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 ~10⁻⁴–10⁻⁵ 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.

preparation.