Phosphorylation of prebiotic precursors on the early Earth

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Abstract

Phosphorus is an essential component of life. Two of the three most essential constituents of life, such as DNA and RNA (responsible for coding, regulating, transmitting, etc. genes in the cell) (1), and phospholipids (constituents of the cell membrane) (2), contain phosphate groups. Simple precursors of these biomolecules could have been phosphorylated under prebiotic reaction conditions before the advent of enzymatic catalysis. However, the complexity of the involvement of natural phosphorus-containing minerals in the phosphorylation reactions of prebiotic molecules makes it an important milestone in the question of the origin of the first primitive life (3). In this work, we present a scenario, a possible mechanism, and potential agents that could be involved in the phosphorylation of prebiotic precursors in the early Earth. We investigated the phosphorylation of two different groups of starting alcohols (such as glycerol derivatives and the nucleosides), the efficacy of different phosphorus sources (orthophosphate with different protonation states, thiophosphate, and cyclic trimetaphosphate) (4-5), and the influence of potentially prebiotic condensing agents (urea, cyanamide and carboxamides) (6-7) on the reaction process. The experiments were carried out under arid prebiotic conditions assumed to cycle around the boiling point of water (75 or 115 ∘C and atmospheric pressure for 24-120 hours) and analyzed afterwards by NMR (nuclear magnetic resonance spectroscopy), MS (mass spectrometry), and HPLC methods (high-performance liquid chromatography). As a conclusion of the work, the main groups of products were identified and quantified, and the most effective and prebiotic precursor phosphorylation pathways on the early Earth were assessed.

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