QUANTUM TUNNELING IN INTERSTELLAR ICE BY AMMONIA (NH_3) AND ACETALDEHYDE (CH_3CHO): CHELATION AGENTS TO ASSIST RNA REPLICATION

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Ion transport represents a vital process in all modern lifeforms, but how early cells could have accomplished this without the complex proteins used by modern cells has remained a mystery. Here, we investigate thermal reactions in interstellar analog ices of ammonia (NH_3) and acetaldehyde (CH_3CHO) with high-sensitivity and isomer-specific tunable vacuum-ultraviolet photoionization techniques. Nucleophilic addition allows access to 1-aminoethanol ($CH_3CH(OH)NH_2$) at temperatures as low as 65 K. Isotopic substitution experiments in concert with computational analysis provide mechanistic information on addition and dehydration reactions in the unique environment of interstellar ices. The high sensitivity of photoionization mass spectrometry reveals the formation of additional products such as ethanimine (CH_3CHNH) and the first observations of 1-(1-hydroxyethylamino)ethanol ($NH(CH(OH)CH_3)_2$) and 1-ethylideneaminoethanol ($CH_3CH(OH)NCHCH_3$). Low-temperature formation of these molecules indicates that sequential addition and dehydration reactions are feasible in cold interstellar environments and represent an unconventional starting point from which large chelating agents of biorelevant metal ions may have been produced abiotically and with delivery to planets like early earth could enable ion transport in primitive cells.