Aging and analytical performances evolution of a gas chromatographic system at Mars

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Aging and analytical performances evolution of a gas chromatographic system at Mars

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Abstract

Health data from the gas chromatography (GC) module onboard the SAM instrument [1] will be presented to assess the analytical performances evolution of a GC device in Martian environment through 3 years.

1. Introduction

Gas chromatography (GC) is a very powerful tool to investigate the chemical diversity in Martian soils and rocks. The NASA Curiosity rover gets on board an analytical chemistry laboratory, the Sample Analysis at Mars (SAM) instruments suite. SAM is composed of three different instruments: a tunable laser spectrometer (TLS), a mass spectrometer (QMS) and a gas chromatography apparatus (SAM-GC). In this work we will focus on the aging and the analytical performances of one of the GC column onboard SAM compared with its nominal state that should not have been modified by the cruise in space [2].

2. Gas chromatography module and health data

The complete GC system that will be presented here is the column 5 of the GC module (GC5). This column was extensively used at Mars during the first 2.5 years of the mission. This system is composed of an injection trap (IT), a chromatography column (GC5) and a TCD detector. It can also be coupled with QMS to have retention times and masses of the molecules. Health data from these three GC sub-systems will be presented.

The column health will be followed using two different housekeeping data sets. The first one is the retention time difference between two compounds observe in all experiments: bezene and toluene. The variation of this parameter can help us assess the separation performance of the column and its evolution. The second parameter is the bleeding signal. This signal corresponds to the detection of molecules coming from the degradation of the stationary phase of the column.

The TCD health will be followed using the benzene signal. The signal detected with the TCD can be compared with the QMS signal. A correlated evolution can be interpreted as a perfectly healthy TCD, while a decorrelated one can be a sign of degradation.

The IT health is more difficult to follow, as there is only one temperature measurement for this sub-system. An important decorrelation between measured and real trap temperature is present and can interfere with health statement. To be able to assess the health state of the trap, mainly the state of the chemical trapping (Tenax), a laboratory study was conducted, on a spare laboratory model, to correlate the measured temperature with the true IT temperature.

3. Results

3.1 Column health state

The column health state is an important parameter to have in mind while interpreting the retention times to identify molecules. The capability of a column to maintain a constant retention time is important or at least it is important to know how the retention time of a compound evolves. On Figure 1, the relative evolution of benzene and toluene retention time is plotted as a function of the experiment number at Mars. What we observe is a decreasing time between benzene and toluene detection with the TCD (confirmed with QMS). This time decreases of 20 seconds while the column was used 21 times to make blank and sample measurements.

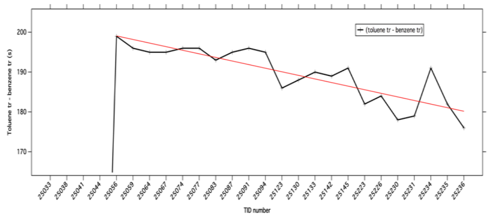

Figure 1: Evolution of the retention time difference between benzene and toluene during Martian experiments.

The bleeding signal is a key parameter that helps us to assess the health of the stationary phase. This can also helps us to interpret the retention times evolution previously described. A few masses can be used to follow the evolution of the bleeding signal through time. The main mass is m/z=207. This mass corresponds to hexamethylcyclotrisiloxane and is the major product of polydimethylsiloxane thermal degradation [3].

3.2 TCD health state

TCD is a detector that is coupled with 5 of the 6 columns onboard SAM. They allow us to have a QMS independent measurement of retention times. These very interesting data also help us to follow column health state. TCD are relatively fragile devices and Figure 2 represents the evolution of the TCD benzene signal compared with the total mass area from QMS at benzene retention time. As seen on this diagram the TCD signal is dropping while the QMS signal is in a "steady mode". This can indicates a lower TCD sensitivity and is a fingerprint of a degrading TCD.

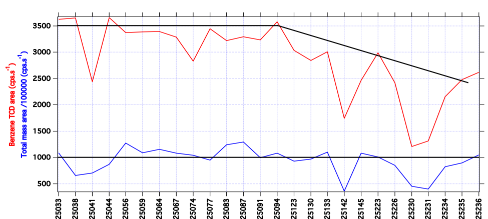

Figure 2: Evolution of the Benzene TCD signal and total mass area through time.

3.3 IT health state

ITs are key devices that allow us to have a time resolved injection into the column. They are composed of an adsorbant (TENAX) that retains organic molecules until it is flashed. This adsorbant is thermally degraded and rapidly became a hard pellet instead of the initial powder. The precise monitoring of the IT temperature is thus of great interest to better constrain the IT health and adsorption capabilities. On SAM the temperature measurement is decoupled from the trap and a huge gradient is observed between real trap temperatures and measured ones. For instance the trap activation sequence allows us to heat it up to 270°C while the measurement is about 49°C. A laboratory experiment on a spare IT was conducted to correlate the measured and the real temperature of the trap and allows us to better follow the health state of this key device.

4. Conclusion

Although GC is a powerful tool to explore the chemical diversity of planetary environments, a complete GC apparatus is relatively fragile. IT, column and TCD detector are all subject to their own degradation and key housekeeping data can help us assess the evolution of their health state. This information is mandatory, not only characterize the instrument status and predict its life times but also to interpret science data. Great caution should then be taken while designing new GC instruments.

References

[1] Paul R. Mahaffy, Christopher R. Webster, Michel Cabane, Pamela G. Conrad, Patrice Coll, et al.. The Sample Analysis at Mars Investigation and Instrument Suite. *Space Science Reviews*, 2012.

[2] Cyril Szopa, R. Sternberg, David Coscia, F. Goesmann, R. Gomes, et al.. Gas chromatography for in situ analysis of a cometary nucleus V. Study of capillary columns' robustness submitted to long-term reduced environmental pressure conditions. *Journal of Chromatography A*, 2014.

[3] Camino, S.M Lomakin, M Lageard, Thermal polydimethylsiloxane degradation. Part 2. The degradation mechanisms, Polymer, 2002.