Geophysical Research Abstracts
Vol. 17, EGU2015-4201, 2015
EGU General Assembly 2015

Extraterrestrial material analysis: loss of amino acids during liquid-phase acid hydrolysis

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Searching for building blocks of life in extraterrestrial material is a way to learn more about how life could have appeared on Earth. With this aim, liquid-phase acid hydrolysis has been used, since at least 1970 , in order to extract amino acids and other organic molecules from extraterrestrial materials (e.g. meteorites, lunar fines) or Earth analogues (e.g. Atacama desert soil). This procedure involves drastic conditions such as heating samples in 6N HCl for 24 h, either under inert atmosphere/vacuum, or air. Analysis of the hydrolyzed part of the sample should give its total (free plus bound) amino acid content. The present work deals with the influence of the 6N HCl hydrolysis on amino acid degradation. Our experiments have been performed on a standard solution of 17 amino acids. After liquid-phase acid hydrolysis (6N HCl) under argon atmosphere (24 h at 100°C), the liquid phase was evaporated and the dry residue was derivatized with N-Methyl-N-(t-butyldimethylsilyl)trifluoroacetamide (MTBSTFA) and dimethylformamide (DMF), followed by gas chromatography-mass spectrometry analysis. After comparison with derivatized amino acids from the standard solution, a significant reduction of the chromatographic peak areas was observed for most of the amino acids after liquid-phase acid hydrolysis. Furthermore, the same loss pattern was observed when the amino acids were exposed to cold 6N HCl for a short amount of time. The least affected amino acid, i.e. glycine, was found to be 73,93% percent less abundant compared to the non-hydrolyzed standard, while the most affected, i.e. histidine, was not found in the chromatograms after hydrolysis. Our experiments thereby indicate that liquid-phase acid hydrolysis, even under inert atmosphere, leads to a partial or total loss of all of the 17 amino acids present in the standard solution, and that a quick cold contact with 6N HCl is sufficient to lead to a loss of amino acids. Therefore, in the literature, the reported increase of the total quantity of amino acids after acid hydrolysis, due to the formation/release of amino acids during the whole water extraction / liquid-phase acid hydrolysis, could have hidden a loss of amino acids. Thus, in extraterrestrial material studies involving liquid-phase acid hydrolysis, the quantities of total amino acids may have been underestimated.