Laboratory experiments to understand the origins of organic matter on interplanetary objects - Contribution of APPI ionization in analogs analyses

Lawry Honold*[1], Jasmine Hertzog[2], Alicja Domaracka[3], and Grégoire Danger[1]

[1]Physique des interactions ioniques et moléculaires – Aix Marseille Université, Centre National de la Recherche Scientifique, Centre National de la Recherche Scientifique : UMR7345 / UMR6633 / URA773, Aix Marseille Université : UMR7345 / UMR6633 / URA773, Aix Marseille Université : UMR7345, Centre National de la Recherche Scientifique : UMR7345 – France

[2]Laboratoire de Chimie et Physique - Approche Multi-échelle des Milieux Complexes – Université de Lorraine, Université de Lorraine : EA4632 – France

[3]Centre de recherche sur les Ions, les MAtériaux et la Photonique – Université de Caen Normandie, Institut Rayonnement Matière de Saclay (DRF), Ecole Nationale Supérieure d'Ingénieurs de Caen, Centre National de la Recherche Scientifique, Institut de Recherche sur les Matériaux Avancés – France

Résumé

The dense regions of our galaxy, known as molecular clouds, are key to understanding the origin of organic matter found in interplanetary objects. Despite extreme conditions, a high organic molecular diversity has been observed, suggesting that organic synthesis may be universal and transmitted to interplanetary objects (asteroids, comets) during accretion phenomena. Pressure and temperature conditions lead to the formation of icy mantles on silicate or carbonaceous grains, favouring surface reactions that contribute to molecular complexity. Physical and chemical processes, such as ionizing radiation, thermal and diffusion effects, further drive the formation of complex organic compounds.
To have better insights into the chemical evolution occurring in the icy mantle of silicate grains, we generate interstellar ices analogues using the MICMOC experiment at the PIIM laboratory. Ice analogues (typically H2O:CO2:CO:CH3OH:NH3 mixtures) are formed under astrophysically relevant conditions (low pressure : 10-7- 10-8 mbar, low temperature : 77 K), irradiated with VUV radiation, and then warmed to 300 K to simulate the protostar evolution. The most volatile compounds are then released in gaseous phase and a refractory organic residue remains on the substrate, which is considered analogous to the soluble organic matter found in meteorites and other interplanetary materials.

We analyze these residues using ultra-high-resolution mass spectrometry (FT-ICR MS), which enables untargeted molecular characterization and precise molecular formula assignment (CwHxNyOz). This data provides insight into structural features such as unsaturation levels (DBE), molecular families (CH, CHN, CHO, CHNO), and acid-base characteristics, depending on the ionization method.
We highlight the contribution of atmospheric pressure photoionization (APPI) in detecting mid- to non-polar species that are poorly ionized by electrospray ionization (ESI). Combining

*Intervenant

APPI with ESI in both negative- and positive-ion mode significantly broadens the molecular coverage and enhances our understanding of the chemical diversity and evolution of organic matter in astrophysical environments.

Mots-Clés: Astrochemistry, Laboratory Analogues, Untargeted Analysis, High Resolution Mass Spectrometry, FT ICR MS, ESI, APPI