

Title: Comparative Investigation of The Mechanisms of Formose-like Reaction for Complex Organic Molecules

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ABSTRACT

The investigation into the origins of interstellar molecules, particularly Complex Organic Molecules (COMs) such as ribose, the essential backbone of ribonucleic acid (RNA) is fundamental to understanding the chemical evolution leading to the origin of life. Within the extreme environments of interstellar molecular clouds, simple precursor molecules like formaldehyde (H_2CO) undergo condensation, forming ice layers on the surfaces of interstellar dust grains. These icy mantles are subsequently processed by Vacuum Ultraviolet (VUV) radiation, generated through the interaction between cosmic rays and molecular hydrogen. This photochemical process facilitates the transformation of simple chemical species into complex prebiotic biomolecules. In this study, the mechanisms of formose-like reactions were comparatively investigated under two distinct activation conditions: thermal energy at $60^\circ C$ and VUV irradiation within a vacuum chamber. The experiments utilized paraformaldehyde and calcium hydroxide in a liquid phase as primary reactions. The results demonstrated a significant divergence in reaction pathways. In the thermal activation group, the initial clear solution transitioned to a distinct yellow hue, signifying the successful progression of the formose reaction. Conversely, the VUV-irradiated samples exhibited no observable color change however, analysis via Attenuated Total Reflectance Fourier Transform Infrared (ATR-FTIR) spectroscopy revealed a spectral profile that was markedly different from the control group. The primary objective of this research is to analyze and compare the influence of VUV radiation on sugar synthesis mechanisms under simulated interstellar conditions relative to traditional thermal processes. This study aims to elucidate the role of photo-energy in the chemical evolution of prebiotic precursors. The insights gained from this work will serve as a critical benchmark for the future development of experiments on cold substrates, designed to more accurately simulate the formation of sugars on interstellar dust grains as it occurs in the natural universe.

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