EPSC Abstracts
Vol. 8, EPSC2013-912, 2013
European Planetary Science Congress 2013

Laboratory simulation of organic molecules evolution at the surface of Mars

O. Poch (1), M. Jaber (2), J.-F. Lambert (2), T. Georgelin (2), C. Szopa (3), F. Stalport (1), P. Coll (1)
(1) LISA, Université Paris-Est Créteil, Université Paris Diderot, UMR CNRS 7583, Créteil, France, (2) LRS, UPMC Univ. Paris 6, CNRS, France, (3) LATMOS, UPMC Univ. Paris 6, Université Versailles St-Quentin, CNRS, Guyancourt, France, (olivier.poch@lisa.u-pec.fr / Fax: +33-145-171-564)

Abstract

Studying the influence of Martian surface environmental conditions on organic molecules is of prime interest to understand their chemical evolution, and to finally guide and discuss past, present and future *in situ* analyses. Here we will present recent results of laboratory simulation revealing the timescales of UV-driven evolution at Mars, and the impact of nontronite clay on this evolution. Chemical end-products of this evolution will also be presented with emphasis on solid residues that may be stable in Martian surface conditions.

1. Introduction

Several evidences suggest that early Mars offered favorable conditions for long-term sustaining water [1]. As a consequence, we can assume that in those days, endogenous chemical processes, or even primitive life, may have produced organic matter on Mars. Moreover, exogenous delivery from small bodies or dust particles is likely to brought fresh organic molecules to the surface of Mars until now [2].

Organic matter is therefore expected to be present at the surface/subsurface of the planet. The search for these organic relics is one of the main objectives of Mars exploration missions. But for about 3 Gy, due to the harsh environmental conditions of the Mars surface (UV radiation, oxidants etc.), the inventory of organic compounds at the current surface or subsurface of Mars may have been narrowed.

Two major questions raised by this putative evolution are:

- What is the evolution pattern of organics in the Martian environment?
- What types of molecules would have been preserved, and if so, under which conditions?

2. The Mars Organic Molecules Irradiation and Evolution (MOMIE) setup

We address these questions using an experimental device simulating UV, pressure and temperature conditions of the surface of Mars [3]. Samples consisted of nanometers thin deposits of a molecular compound or of a mineral in which the molecular compound has been embedded (Figure 1).

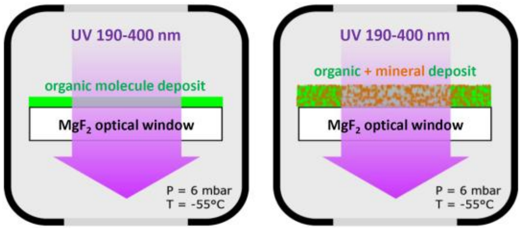

Figure 1 : Scheme of two possible configurations of the MOMIE reactor

We study the evolution of some of the most likely molecular compounds potentially synthesized or brought to Mars (amino acids, hydrocarbons, nucleobases etc.). In order to study the impact of a mineralogical representative environment for organic molecules, we synthesized nontronite smectite clay, an iron-rich phyllosilicate extensively detected from orbit at the surface of Mars, and especially at Gale crater [1].

3. Results of the chemical evolution

During the evolution of the samples at Martian simulated conditions, qualitative and quantitative changes are monitored, mainly using transmission infrared spectroscopy (Figure 2).

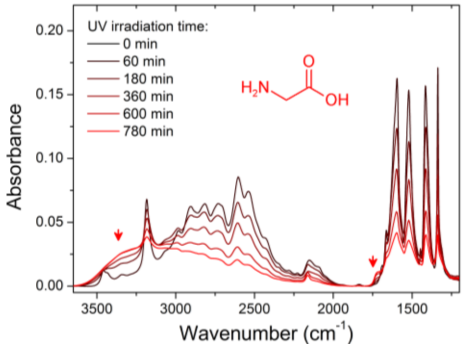

Figure 2 : *In-situ* infrared transmission spectra of a sample of pure glycine at -55°C and 6 mbar and under UV irradiation similar to the Martian one. We observe the decreasing absorbance of the main infrared bands of glycine and the rise of new absorptions (red arrows).

These data allow the determination of kinetic parameters controlling the evolution of organic molecules directly exposed to Martian UV flux, or in interaction with nontronite clay. Quantum efficiency of photodecomposition from 200 to 250 nm have been determined for several molecules (Figure 3). The results indicate that aromatic molecules, especially PAH, are at least ten times more resistant to Martian UV compared to non-aromatic molecules.

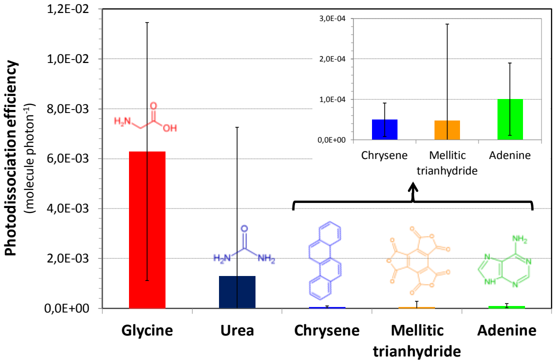

Figure 3 : Quantum efficiency of photodecomposition from 200 to 250 nm for several molecules studied in the MOMIE setup (UV only, no mineral here)

In addition, infrared spectra and ex-situ analyses of the residues obtained after simulation reveal end-products of the chemical evolution occurring during the simulation. In the case of glycine, we detect the production of a solid residue tentatively produced via polymerization [3]. Red arrows in Figure 2 indicate new absorptions possibly due to H_2O (OH stretching around 3250 cm^{-1}) released by the formation of peptide bonds (C=O stretching of amide at 1680 cm^{-1}). Detailed results obtained for other molecules will also be presented at EPSC.

Finally, the kinetic parameters determined by this laboratory setup provide essential input data for numerical modeling of the current reservoir of organic molecules on Mars.

Acknowledgements

The authors wish to thank the French National Program of Planetology (PNP), the Pierre Simon Laplace Institute (IPSL), and the Institut Universitaire de France (IUF).

References

[1] Ehlmann, B.L., Berger, G., Mangold, N., Michalski, J.R., Catling, D.C., Ruff, S.W., Chassefière, E., Niles, P.B., Chevrier, V., Poulet, F.: Geochemical Consequences of Widespread Clay Mineral Formation in Mars' Ancient Crust, Space Science Reviews, 174, 1-4, 329-364 (2013)

[2] Moores, J.E., Schuerger, A.C.: UV degradation of accreted organics on Mars: IDP longevity, surface reservoir of organics, and relevance to the detection of methane in the atmosphere, Journal of Geophysical Research: Planets, 117, E08008 (2012)

[3] Poch, O., Noblet, A., Stalport, F., Correia, J.J., Grand, N., Szopa, C., Coll, P.: Chemical evolution of organic molecules under Mars-like UV radiation conditions simulated in the laboratory with the "Mars Organic Molecule Irradiation and Evolution" (MOMIE) setup, submitted to Planetary and Space Science