Exploiting Modern Photoionization Tools to Untangle the Formation of Astrobiologically Relevant Molecules in Extraterrestrial Ices

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Astrobiologically relevant molecules such as the sugar glycolaldehyde are ubiquitous in the interstellar medium, but traditional gas phase astrochemical models cannot explain their formation routes. By systematically exploiting *on line* and *in situ* vacuum ultraviolet photoionization coupled with reflectron time of flight mass spectrometry (PI-ReTOF-MS) and combining these data within infrared spectroscopy (FTIR), we reveal that complex organic molecules - among them astrobiologically relevant species - can be synthesized within interstellar ices that are condensed on interstellar grains via non-equilibrium reactions at temperatures as low as 5K. By probing for the first time specific structural isomers withour their degradation (fragment-free), the incorporation of tunable vacuum ultraviolet photoionization allows for a much greater understanding of reaction mechanisms that exist in interstellar ices compared to traditional methods thus eliination the significant gap between observational and laboratory data that existed for the last decades. With the commisiton of the Atacama Large Millimeter/Submillimeter Array (ALMA), the detection of more complex organic molecules in space will continue to grow - including biorelevant molecules connected to the *Origins of Life* theme - and an understanding of these data will rely on future advances in hard core physical chemistry laboratory experiments.

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