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Optimization of thermochemolysis analysis conditions for the in situ detection of organic compounds in Martian soil with the Mars Organic Molecule Analyzer (MOMA) experiment

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Martian surface is exposed to harsh radiative and oxidative conditions which are destructive for organic molecules. That is why the future ExoMars rover will examine the molecular composition of samples acquired from depths down to two meters below the Martian surface, where organics may have been protected from radiative and oxidative degradation. The samples will then be analyzed by the Pyrolysis-Gas Chromatography-Mass Spectrometry (Pyr-GC-MS) operational mode of the Mars Organic Molecule Analyzer (MOMA) instrument. To prevent thermal alteration of organic molecules during pyrolysis, thermochemolysis with tetramethylammonium hydroxide (TMAH) will extract the organics from the mineral matrix and methylate the polar functional groups, allowing the volatilization of molecules at lower temperatures and protecting the most labile chemical groups from thermal degradation. This study has been carried out on a Martian regolith analogue (JSC-Mars-1) with a high organic content with the aim of optimizing the thermochemolysis temperature within operating conditions similar to the MOMA experiment ones. We also performed Pyrolysis-GC-MS analysis as a comparison. The results show that, unlike pyrolysis alone – which mainly produces aromatics, namely thermally altered molecules – thermochemolysis allows the extraction and identification of numerous organic molecules of astrobiological interest. They also show that the main compounds start to be detectable at low thermochemolysis temperatures ranging from 400°C to 600°C. However, we noticed that the more the temperature increases, the more the chromatograms are saturated with thermally evolved molecules leading to many coelutions and making identification difficult.