Subcritical Water Extraction of Amino Acids from Arid Atacama Desert Soils: Laboratory Study in Support of in situ Urey Instrument Suite

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The results of the Viking experiments suggest that more sensitive methods for the detection and analysis of biomarker compounds are needed for in situ characterization of organic compounds in Martian regolith or on other planetary bodies that may contain trace amounts of organic materials. The extraction methods by which these biomarker molecules are obtained from their native environments are critical to the success of the detection and analysis experiments. For the past few years, we have been developing a front-end system for extraction of these compounds based on subcritical water technology. The operational principles of subcritical water extractor (SCWE) developed in our laboratory are based on the unique property of liquid water to change its dielectric constant as a function of its temperature and pressure. SCWE adjusts water temperature and pressure, so water can be utilized in place of commonly used organic solvents to extract compounds with dissimilar physical and chemical properties (i.e., volatility, polarity, charge and size). We have tested the performance of SCWE in the extraction of amino acids from Atacama Desert soils. Amino acids (alanine, aspartic acid, glycine, glutamic acid, serine and valine) were extracted with subcritical water (T = 30 – 325 deg Celsius and P = 17.2 -20.0 MPa). The concentration of amino acids in the exposed duracrust soils samples was in the 1 – 70 parts-per-billion range. The amino acid extraction efficiency was defined by the dielectric constant of water and the rates of the hydrolysis and decomposition reactions, all of which were functions of subcritical water temperature, pressure, and equilibrations time (i.e., the time that subcritical water reacts with the soil samples). No detectable amounts of amino acids were extracted at 30 deg Celsius and 17.2 MPa, suggesting that most of the amino acids were strongly bound within the soil matrix. Amino acids were not detected in the extracts collected at 325 deg Celsius and 20.0 MPa, indicating that amino acids most likely undergo rapid decomposition reactions under these subcritical water conditions. The optimal SCWE extraction conditions for amino acids in the exposed duracrust Atacama soils reported here were 200 deg Celsius, 17.2 MPa and 10 min equilibration time. Our data demonstrates the successful extraction of trace amounts of amino acids from arid Atacama soils with SCWE. The extraction data is used to advance the development of miniaturized, portable SCWE instrument. Laboratory studies were undertaken to support the development of the Urey instrument suite that has been selected to participate on ESA ExoMars mission.