Extraction and derivatization of the organic matter on Mars, preparing the MOMA instrument for the Exomars mission in 2028

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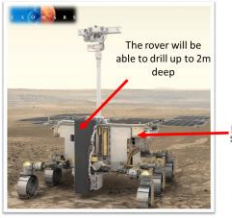
Context

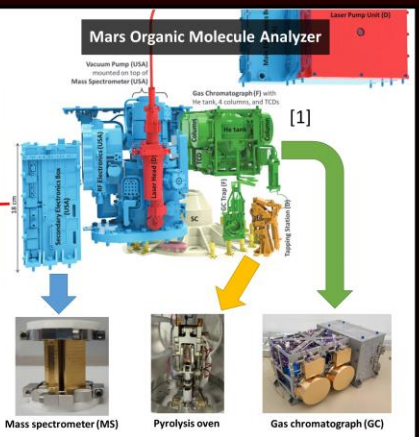
EXOGENOUS organic matter sources: comets, meteorites, IDPs...

- Mars is a planet of exobiological interest because it could have contained liquid water in the past and be habitable.
- The Rosalind Franklin rover of the Exomars mission (ESA) aims to search for traces of past or present life.
- The MOMA instrument will seek to detect organic matter, in order to understand its sources and origins [1].

Rosalind Franklin rover from Exomars mission(ESA)



Mars Organic Molecule Analyzer



Mass spectrometer (MS)

Pyrolysis oven

Gas chromatograph (GC)

Thermal desorption optimization on natural sample

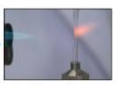
Thermal desorption facilitates the extraction of molecules before functionalization with MTBSTFA. It has been previously optimized for amino acids. The extraction of **carboxylic acids**, which are molecules of interest, is also to be optimized.

- Sample used for optimization : ORBAGNOUX, (152.1 – 157.3 Ma), rich in kerogen and organic matter of biological origin [2]

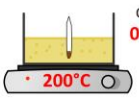

Orgbanoux sample


Unextrated powder


Glass tube : 5mg of sample


Sealed by micro torch

Thermal desorption



Optimal time : **0 – 10 min ?**

Extraction

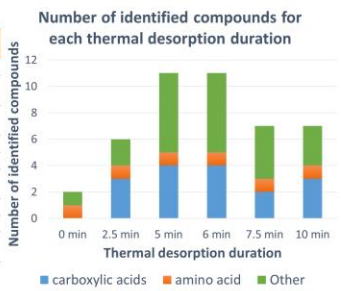
Derivatization with MTBSTFA

Results

Table of main compounds detected

Retention time	m/z	Molecules
13,23 min	132, 88, 75	Glycine isomer, mono TBDMS
13,83 min	188, 146, 130, 73	Bis(tert-butyldimethylsilyl)amine
14,12 min	146, 102, 72, 59	N,N-dimethyl-, carbamic acid TBDMS ester
15,14 min	173, 131, 75	Hexanoic acid, TBDMS
18,39 min	253, 147, 73	Bis(tert-butyldimethylsilyl) sulfite
18,62 min	300, 247, 189, 147, 73	Glycolic acid, 2TBDMS
19,01 min	246, 147, 73	Glycine isomer, 2TBDMS
19,28 min	261, 147, 73	Oxalic acid, 2TBDMS
19,71 min	269, 189, 147, 73	Sulfuric acid, 2TBDMS derivative
24,83 min	317, 141, 111, 73	Adipic acid, 2TBDMS

Number of identified compounds for each thermal desorption duration



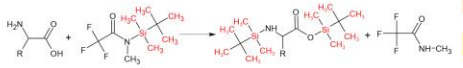
- The first results indicate that a maximum of compounds are extracted between 5 and 7.5 min of thermal desorption.

Aging tests of derivatization reagents

Derivatization is needed to **volatilize** polar compounds and make them detectable by GC-MS analysis. An hydrogen atom is replaced by a more apolar group which decreases the molecules boiling point.

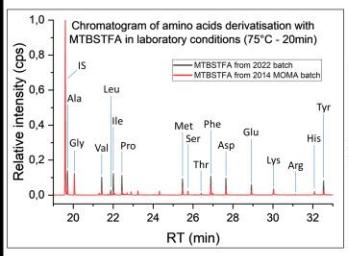

Derivatization reagents are contained in metal capsules (15µL) that open at a specific temperature.

309°C TMAH
221°C MTBSTFA
145°C DMF-DMA

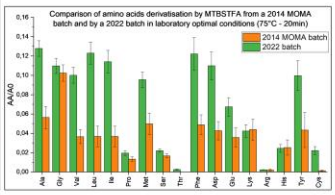

Exemple of amino acid derivatization by MTBSTFA

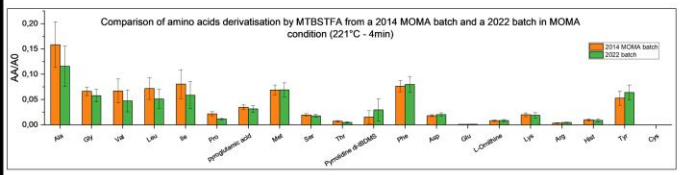
- These capsules are already filled in 2015. There is a need to understand how reagents evolve through time until *in-situ* analysis.

Results for MTBSTFA study



$$\frac{AA}{A0} = \frac{Area\ of\ amino\ acid}{Area\ of\ IS\ (methyl\ laurate)}$$





- In laboratory conditions, MTBSTFA from a MOMA batch is less efficient but in MOMA conditions, this effect is compensated.

Conclusion

- The thermal desorption time of carboxylic acids should be optimized between **5 and 7.5 min.**
- MTBSTFA from a 2014 MOMA batch has a similar derivatization efficiency than a MTBSTFA batch from 2022 in MOMA conditions.

Perspectives

- **Other natural samples** will be tested to validate the method. It will also be tested on a replicate of MOMA.
- Aging test will be carried out on **DMF-DMA** that will be used on MOMA instrument for chiral separation.


ETU

References :
[1] Goesmann, F. et al. (2017) 'The Mars Organic Molecule Analyzer (MOMA) Instrument: Characterization of Organic Material in Martian Sediments', Astrobiology, 17(6–7), pp. 655–685.
[2] Sarret, G. et al. Sulfur speciation in kerogens of the Orbagnoux deposit (Upper Kimmeridgian, Jura) by XANES spectroscopy and pyrolysis. Organic Geochemistry 33, 877–895 (2002).