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H-atom irradiation of solid state formamide at 12 K

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Abstract. The aim of this work is to understand the stability and investigate the chemical evolution of formamide ice due to thermal hydrogenation at simulated interstellar conditions.

Keywords. Astrochemistry, molecular processes, methods: laboratory, techniques: spectroscopic

1. Introduction

Formamide (NH_2CHO) is the simplest H, N, C, and O containing molecule with a peptide linkage. Formation route of formamide in solid and gaseous state has been a topic of interest for astrochemists and astrobiologists as formamide has been proposed as a prebiotic precursor and at the same time identified in a number of astrophysical environments. Formamide is identified in a variety of star forming regions (Raunier *et al.* (2004), López *et al.* (2015) and references therein) and in cometary comae (Bockelèe *et al.* (2000)) of Hale-Bopp and very recently in cometary soil of 67P/Churyumov-Gerasimenko (Goesmann *et al.* (2015)). In star formation regions, there is a high abundance of hydrogen atoms which can interact with formamide on icy grain mantles due to their high mobility.

2. Experimental

In a vacuum set-up (a few 10^{-8} mbar), NH_2CHO vapour is deposited by a needle valve on a CsI substrate cooled down to 12 K. The ice is irradiated by an atomic hydrogen beam produced by microwave dissociation of molecular hydrogen (99.9999% purity). The beam has a Maxwellian distribution of the velocity of H atoms at 300 K (Mennella (2010)). *In situ* Fourier transform infrared (FTIR) spectroscopy in transmittance mode is performed before and after ice irradiation. Thickness of the deposited ice is derived from the 7.2 μm (1388 cm^{-1}) infrared band of NH_2CHO, using a band absorbance of 6.8×10^{-18} cm mol^{-1} and a density of 0.937 g cm^{-3} (Brucato *et al.* (2006)). The thickness is 2.8 μm. The spectrometer works at a spectral range between 7500-400 cm^{-1} (1.33-25 μm) and 2 cm^{-1} resolution. For each single measurements 1024 scans are co-added.

3. Results and final remarks

During H-atom irradiation, IR peaks due to NH_2CHO are reduced and new peaks appeared at 2265 cm^{-1} and 2172 cm^{-1} which are assigned to N=C=O asymmetric stretching of isocyanic acid (HNCO) and OCN^-, respectively as seen in Figure 1. Increasing the H atom fluence results in the continuous decrease of formamide peaks and a gradual increase of HNCO peaks, until a saturation is reached. No aminomethanol is formed. The efficiency of degradation of formamide to form HNCO is estimated at *ca.* 17 % at H atom fluence of 6×10^{16} H atoms cm^{-2}. A previous attempt of H atom

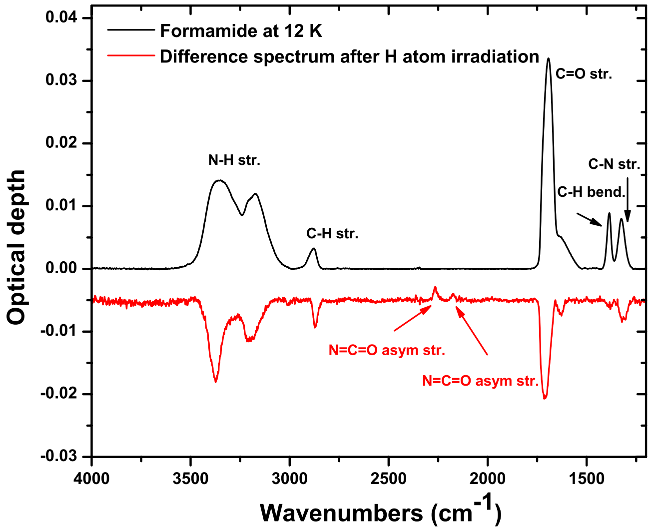

Figure 1. IR spectrum of 2.8 μm pristine formamide (black) and difference spectrum (red) after H-atom bombardment ($6{\times}10^{16}$ H atoms cm^{-2}) at 12 K. The red curve is translated by -0.005 and scaled by a factor of 5 for the sake of clarity.

bombardment reaction of NH_2CHO deposited on graphite (Noble *et al.* (2015)) yielded no degradation product. The results could be useful to reconsider a possible chemical link between formamide and isocyanic acid.

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