organic molecules preserved in minerals from planetary field analogue sites, such as in siliceous speleothems from lava tubes.

Pyrolysis-compound specific isotopic analysis (Py-CSIA) is a cutting-edge method used to measure stable isotope composition (e.g, δ13C, δ15N and δ2H) in specific compounds released by pyrolysis. This technique combines analytical pyrolysis (Py-GC/MS) and isotope ratio mass spectrometry (IRMS) for characterizing the isotope composition of each individual compound separated by gas chromatography. It can provide valuable information on molecular fingerprinting of solid materials not amenable by conventional GC/IRMS techniques allowing traceability of formation processes and origin. The analysis can be done in small samples with minimum sample handling and pre-treatment minimizing the chance of contamination and artefacts.

This technique is based on the coupling of an analytic pyrolyser to a gas chromatograph (GC) and using an isotope ratio mass spectrometer (IRMS) as detector. In short, the individual volatile pyrolysis products separated by gas chromatography are directed to a combustion (carbon and nitrogen) or a pyrolysis (hydrogen) micro-reactor and finally the isotope composition of the gases produced measured by IRMS via an appropriate interface. With this technique, it is possible to make measures of stable isotope composition in chromatographically separated compounds directly from solid samples (i.e. δ13C, δ15N, δ2H and δ18O).
In this communication, we will introduce the Py-CSIA technique as a novel technique for the detection of bio-signatures and the direct determination of the isotopic composition of

*Speaker

†Corresponding author: anamiller@irnas.csic.es

environmental samples from extreme and Mars analogue field sites. Case studies on lava tubes using Py-CSIA for the detection of biosignatures preserved in mineral deposits will be presented and the potential application in the field of astrobiology and geomicrobiology discussed.