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Formation of Amino Acids and Nucleotide Bases in a Titan Atmosphere Simulation Experiment

Sarah M. Hörst (1), Roger V. Yelle (1), Arnaud Buch (2), Nathalie Carrasco (3), Guy Cernogora (3), Odile Dutuit(4), Eric Quirico (4), Ella Sciamma-O'Brien (3), Mark A. Smith (1,5), Árpád Somogyi (5), Cyril Szopa (3), Roland Thissen (4), and Véronique Vuitton (4)

(1) Lunar and Planetary Laboratory, The University of Arizona, Tucson, AZ, USA, (2) Laboratoire de Génie des Procédés et Matériaux, Ecole Centrale Paris, Chatenay-Malabry Cedex, France, (3) Laboratoire Atmosphères, Milieux, Observations Spatiales, Université Versailles St-Quentin, UMPC Univ. Paris 06, CNRS, Guyancourt, France, (4) Laboratoire de Planétologie de Grenoble, CNRS, Université J. Fourier, Grenoble, France, (5) Department of Chemistry and Biochemistry, The University of Arizona, Tucson, AZ USA, horst@lpl.arizona.edu

Abstract

Titan has been a subject of astrobiological interest since the Voyager spacecraft first revealed the diversity of the organic chemistry occurring in the atmosphere. However, it was not until the arrival of the Cassini orbiter and its Huygens probe that the chemical complexity of Titan's atmosphere was fully appreciated. The Cassini Plasma Spectrometer (CAPS) observed negative ions with m/z values up to 10,000 u/q at 950 km [1] and positive ions with m/z up to 400 u/q [2]. CAPS has also observed O+ flowing into Titan's atmosphere [3], which appears to be the source, along with micrometeorites, of the oxygen in Titan's atmosphere [4]. While Titan's atmosphere is relatively oxygen poor compared to terrestrial planets, CO is the fourth most abundant molecule in the atmosphere (∼50 ppm [5]. The fact that the observed O+ flux into Titan's atmosphere is deposited in the region now known to contain large organic molecules leads to the exciting possibility that oxygen can be incorporated into these molecules resulting in the production of prebiotic molecules.

In this work, aerosols (or "tholins") produced in PAMPRE [6], a Titan atmosphere simulation experiment, have been analyzed in a very high resolution LTQ Orbitrap mass spectrometer. The tholins were found to contain 18 molecules with molecular formulae corresponding to biological amino acids and nucleotide bases. GC-MS measurements have confirmed the structure of seven: adenine, cytosine, uracil, thymine, guanine, glycine and alanine. The production of prebiotic molecules under atmospheric conditions presents a new source of prebiotic material and may increase the range of planets where life could begin.

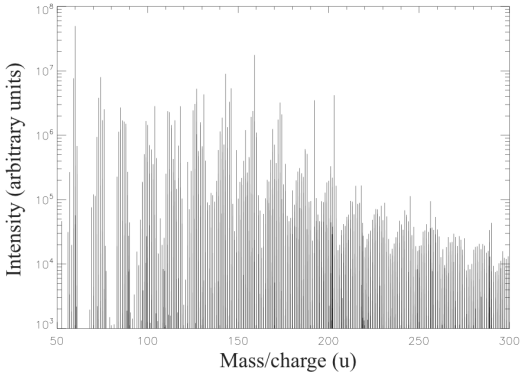

Figure 1: Typical tholin Orbitrap positive ion mass spectrum. The data shown is for a sample produced using 98% N_2 and 2%CH_4

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