GC-orbitrap as an organic matter analyzer for future space missions

Specialty : M2R in analytical chemistry

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Team : Astrochimie, Spectrométrie, Théorie, Réactivité et Origine (ASTRO)

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In 2013, the PIIM developed with an ANR funding (VAHIIA) an innovative system for analyzing volatile organic compounds (VOCs) coming from the heating of cometary ice analogues. Compared to existing systems, the approach developed is the only one currently used to quantify the species present in the gas phase. This quantification was thus possible by coupling the simulation chamber to a gas chromatograph coupled to a mass spectrometer (GC-MS). The data obtained can be directly compared to observations. However, the mass spectrometer used had only one unit resolution, making VOC identification difficult. In parallel with these VOC analyzes, the PIIM has developed an innovative analytical strategy to test the potential of the FT-orbitrap technology which is a very high resolution mass analyzer for the analysis of refractory organic matter (residues) formed during the experiments. As this organic material is considered as an analogue of the soluble organic matter of meteorites, these experiments allowed highlighting the relevance of using such a technology for the analysis of organic matter of astrophysical objects. CNES strongly supports these two approaches. In addition, the spatialization of orbitrap is currently being developed within the CosmoOrbitrap consortium through a CNES research and technology operation.

The present application aims to demonstrate the potentialities provided by the coupling of a gas chromatograph with a high-resolution mass spectrometer (GC-orbitrap financed by ANR, région PACA and CNES) for the VOC analysis of astrophysical objects. The second objective is to demonstrate the capacity of such a system for the analysis of target molecules (amino acids, sugars ...) within analogs of organic matter of the solar system. The samples analyzed will correspond to Martian soil analogs, Titan aerosols, volatiles formed from Europa or cometary ices, and organic residues analogues of meteoritic material.

This GC-orbitrap, which is an advanced technology, very recent, unique in the planetology community, will be a central element of astrochemical and astrophysical research at the Pôle de Sciences Planétaires in Marseille and the région PACA. The data resulting from this research will therefore be the first to be made from such a technology in a context of understanding the evolution of interplanetary objects and in order to demonstrate the interest of a spatialization of a GC-orbitrap for in situ analysis of extraterrestrial organic matter.

The student, possibly from an M2R with a specialty in analytical chemistry, should have a good knowledge of infrared spectroscopy, gas chromatography (GC), high performance liquid chromatography (HPLC) and mass spectrometry. Knowledge in organic chemistry and chemical reactivity would also be appreciated.

References:

1. Insight into the molecular composition of laboratory organic residues produced from interstellar/pre-cometary ice analogues using very high resolution mass spectrometry. G. Danger, A. Fresneau, N. Abou Mrad, P. de Marcellus, F.-R. Orthous-Daunay, F. Duvernay, V. Vuitton, L. Le Sergeant d'Hendecourt, R. Thissen, T. Chiavassa. Geochimica & Cosmochimica Acta, 2016, 189, 184-16

2. Methanol ice VUV photo-processing: GC-MS analysis of volatile organic compounds. N. Abou Mrad, F. Duvernay, T. Chiavassa and G. Danger. Monthly Notices of the Royal Astronomical Society, 2016, 458, 1234-1241

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4. Characterization of interstellar/cometary organic residue analogs using very high resolution mass spectrometry, G. Danger, F-R. Orthous-Daunay, P. de Marcellus, P. Modica, V. Vuitton, F. Duvernay, L. Le Sergeant d'Hendecourt, R. Thissen, and T. Chiavassa, Geochimica & Cosmochimica Acta, 2013, 118, 184-201

5. Meinert C., Myrgorodska I., de Marcellus P., Buhse T., Nahon L., Hoffmann S.V., d'Hendecourt L., Meierhenrich U.J.: Ribose and related sugars from ultraviolet irradiation of interstellar ice analogs. Science 352 (2016), 208-212