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Effect of nontronite smectite clay on the chemical evolution of several organic molecules under simulated Mars surface UV radiation conditions

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The search for organic carbon-containing molecules at the surface of Mars, as clues of past habitability or remnants of life, is a major scientific goal for Mars exploration. Several lines of evidence, including the detection of phyllosilicates, suggest that early Mars offered favorable conditions for long-term sustaining of water. As a consequence, we can assume that in those days, endogenous chemical processes, or even primitive life, may have produced organic matter on Mars. Moreover, exogenous delivery from small bodies or dust particles is likely to have brought fresh organic molecules to the surface of Mars up today. Organic matter is therefore expected to be present at the surface/subsurface of the planet. But the current environmental conditions at the surface - UV radiation, oxidants and energetic particles - generate physico-chemical processes that may affect organic molecules. On the other hand, on Earth, phyllosilicates are known to accumulate and preserve organic matter. But are phyllosilicates efficient at preserving organic molecules under the current environmental conditions at the surface of Mars?

We have monitored the qualitative and quantitative evolutions of glycine, urea and adenine interacting with the Fe^{3+}-smectite clay nontronite, one of the most abundant phyllosilicates present at the surface of Mars, under simulated Martian surface ultraviolet light (190-400 nm), mean temperature (218 $\pm$ 2 K) and pressure (6 $\pm$ 1 mbar) in a laboratory simulation setup. We have tested organic-rich samples which may be representative of the evaporation of a warm little pond of liquid water having concentrated organics on Mars. For each molecule, we have observed how the nontronite influences the quantum efficiency of its photodecomposition and the nature of its solid evolution products.

The results reveal a pronounced photoprotective effect of nontronite on the evolution of glycine and adenine: their efficiencies of photodecomposition are reduced by a factor of 5 when mixed with nontronite at a concentration of 2.6×10^{-2} mole per gram. Moreover when the amount of nontronite in the sample of glycine is increased by a factor of two, the gain of photoprotection is multiplied by a factor of five. This indicates that the photoprotection provided by the nontronite is not a purely mechanical shielding effect, but is at least partly due to stabilizing interactions. No new evolution product was firmly identified, but the results obtained with urea suggest a particular reactivity in the presence of nontronite, leading to an increase of its dissociation rate, in strong contrast with the other two molecules.