

FORMATION OF THE BIORELEVANT MOLECULE PYRUVIC ACID IN INTERSTELLAR ANALOG ICES

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More than 200 molecules have so far been detected in the interstellar medium (ISM), of which close to one third are complex organic molecules containing six or more atoms. Over the last decades, laboratory experiments simulating the conditions in cold molecular clouds have demonstrated that these COMs can form from interaction of ionizing radiation with simple ices deposited on interstellar dust particles (H_2O , CO , CO_2 , CH_3OH , HCO , CH_4 , NH_3). These experiments have unveiled multiple pathways towards the formation of acetaldehyde (CH_3CHO) in such ices, explaining its detection in many interstellar and circumstellar environments including tentative detections in interstellar ices. By condensing acetaldehyde and carbon monoxide at 5 K and irradiating the ice with 5 keV electrons, we simulate secondary electrons generated in the trace of galactic cosmic rays interacting with ices around cosmic dust particles. Combined infrared and photoionization reflectron time-of-flight mass spectrometry studies were employed to unambiguously identify pyruvic acid as reaction product from the irradiation by a barrierless radical-radical reaction of the acetyl (CH_3CO) and hydroxycarbonyl (HOCO) radicals. These results present an abiotic pathway towards the formation of this prebiotic molecule in the interstellar medium. As molecular clouds eventually collapse into a star-forming region, molecules formed in the ices can be incorporated into matter in the circumstellar disks, in which planets, planetoids, and comets can form. Fractions of these molecule can survive on their parent bodies to eventually be delivered to planets upon impact, presenting an exogenous source of prebiotic molecules on Earth. Among these, pyruvic acid constitutes a key starting material for the Krebs cycle, which supplies living organisms with energy. Furthermore, it may serve as a prebiotic building block for important biological compounds such as lactic acid or alanine.