EFFICIENT FORMATION ROUTE OF THE PRE-BIOTIC MOLECULE FORMAMIDE ON INTERSTELLAR DUST GRAINS

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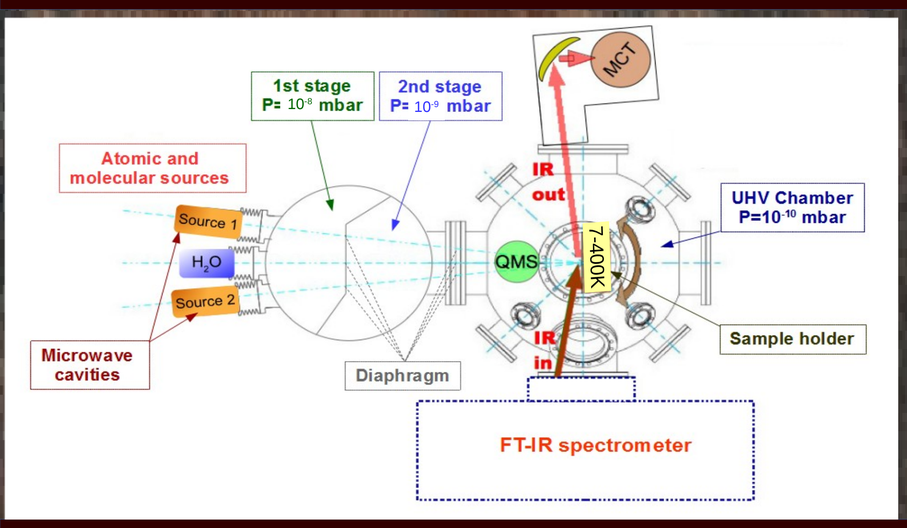
INTRODUCTION

- Formamide (NH_2CHO), is presented as a pre-biotic precursor, the starting point of both pre-genetic and pre-metabolic species.
- There are three different possible scenarios to explain the formation of NH_2CHO:

1. The formation of NH_2CHO has been formed from the reaction of NH_2 and H_2CO in the gas phase.
2. NH_2CHO has been formed via energetic processing of ice mantles: $CO:NH_3$ ice mixture or via hydrogenation and UV photolysis of NO in CO rich ice analogues.
3. NH_2CHO has been formed via non-energetic pathways.

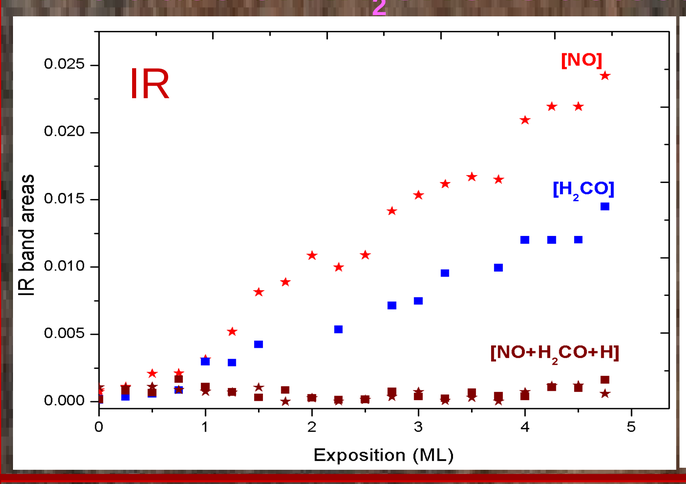
METHODS

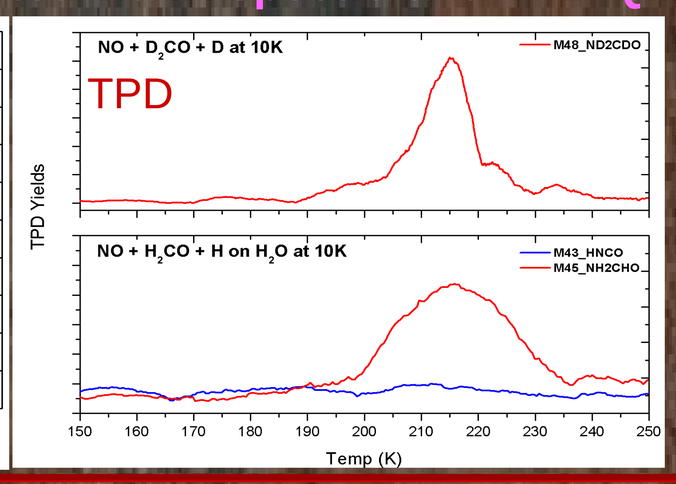


- UHV chamber with the pressure of 10^{-10} mbar.
- The triples beamlines are used to inject NO, H_2CO, and H atoms onto the sample holder.
- $T_{surface}$ = 10 K.
- Water ice layer: porous amorphous solid water (4 Mls).
- TPD- QMS; FT-RAIRS.

THE TRACE OF FORMAMIDE (NH_2CHO)

♦The trace of NH_2CHO is detected via IR spectra and TPD-QMS





- IR spectra: NO and H_2CO are consumed by addition of H atoms → All reactions occur on the surface at low temperatures.
- TPD profiles: ND_2CDO (top panel) is formed via co-deposition of NO, D_2CO, and D atoms on the gold surface at 10K.
- NH_2CHO (bottom panel) is formed via co-deposition of NO, H2CO, and H atoms on porous ASW at 10K.

→ NH_2CHO is formed via the co-hydrogenation of NO and H_2CO on the surface under our laboratory conditions.

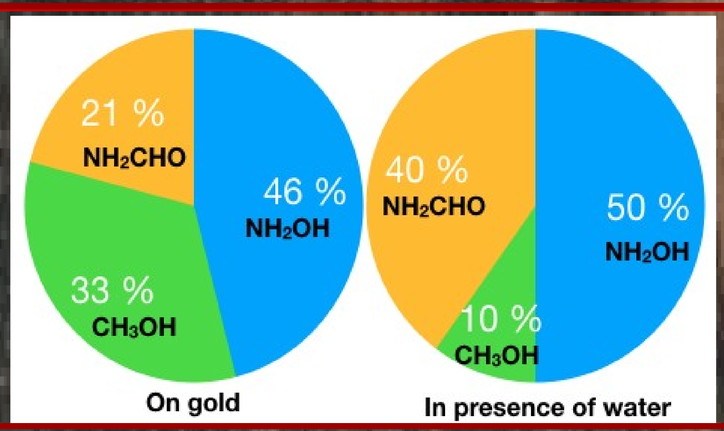
♦ Ratio of relative products (NH_2OH, CH_3OH and NH_2CHO)

- On gold surface: one third H_2CO contributed to the formation of NH_2CHO.
- On porous water ice: mostly H_2CO converted to the formation of NH_2CHO.
- The back reaction of NH_2OH by abstraction of H atoms:

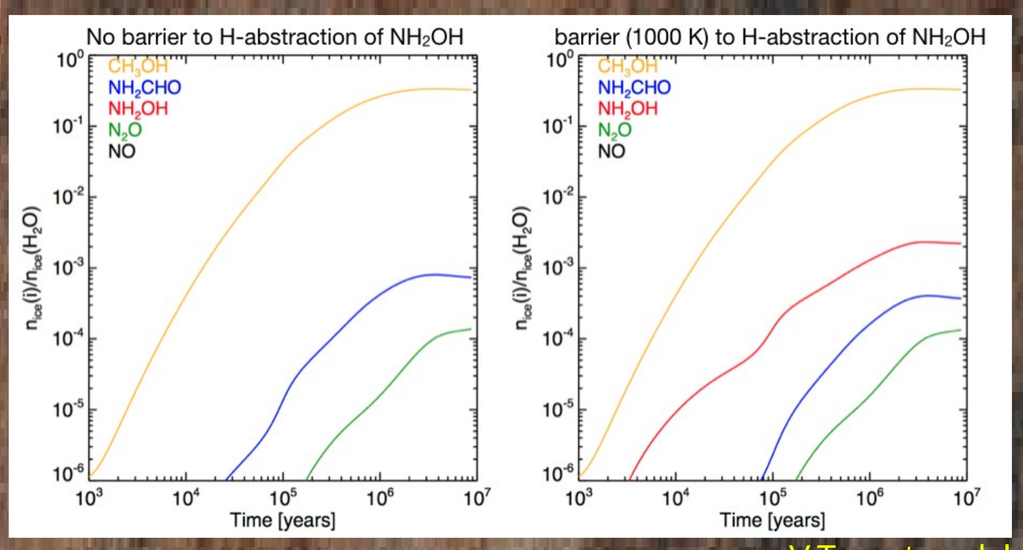
→ $NH_2OH + H \rightarrow NHOH/NH_2O + H_2$

- The chemical reaction of the formation of NH_2CHO:

→ $H_2NO/NHOH + H_2CO \rightarrow NH_2CHO + OH$



♦ Astrochemical model



V.Taquet model

- A production of NH_2CHO is about 10^{-4} relative to water.
- There is no barrier to H abstraction of NH_2OH:

NH_2OH would be consumed and NH_2CHO would be formed at the surface of the dust grains.

♦ Astrophysical implications

- NH_2CHO is formed via the co-hydrogenation of two simple molecular precursors on solid phases without external energy.
- In dark clouds, NH_2CHO is produced on grains with an abundance of about 10^{-4} relative to water.
- The existence of an effective and direct mechanism of the formation of NH_2CHO on the solid state without the external energy supports arguments about cometary materials and their interstellar matrix, in pre-stellar cores.

→ Comets that collide with planets would contribute the delivery NH_2CHO on Earth because of the high binding energy (refractory).

- Formamide is to be considered a key molecule for the early development of life.

REFERENCES

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