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OLYMPIA - a compact laboratory Orbitrap-based high-resolution mass spectrometer laboratory set-up: Performance studies for gas composition measurement in analogues of planetary environments

Illia Zymak[1], Arnaud Sanderink[1], Bertrand Gaubicher[1], Jan Žabka[2], Jean-Pierre Lebreton[1], and Christelle Briois[1]

[1]Laboratoire de Physique et Chimie de l'Environnement et de l'Espace (LPC2E), UMR7328 CNRS/Université d'Orléans/CNES, 3A, Avenue de la Recherche Scientifique, 45071 Orléans, France

[2]J. Heyrovský Institute of Physical Chemistry of the CAS, v. v. i., Dolejškova 2155/3, 182 23 Prague 8, Czech Republic

In situ composition measurements at Saturn and its moons (Cassini-Huygens[1,2]) and at comet 67P/Churyumov-Gerasimenko (Rosetta[3,4]) unveiled the complexity of the atmospheric chemical composition and high abundance of organic compounds in the environments of Solar System bodies. The deciphering of the measurements, obtained by current state-of-the-art instruments, to obtain the composition of complex gas mixtures that include polyatomic molecules and volatile organic compounds (VOCs) often requires having recourse to instrument response modeling supplemented by theoretical chemical models.

One of the limitations in currently flown mass spectrometers is their limited mass resolving power. High mass-resolving power offers the capability to identify unambiguously almost all complex organic compounds. Such technique offers identification of almost all complex organic compounds without application of complementary separation techniques, e.g. chromatography, spectroscopy or collision induced dissociation. A new generation of space mass spectrometers under development (MASPEX[5], MULTUM[6], CORALS[7], CRATER[7], among others), aims at reaching mass resolution of > 50 000. CORALS and CRATER are Orbitrap-based instruments using CosmOrbitrap elements.

In collaboration with J. Herovsky institute, the Laboratoire de Physique et de Chimie de l'Environnement et de l'Espace (LPC2E) has developed a new laboratory test-bench based on the Orbitrap™ technology OLYMPIA (Orbitrap anaLYseur MultiPle IonisAtion) to evaluate several space applications of an Orbitrap-based space instrument using different ionization techniques. OLYMPIA is a compact, transportable set-up and is intended to be used as a stand-alone device (currently with an EI ionization source), but later intended to be coupled to different sources of ions. The next step in the next few months is to couple it with the LLILBID set-up in Berlin[8].

OLYMPIA is currently directly coupled with a first prototype of a compact electron impact ionization source. A single shot provides a useful signal duration of 200-250ms second before it decays to the noise level, and provide mass resolution for Kr ion isotopes of the order of 30 000

and on C_2H_4 on fragments of the order of 40 000. Kr is mostly being used to characterize the isotopic measurement capability of OLYMPIA and mixtures of C_2H_4, CO and N_2gases in different proportions. In this presentation we concentrate on the capability to detect low ethylene lighter VOC concentration in different mixtures of CO and N_2. Sensitivity of the instrument is sufficient to detect traces of the carbon dioxide gas in mixture with molecular nitrogen abundant in less than 1% volume ratio.

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