Amino acids from ultraviolet irradiation of interstellar ice analogues

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In order to understand availability and distribution of molecular building blocks of biological systems during defined phases of the Cosmic and the Chemical Evolution we studied and simulated interstellar/circumstellar processes in the laboratory. In dense interstellar clouds dust particles accrete ice mantles. As seen in infrared (IR) observations, this ice layer consists mainly of water ice, but also of carbon and nitrogen containing molecules. We deposited a gas mixture consisting of H2O, CO2, CO, CH3OH and NH3 onto an aluminium surface at 12 K under high vacuum, 10E-7 mbar. During deposition the molecules were subjected to ultraviolet radiation with main intensity at Lyman-a. After warm-up, the refractory material was extracted from the aluminium block, hydrolysed for 24 h at 110 degree C with 6 M HCl, derivatized and finally analysed by enantioselective GC-MS. We were able to identify 18 amino acids in the room temperature products of irradiation [1]. The results were confirmed a) by parallel experiments using 13C-labelled ices in order to exclude contamination and b) by the identification of six diamino acids in a sample of the Murchison meteorite [2]. Amino acids are assumed to serve as the precursors of peptides and proteins [3]. Diamino acids are suggested to contribute to the development of the first genetic material, the peptide nucleic acid PNA. Beside the two groups of amino acids, N-heterocyclic organic molecules were identified that resemble the molecular building block of biological cofactors [4]. The obtained results support the assumption that the photochemical products could be preserved in interstellar objects, and in term be delivered to the Earth during the heavy bombardment which ended about 3.8 Gyr ago. The remaining organic molecules might have played an important role on the appearance of primitive life on Earth. The identification of amino acids in interstellar ice analogues is suggested to be linked with the prebiotic development of proteins, genetic material and biological cofactors on Earth.

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[3] Meierhenrich et al. Angew. Chem. Int. Ed. 44 (2005), 5630-5634.
[4] Meierhenrich et al. Chem. Eur. J. 11 (2005), 4895-4900