

What can we learn from Wet Chemistry onboard the Mars Science Laboratory SAM Suite?

A. Buch (1), C. Szopa (2), P. Coll (3), C. Freissinet (4), D. Glavin (4), J. Eigenbrode (4), A. Brunner (4), K. Miller (5), S. Teinturier (3), D. Coscia (2), R. Navarro Gonzalez, M. Cabane (2), P. Mahaffy (4) and the MSL Science team
(1) Ecole Centrale Paris, 92295 Chatenay-Malabry, France (2) LATMOS, Univ. Pierre et Marie Curie, Univ. Versailles Saint-Quentin & CNRS, 75005 Paris, France (3) LISA, Univ. Paris-Est Créteil, Univ. Denis Diderot & CNRS 94010 Créteil, France (4) NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA, (6) Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA, (5) Universidad Nacional Autónoma de México, México, D.F. 04510, Mexico.

Abstract

Direct pyrolysis of Mars soil samples has been used up today today to analyse their content in volatile molecules. However, this technique has been shown to have limitation for the analysis of a few chemical families, or macromolecules. The SAM experiment is the first space instrument onboarding a device based on wet chemistry to overcome this limitation.

1. Why to use wet chemistry ?

Polar and high molecular weight organic compounds cannot be volatilized without any degradation, or are not volatile enough to be analyzed by direct GC-MS analysis. This is the case for key organic compounds such as amino acids or carboxylic acids.

This is the reason why wet chemistry has been implemented in the SAM experiment. The objective is to make possible the analysis and detection of organic compounds that would not be detected by using only direct thermal degradation (pyrolysis) of the sample.

The wet chemistry onboard SAM is supported by two different techniques, using two specific chemical reactants: N-Methyl-N-tert-butyltrimethylsilyltrifluoroacetamide (MTBSTFA) and Tetramethylammonium Hydroxide (TMAH).

2. MTBSTFA wet chemistry

MTBSTFA is dedicated to the derivatization of polar compounds bearing a labile hydrogen in their structure. It allows to transform a non-volatile compound into a volatile one, without any degradation of the mother molecule (Figure 1), by replacing the labile H atom with a much bigger molecular group. The other advantage of this technique is that it also enables to enhance the MS

detector response. Then by using TMAH we expect to reach for the time - if they are present in the sample - key molecules of exobiological interest.

3. TMAH wet chemistry

TMAH is dedicated to the analysis of heavy molecules. The reactivity occurs in combination with the pyrolysis process. If it does not keep safe the structure of the parent molecules, it limits the thermal degradation of them during the pyrolysis process. It protects thermolabile compounds and allows the chromatographic separation of both polar and non-polar targets in the same run. Pyrolysis in the presence of tetramethylammonium hydroxide (TMAH) allows both an efficient cleavage of polar bonds and the subsequent methylation of COOH, OH and NH₂ groups, hence the release of less polar, GC-amenable compounds. Using TMAH on soil samples will provide information on the possible presence of macromolecules including biopolymer, carbohydrates and kerogen.

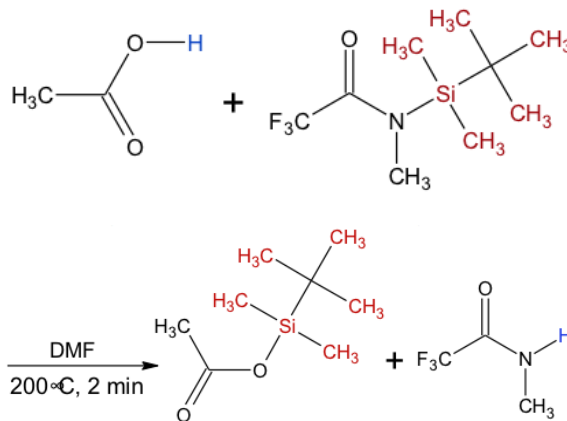


Figure 1: Illustration of a derivatization reaction of a carboxylic acid reacting with MTBSTFA and DMF as solvent, producing a specific derivative compound,

volatile enough to be analyzed by SAM GC-MS technique.

Acknowledgments

SAM-GC team acknowledges support from the French Space Agency (CNES), French National Programme of Planetology (PNP), National French Council (CNRS), Pierre Simon Laplace Institute, Institut Universitaire de France (IUF) and ESEP Labex.