

Amino acid synthesis simulating hydrothermal reactions inside asteroids

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Carbonaceous meteorites contain diverse amino acids. The origins of these amino acids have been discussed for decades. Several reactions including Strecker reaction from aldehyde, ammonia, and hydrogen cyanide and ammonia-involved formose-type reaction from aldehyde and ammonia have been proposed. However, amino acid synthesis by Strecker reaction has not been well investigated. Further, other volatiles in asteroids might be involved in the amino acid synthesis. Thus, it remains unclear how amino acids were formed in asteroids. This study investigates amino acids formed by the incubations of cometary volatiles, simulating early aqueous processes in carbonaceous asteroids. Several solutions containing aldehydes, ammonia, and/or cyanide were incubated for up to 10 days. Product amino acids were investigated with liquid chromatography tandem mass spectrometry (LC-MS/MS). We identified the formation of amino acids of different molecular sizes: glycine, alanine, sarcosine, serine, α -aminobutyric acid, γ -aminobutyric acid, homoserine, threonine, aspartic acid, valine, glutamic acid, and histidine. When cyanide was not included in the starting materials, both small and large amino acids formed relatively close concentrations, indicating the contribution of formose-type reaction. However, when abundant cyanide was included in the starting material, relatively small amino acids were prominently increased, indicating their formation via Strecker reaction. Because typical carbonaceous chondrites such as the Murchison meteorite contain moderately higher abundances of small amino acids, moderate effects by cyanide would explain the relative compositions of amino acids in such meteorites. This further suggests that the simultaneous progress of Strecker and formose-type reactions formed amino acids in carbonaceous asteroids in the early solar system.

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