Western Pacific Geophysics Meeting (WPGM),
22–25 June 2010, Taipei, Taiwan

Ultraviolet irradiation of pyrimidine in interstellar ice analogs: Formation and photo-stability of nucleobases

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Astrochemistry laboratory experiments recently showed that molecules of prebiotic interest can potentially form in space, as supported by the detection of amino acids in organic residues formed by the UV photolysis of ices simulating interstellar and cometary environments (H_2O, CO, CO_2, CH_3OH, NH_3, etc.). Although the presence of amino acids in the interstellar medium (ISM) is still under debate, experiments and the detection of amino acids in meteorites both support a scenario in which prebiotic molecules could be of extraterrestrial origin, before they are delivered to planets by comets, asteroids, and interplanetary dust particles. Nucleobases, the informational subunits of DNA and RNA, have also been detected in meteorites, although they have not yet been observed in the ISM. Thus, these molecules constitute another family of prebiotic compounds that can possibly form via abiotical processes in astrophysical environments. Nucleobases are nitrogen-bearing cyclic aromatic species with various functional groups attached, which are divided into two classes: pyrimidines (uracil, cytosine, and thymine) and purines (adenine and guanine). In this work, we study how UV irradiation affects pyrimidine mixed in interstellar ice analogs (H_2O, NH_3, CH_3OH). In particular, we show that the UV irradiation of H_2O:pyrimidine mixtures leads to the production of oxidized compounds including uracil, and show that both uracil and cytosine are formed upon irradiation of H_2O:NH_3:pyrimidine mixtures. We also study the photostability of pyrimidine and its photoproducts formed during these experiments.