NUCLEOBASES AND OTHER PREBIOTIC SPECIES FROM
THE UV IRRADIATION OF PYRIMIDINE IN
ASTROPHYSICAL ICES.
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Introduction: Nucleobases are aromatic N-heterocycles that constitute the informational subunits of DNA and RNA, and are divided into two families: pyrimidine bases (uracil, cytosine, and thymine) and purine bases (adenine and guanine). Nucleobases have been detected in meteorites [1,2] and their extraterrestrial origin confirmed by isotope measurement [3]. Although no N-heterocycles have been individually identified in the ISM [4,5], the 6.2-μm interstellar emission feature seen towards many astronomical objects suggests a population of such molecules is likely present [6]. We report on a study of the formation of pyrimidine-based molecules, including nucleobases and other species of prebiotic interest, from the ultraviolet (UV) irradiation of pyrimidine in low temperature ices containing H₂O, NH₃, CH₃OH, and CH₄, to simulate the astrophysical conditions under which prebiotic species may be formed in the interstellar medium, protosolar disk, and icy bodies in the Solar System.

Experimental: Gas mixtures were prepared in a glass mixing line (background pressure ~10⁻⁸–10⁻⁵ mbar; relative proportions between components were determined by their partial pressures). Gas mixtures were then deposited on an Al foil attached to a 15-20 K cold finger and simultaneously irradiated with an H₂ lamp emitting UV photons (Lyman α and a continuum centered around 160 nm). After irradiation samples are warmed to room temperature, at which time any remaining residues are recovered to be analyzed with liquid and gas chromatographies.

Results: These experiments showed that the UV irradiation of pyrimidine mixed in these ices at low temperature leads to the formation of several photo-products derived from pyrimidine, including the nucleobases uracil [7,8] and cytosine [8], as well as their precursors 4(3H)-pyrimidone and 4-aminopyrimidine [7,8]. Theoretical quantum calculations on the formation of 4(3H)-pyrimidone and uracil from the irradiation of pyrimidine in pure H₂O ices are in agreement with their experimental formation pathways [9]. In those residues, other species of prebiotic interest such as urea and the amino acids glycine and alanine are also be identified [8]. Pyrimidine derivatives containing CH₃ groups, including the nucleobase thymine, are also seen, but are made with much lower efficiencies [10], perhaps explaining why this nucleobase has yet to be identified in meteorites.