AMINO ACID DESTRUCTION IN THE MARTIAN SURFACE ENVIRONMENT. I. L. ten Kate[1], J. R. C. Garry[1], Z. Peeters[1], B. H. Foing[2], P. Ehrenfreund[1]. [1] Astrobiology Laboratory, Leiden Institute of Chemistry, Leiden University, P. O. Box 9502, 2300 RA Leiden, the Netherlands. tenkate@strw.leidenuniv.nl. [2] ESA Research and Scientific Support Department, ESTEC/SCI-SR, P. O. Box 299, 2200 AC Noordwijk, the Netherlands.

Introduction: The search for organic molecules and traces of life on Mars has been a major topic in planetary science for several decades. 26 years ago Viking, a mission dedicated to the search for life on Mars, detected no traces of life. The search for extinct or extant life on Mars is the future perspective of several missions to the red planet. In order to determine where and what those missions should be looking for, laboratory experiments under simulated Mars conditions are crucial. Organic compounds that are abundant in meteorites such as carbonaceous chondrites are a logical target for those experiments since they may have accumulated to form significant deposits on the martian surface via exogenous delivery [1]. We have examined the photostability of simple amino acids, given their well-characterised properties and their ubiquitous presence in meteoritic samples. Experiments have been performed to study the stability of thin films of amino acids against UV irradiation. The results showed that thin films of glycine and D-alanine are expected to have a half-life of 22 ± 5 hours and of 4 ± 2 hours, respectively, when irradiated with Mars-like UV flux levels [2]. In this paper we present the results of additional experiments, in which thin films of glycine have been irradiated with UV in a CO_2 atmosphere, and cooled to an average martian surface temperature of 210 K.

Equipment and experiments: Thin (~300 nm) films of glycine deposited in vacuum on silicon waivers [2] have been irradiated with UV radiation emitted from a deuterium discharge lamp (Heraeus-Noblelight, DX 202, range 190-325 nm). The UV part of the spectrum emitted by this lamp is ~12 times less intense than the noon-time equatorial solar UV illumination on the martian surface as calculated by [3]. A vacuum chamber as described in [2] has been used for these experiments. This chamber has been modified for sample cooling to 210 K, using a temperature regulated liquid nitrogen cooling system. In the first experiment the glycine sample was placed in ~10^{-6} mbar vacuum and cooled to 210 K prior to irradiation. In the second experiment the chamber was refilled with ~7 mbar CO_2 before the sample was cooled and irradiated. In both experiments the temperature of the sample was constant during the ~55 hour irradiation. Destruction of the glycine thin films was measured using Fourier transform infrared (IR) spectroscopy (Excalibur FTS-4000, BioRad, range 4000 - 500 cm^{-1}, 4 cm^{-1} resolution).

Results: We have monitored the destruction of the amino acid glycine under martian conditions using IR spectroscopy. The films of glycine are optically thin [2], which allowed us to use first order reaction kinetics as described by [4] to measure the destruction rate and to calculate the half-life of glycine. Figure 1 shows the destruction rate of glycine determined by the slope of a linear fit through the natural logarithm of the normalised integrated absorbance plotted against time. From the destruction rate the half-life of glycine was calculated, see Table 1.

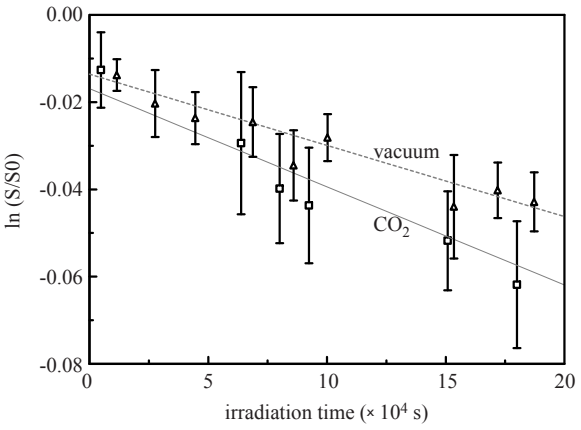

Figure 1. The natural logarithm of the normalised integrated absorbance ($\ln(S/S_0)$) plotted against time, for the deuterium irradiation of cold (210 K) glycine films in vacuum and in a CO_2 atmosphere.

Table 1 shows the half-life of a cold (210K) thin film of glycine irradiated with UV in vacuum as well as in a CO_2 atmosphere. These values have been extrapolated to a martian surface illumination scenario (second column of Table 1).

Table 1. Half-lives of glycine thin films at 210 K when irradiated with UV (190 - 325 nm) for 55 hours.

condition	half-life lab (s)	half-life Mars (h)
vacuum (10^{-6} mbar)	$3.7 \pm 2.9 \times 10^6$	86 ± 66
CO_2 (7 mbar)	$2.9 \pm 1.7 \times 10^6$	66 ± 39

Discussion: It is practically impossible to fully recreate planetary conditions in the laboratory. However, one of the advantages of experimental work is that simultaneously occurring effects may be studied separately, thus allowing us to investigate individual processes that give crucial insights into the complex multiparameter destruction processes of organics on Mars. We have recently obtained results on the UV photostability of amino acids in vacuum [2]. The effects of a CO_2 atmosphere and simultaneous cooling on the destruction on glycine samples have been investigated in this study. The results of previous experiments [5] showed that cooling the glycine film to 210 K increased the half-life with a factor by 5. We measured the destruction rate of ~300 nm thick polycrystalline films of glycine deposited on silicon substrates, when irradiated for with UV (190-325 nm) in vacuum (~10^{-7} mbar), in a CO_2 atmosphere (~7 mbar), and when cooled to 210 K. Table 1 shows that the destruction of cold glycine films in the presence of a CO_2 atmosphere is slighty reduced compared to vacuum. Regolith mineralogy and chemistry are not taken into account in these experiments. When the results on thin films of glycine by [2] and the results of this work are scaled for martian noontime lighting conditions, glycine exposed to UV at 210 K in the presence of a CO_2 atmosphere has a half-life of approximately 66 hours under continuous irradiation. Our low temperature experiments performed at 210 K are representative of mid and high latitude regions on Mars. Our results form a basis for the understanding of more complex processes occurring on the martian surface, in the presence of regolith and other reactive agents.

References:

[1] Bland P. A. and Smith T. B. (2000) *Icarus, 144,* 21-26.
[2] ten Kate I. L. et al. (2005) *MAPS, 40,* 1185-1193.
[3] Patel M. R. et al. (2002) *PSS, 50,* 915-927.
[4] Cottin H. et al. (2003) *ApJ, 590,* 874-881.
[5] ten Kate I. L. et al. (2006) *PSS,* in press.

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