DEGRADATION OF ORGANIC COMPOUNDS UNDER SIMULATED MARTIAN CONDITIONS

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Results of the Viking biology experiments indicate that a ubiquitous layer of highly oxidizing material, devoid of organics, covers the Martian surface[1]. At least 3 different oxidants were hypothesized to explain the results of the Viking biology experiments[1]. Consistent with the putative highly-oxidized condition, the Viking GCMS experiment was unable to detect organic compounds on Mars[2]. A concentration of organics that was greater than the detection threshold of the Viking GCMS was expected due to the accumulation of organics from meteoritic impact.

We have performed a series of experiments to study organic degradation under conditions that simulate the surface of Mars. The amino acid glycine was mixed with samples of the Mars-analog soil palagonite[3] at 0.1% (wt/wt) concentration and placed in evacuated chambers which were pressurized to 100 mbar with a simulated Martian atmosphere. The chambers were irradiated at room temperature with a high pressure Xenon lamp which was filtered to exclude the infrared part of the spectrum. The flux of ultraviolet photons (250 - 350 nm) irradiating the chambers was calibrated to be 7 times greater than the average flux on Mars at the equator. Gas samples were periodically withdrawn from the chamber and analyzed via gas chromatography (GC).

Glycine mixed with palagonite first degraded to methane at a rate of 0.72 ± 0.01 nmoles/hr. After 160 hrs we also detected the production of ethane (0.08 nmoles/hr), and ethylene (0.03 nmoles/hr). Glycine without palagonite photooxidized to methane at a rate of 0.52 ± 0.1 nmoles/hr and neither ethane nor ethylene was observed over the duration of the experiment (217 hours).

To investigate the possible mechanism of organic destruction, the polycrystalline samples of glycine were subjected to active detection of free radicals using electron spin resonance (ESR) while the samples were irradiated with a Xenon lamp at room temperature. ESR signals attributable to $-CH_2$ organic free radicals were detected in the UV irradiated glycine. The ESR signals observed at 23°C are quite stable even in the presence of room air. The organic free radicals as detected by ESR in glycine are apparently generated by the following photodegradation process:

$$NH_2-CH_2-\underset{\substack{\| \\ O}}{C}-OH \xrightarrow{h\nu} NH_2-CH_2 + \bullet\underset{\substack{\| \\ O}}{C}-OH$$

Chain scission, hydrogen abstraction and recombination reactions of $NH_2-\dot{C}H_2$ radical can subsequently produce such species as methane, ethane and ethylene as detected in GC experiments. The fact that only methane was seen in the experiment using glycine without palagonite, whereas the higher hydrocarbons ethane and ethylene were observed in the experiment using a palagonite and glycine mixture, indicates that the presence of minerals, which may form radicals and/or stabilize the organic radicals that are formed, allows for the production of ethane and ethylene.

The results of these experiments were used to estimate the expected rate of organic decomposition on Mars of 3.1×10^{-1} g $m^{-2}yr^{-1}$. This rate has been compared to the estimated organic supply rate from micrometeorite given in Flynn and McKay[4] of 5×10^{-5} - 7×10^{-7} g $m^{-2}yr^{-1}$. Since the rate at which organic compounds are degraded on Mars far exceeds the rate at which they are supplied, we conclude that organic compounds from micrometeorites do not accumulate on Mars. Thus, the results of the Viking GCMS experiment does not, by itself, require the presence of oxidizing agents in Martian soil.

REFERENCES

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