High resolution mass spectrometry for future space missions: comparative analysis of Titan's tholins

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Abstract

Part of Titan's secrets have been revealed by the Cassini-Huygens mission. Among many discoveries, the unexpected detection of positive and negative ions, some of them at very high masses (Waite *et al* 2007, Coates *et al* 2007) has shown the surprisingly complex organic chemistry occurring in the exosphere of this unique moon.
In the laboratory, synthesis then analyses of tholins, analogues of Titan's aerosols, help understanding the chemical processes occurring in the atmosphere of Titan. One of the experiments allowing this tholins synthesis is named PAMPRE (Production d'Aérosols en Microgravité par Plasmas REactifs) and produces solid particles in a N2-CH4 gaseous mixture (Szopa *et al* 2006). Samples studied in this work were produced with an initial amount of 5% of CH4 and 95% of N2.

This tholins analysis was performed with the new high resolution mass analyzer CosmOrbitrap development (Briois *et al.,* 2016, Selliez *et al.,* 2019), based on the OrbitrapTM technology (Makarov 2000), coupled with a commercial Nd-YAG laser at 266 nm, as ionization source (Laser Ablation-CosmOrbitrap). The analysis of the same sample is made with a FTICR equipped with a laser desorption ionization at 355 nm (LDI-FTICR) leading to a challenging comparison as the FTICR is a laboratory benchmark in mass spectrometry.

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Significant similarities are shown between both techniques. Species are similarly detected and identified. In addition we also present the formation of clusters ions with the LAb-CosmOrbitrap which allows informative indirect detections about the chemical compounds of tholins such as the detection of HCN assumed to be involved in the polymeric growth of tholins by laboratory ESI-HRMS (High Resolution Mass Spectrometry) studies (Gautier *et al.*, 2014, Pernot *et al.*, 2010).
The capabilities of the LAb-CosmOrbitrap are demonstrated on highly complex organic compounds simulating extraterrestrial matter. This study validates the relevance of a space Laser-CosmOrbitrap mass spectrometer for the future planetary exploration and exobiological space missions.