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Photoprocessing of formamide ice: route towards prebiotic chemistry in space

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Abstract

Formamide (HCONH2) is the simplest molecule containing the peptide linkage of crucial importance in prebiotic chemistry and physics in the fascinating open questions of modern science about the origin of life. These peptide links are known to be the basis for assembling proteins and polypeptides from amino acids with a crucial role in the biotic processes of Earth life, as was argued by a recent study by Saladino et al. (2012) [1]. Formamide was observed in the interstellar medium and it's a molecule very important for its active role in prebiotic chemistry, because the chemical reactions of molecules like Formamide containing H,C,N and O are considered a plausible pathway for synthesis on the Earth of biomolecules under prebiotic conditions [2]. For these reasons, the Formamide is of great interest for astrochemists and astrobiologist and many experimental and theoretical studies have been carried out in order to understand the physical and chemical properties of Formamide under space conditions.
Formamide was first detected in the gas phase in Orion-KL and SgrB2 (Turner 1991 [3]; Nummelin 1998 [4]; Halfen 2011 [5]), but it is possible that the Formamide, observed in the gaseous phase, is initially absorbed on the surface of the grains of the ISM and then evaporates as a consequence of the radiation coming from the stars.

1. Laboratory work

The goal of our laboratory work is to study the Formamide under simulated astrophysical conditions such as UV irradiation at low temperature. In laboratory we can carry out experiments at 65 K irradiating with UV-Enhanced Xenon lamp, a good simulator of the radiation of solar type stars. We report two analysis. The first is UV irradiation of pure Formamide samples and Formamide adsorbed on various space relevant minerals, like forsterite, pyrite and TiO2, at 65 K investigated by infrared spectroscopy (FTIR) in order to understand the photostability of Formamide under simulated space condition. The second analysis is carried out in ultra-high vacuum chamber to investigate the same process of UV irradiation of pure Formamide by mass spectrometry and Temperature Programmed Desorption (TPD) in order to understand the physical properties during the photo-destruction process in simulated space conditions.

2. Results

We have seen that during the irradiation some bands of the spectra are reduced, like the band at 1721 cm^{-1}, assigned to CO stretching. Through the analysis of the TPD curves it is seen that the pure Formamide splits into NH2, HCO and CH2NO. We have analyzed these fragments after 5 hours of irradiation and what we notice is that they sublimate before Formamide (the Formamide subimates at 220 K, HCO and NH2 at 184 K and CH2NO at 182 K). After 5 hours of UV irradiation, we have not seen the synthesis of more complex molecules, both in UHV and when the Formamide is absorbed on minerals. These results allows us to take a step forward on the knowledge of the physical and chemical properties of the Formamide in space.

References

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