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Evolution of organic molecules under Mars-like UV radiation conditions in space and laboratory

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Abstract

The detection and identification of organic molecules at Mars are of prime importance, as some of these molecules are life precursors and components. While *in situ* planetary missions are searching for them, it is essential to understand how organic molecules evolve and are preserved at the surface of Mars. Indeed the harsh conditions of the environment of Mars such as ultraviolet (UV) radiation or oxidative processes could explain the low abundance and diversity of organic molecules detected by now [1].

In order to get a better understanding of the evolution of organic matter at the surface of Mars, we exposed organic molecules under a Mars-like UV radiation environment. Similar organic samples were exposed to the Sun radiation, outside the International Space Station (ISS), and under a UV lamp (martian pressure and temperature conditions) in the laboratory.

1. The EXPOSE R2 experiment

The EXPOSE R2 facility has been placed in low Earth orbit (LEO) under Solar radiation, outside the International Space Station (ISS) in 2014. One of the EXPOSE R2 experiment, called PSS (Photochemistry on the Space Station), is dedicated to astrobiology- and astrochemistry-related studies. Part of PSS samples have been dedicated to the study of the evolution of organic molecules under Mars-like surface radiation conditions. Organic samples have been exposed directly to the Sun under KBr filters (UV transmission >200 nm) from November 2014 to February 2016, mimicking the UV radiation conditions of the surface of Mars. Four types of samples were exposed in the form of thin layers of solid molecules: adenine, adenine with nontronite (a

clay mineral detected on Mars), chrysene and glycine with nontronite.

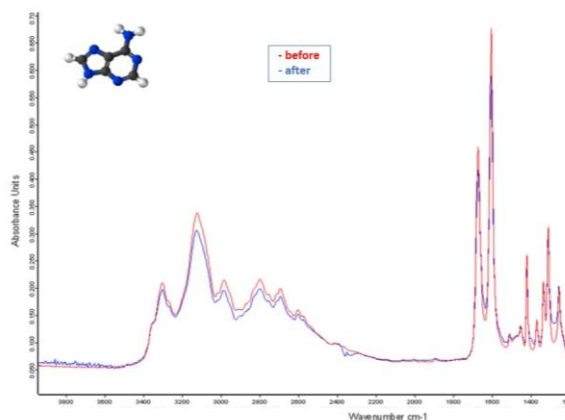


Figure 1: IR spectrum of a thin film of adenine before (in red) and after (in blue) being exposed on the International Space Station.

To characterize the evolution of our samples under irradiation, analyses by infrared spectroscopy (IRTF) were performed, before the launch of EXPOSE R2 to the ISS in 2014, and after the exposure in space and the return on Earth, this year (see figure 1). These analyses allowed determining whether each molecule is preserved or photodegraded, and if so, its photolysis rate. The effect of nontronite on organic molecules preservation has been investigated as well. We also compared these results from LEO with laboratory data.

2. The MOMIE lab experiment

The MOMIE (Mars Organic Matter Irradiation and Evolution) experiment has been set up to study the evolution of organic matter under martian radiation within the laboratory [2] [3]. Organic samples, under the form of thin films, are in this case exposed under a UV lamp (200-400 nm). Adenine, adenine with nontronite, chrysene and glycine were also studied in this experiment, allowing us to compare their evolution with the results in LEO, followed by other molecules such as uracil.

To characterize the evolution of our samples, analyses by infrared spectroscopy (IRTF) are also performed all along the irradiation. Thus, we are able to follow the sample photodegradation and the possible formation of new products at any time.

3. Conclusions

Concerning the search for organic molecules at Mars, mimicking martian radiation conditions in space and in the laboratory has been the best way to understand and interpret *in situ* results so far. In both experiments, organic molecules tend to photodegrade under Mars-like UV radiation. Minerals, depending on their nature, can protect or accelerate the degradation of organic molecules. For some molecules, new products, possibly photoresistant, seem to be produced. Finally, experimenting in space allow us to get close to *in situ* conditions and to validate our laboratory experiment while the laboratory experiment is essential to study the evolution of a large amount and diversity of organic molecules.

References

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