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Environmental Conditions for Synthesizing Selective Amino Acids from CO and NH_3

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Geochemical processes on early Earth could have supplied amino acids as a fundamental building block of life. Despite Earth's life using only homochiral L-α-amino acids, the selectivity inherent to amino acid synthesis from various prebiotic reactions remains largely unexplored. In this study, we investigate the environmental conditions that favor the selective synthesis of α-amino acids via UV photochemistry of CO and NH_3. Experiments were conducted by photolyzing mixtures of CO, NH_3, and H_2O in the presence of ten different minerals. Notably, the addition of $Ca(OH)_2$ significantly enhanced overall amino acid production. Moreover, when metal sulfides (FeS, NiS, CuS, and ZnS) were included, the synthesis of α-amino acids—specifically glycine, alanine, serine, and aspartic acid—was selectively increased compared to control experiments without minerals. In further experiments, the pH was buffered to acidic (pH = 2) and basic (pH = 12) conditions by the controlled addition of HCl, NaOH, and NaCl. The systematic analysis revealed that amino acid production under alkaline conditions was an order of magnitude higher, regardless of mineral presence. In contrast, acidic conditions yielded less amino acids but produced significant L-excesses in alanine, serine, and glutamic acid, suggesting the involvement of multiple synthetic pathways—one of which may induce enantiomeric excess in low pH environments. These findings contribute to our understanding of how mineral-organic interactions and environmental parameters could have steered selective amino acid synthesis on early Earth.