Radical and iCOM Formation From VUV Photolysis of H_2O:CO Interstellar Ice Analogues: an EPR Coupled to IR and QMS-TPD Study

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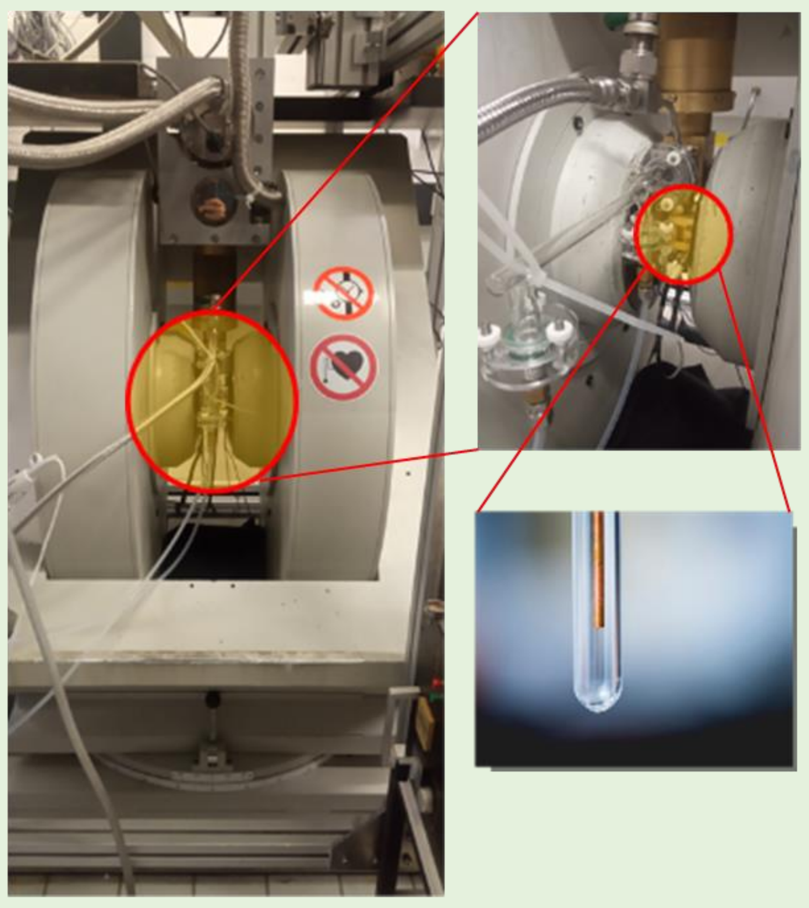
Introduction



Bochum EPR experiment

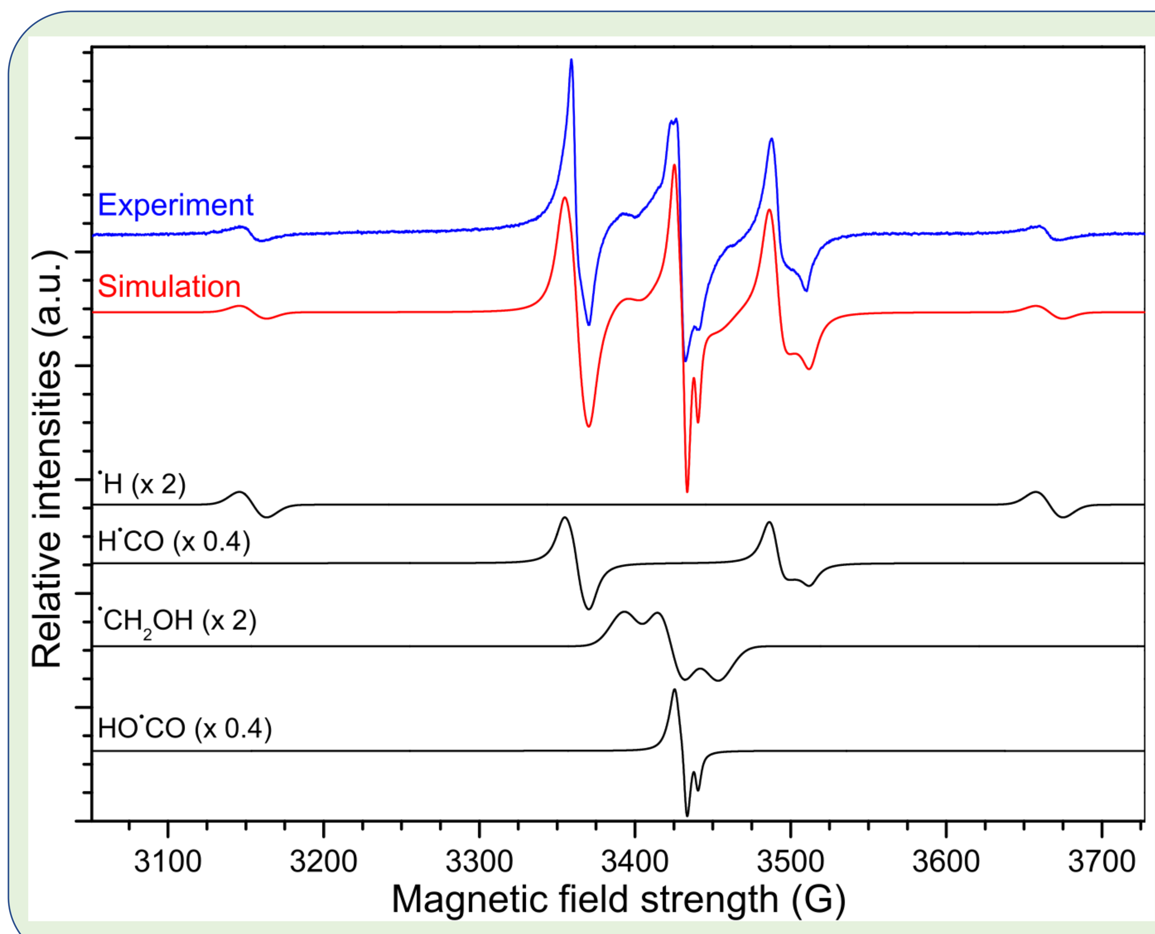
- COM formation mechanisms are not well established and could take place either in gas or solid phase. [1,2]
- We developped an unique experimental procedure allowing the detection of intermediary (radical) species and stable products in the same experimental conditions. [3]
- This work aims to apply this methodology to interstellar ice analogues with the astro relevant CO/H_2O system.
- We propose **solid phase formation mechanisms** of some carboxilic acids under VUV photolysis at Lyman-α wavelength.

RING experiment

Experimental procedure

- CO/H_2O = 1/1 deposition at 4 K (Bochum) or 12 K (*RING*).
- Photolysis (121.6 nm) and EPR/IR acquisition at 4 K/12 K.
- QMS-TPD acquisition (EI, 70 eV) between 160 and 300 K.

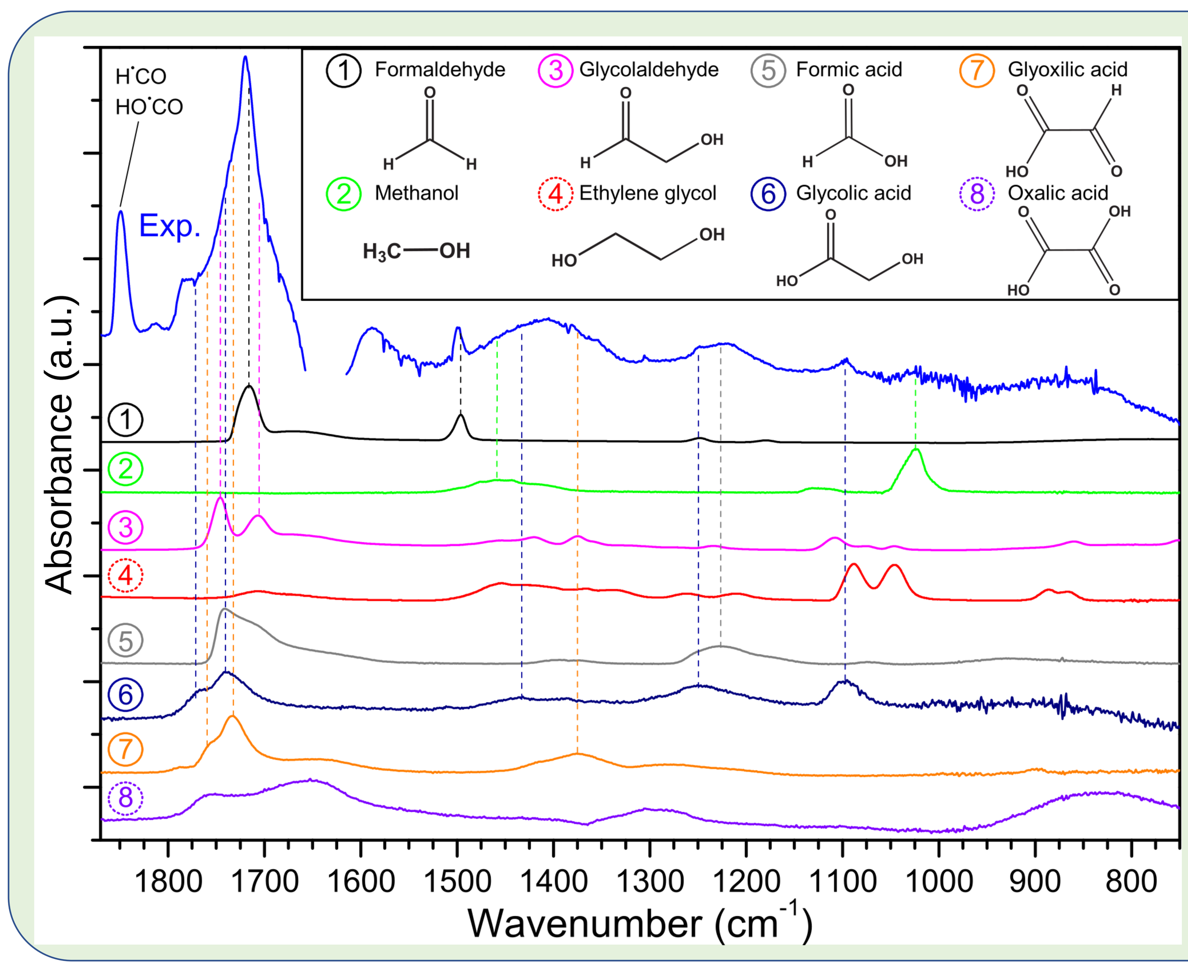
EPR detection of radical intermediates



- Radicals simulated with EasySpin in MATLAB.
- Detected radicals: **H•, H•CO, •CH$_2$OH, HO•CO.**
- Intensities proportionnal to species quantity.

➢ Two major intermediaries: HO•CO & H•CO.

IR detection of radicals and COMs



➢ Two detectable radicals: HO•CO & H•CO.

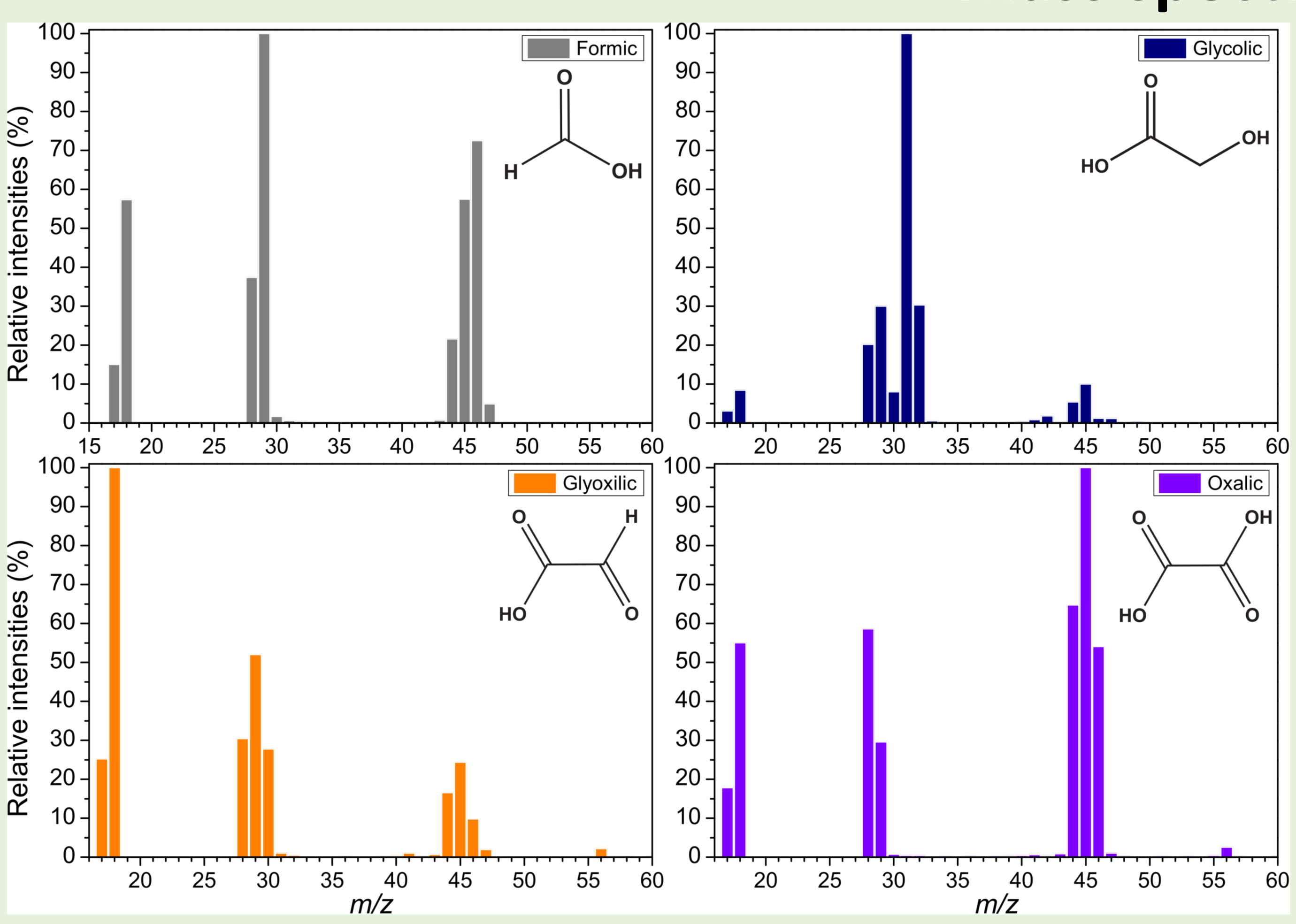
➢ CO hydrogenation products [4]:

$CO \xrightarrow{2H} \mathbf{H_2CO} \xrightarrow{2H} \mathbf{CH_3OH}$

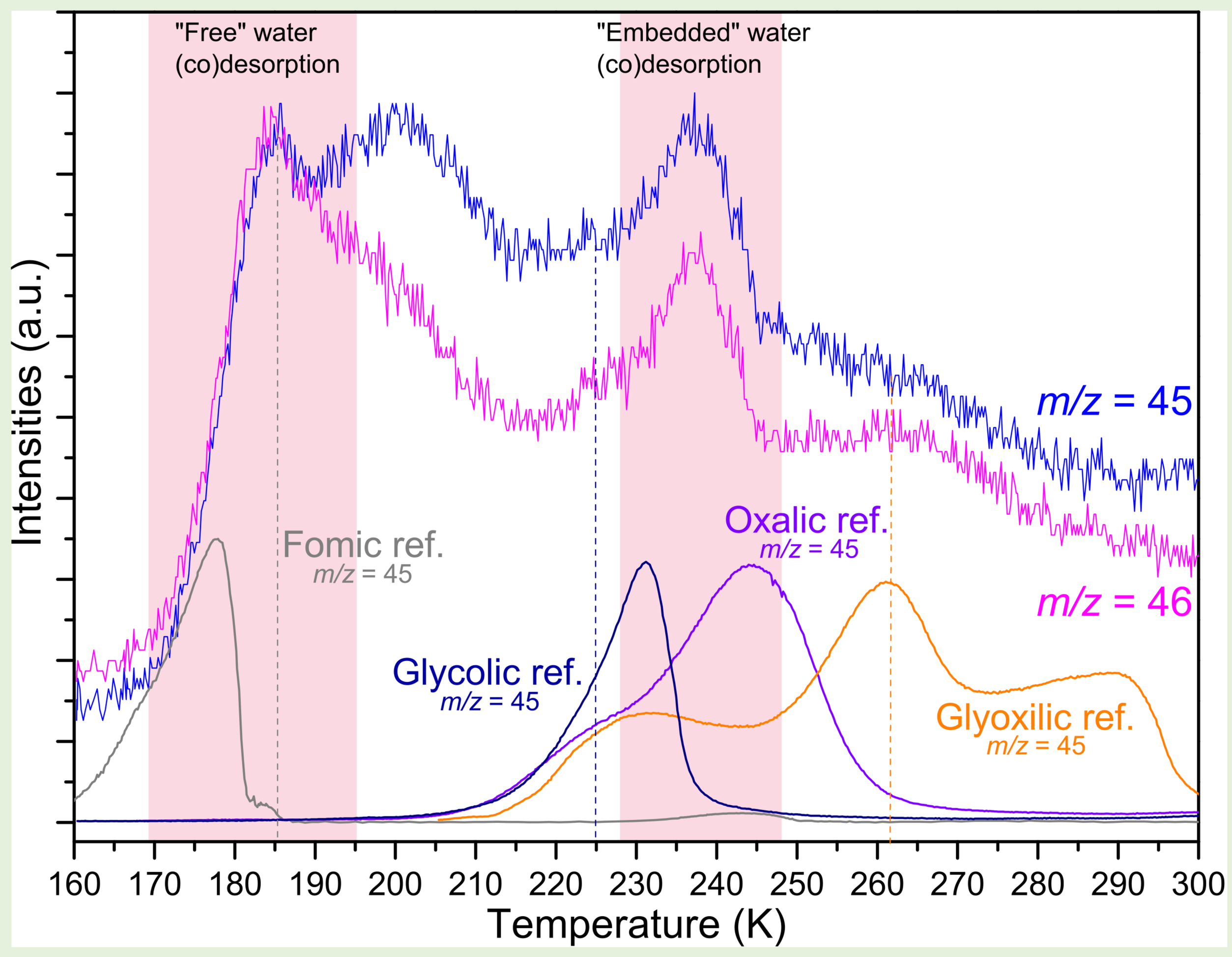
➢ Strong hints: Formic and glycolic acids.

➢ Not conclusive: GA, EG, oxalic and glyoxilic acids.

Mass spectrometry (QMS-TPD) detection of products



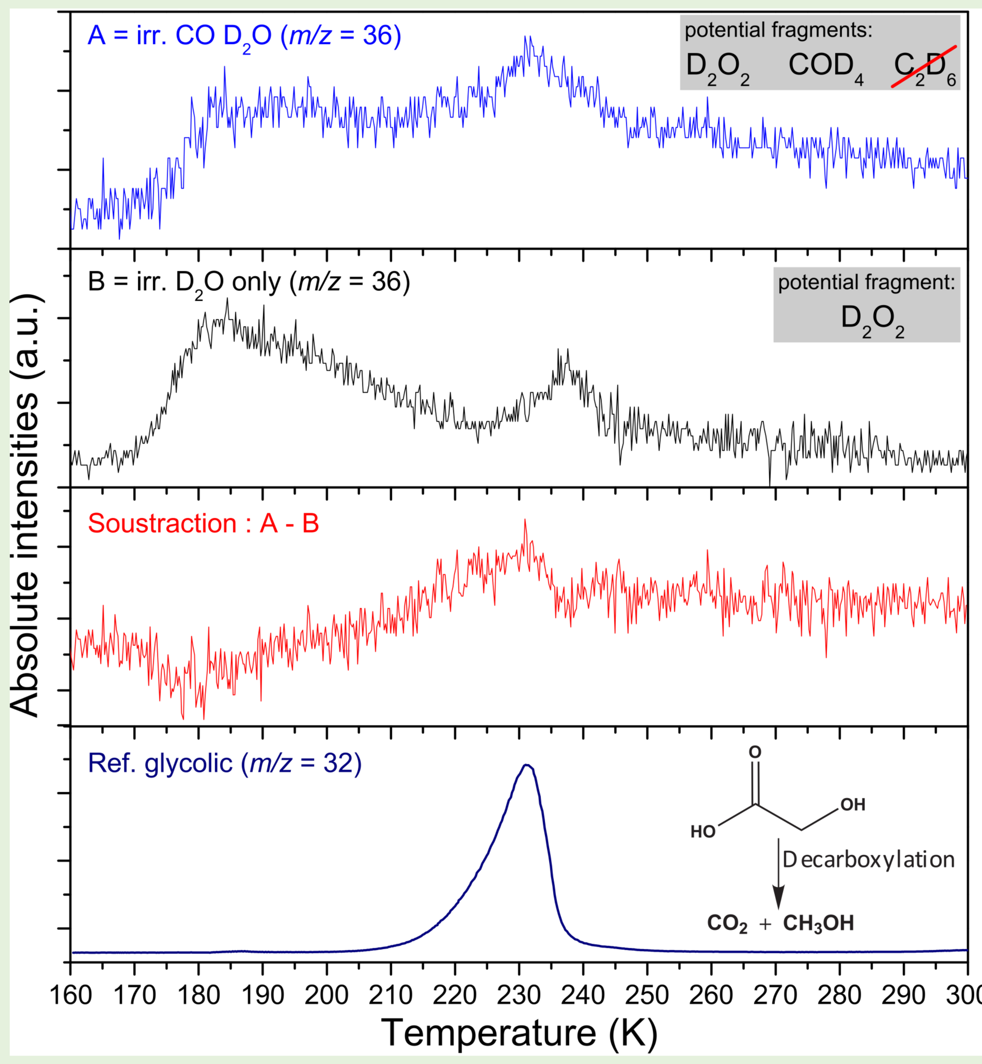
- *RING* apparatus references.
- All acids share same *m/z* fragments.
- *m/z*=46 > *m/z*=45 only for FA.
- *m/z*=31 & *m/z*=32 only for glycolic acid.



➢ Codesorption of all acids between 160 and 300 K.

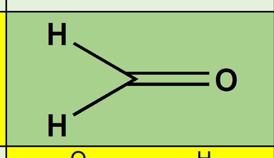
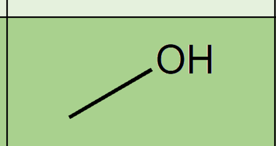
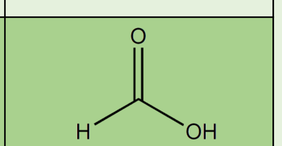
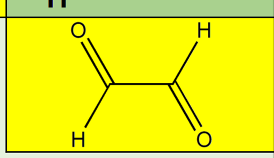
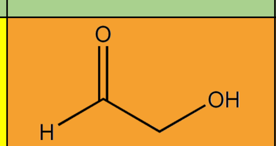
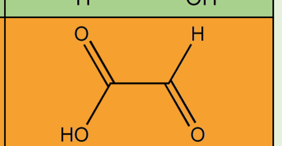
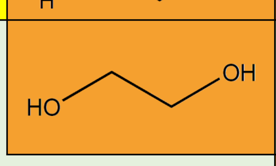
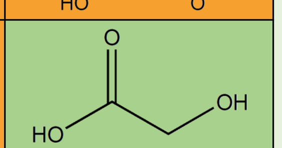
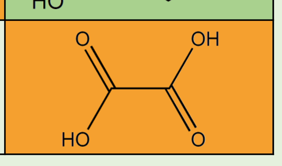
➢ [170K ; 190K]: *m/z*=45 = *m/z*=46 → Mainly FA desorbing.

➢ Some concordances for glycolic and glyoxilic acids.



- Glycolic *m/z*=32 (COH_4) → *m/z*=36 (COD_4).
- [210K ; 240K]: desorption of a COD_4 fragment correlated to glycolic reference.

Conclusion

	H•	H•CO	•CH$_2$OH	HO•CO
H•	H_2			
H•CO				
•CH$_2$OH				
HO•CO				

Detected molecules — Not enough evidence — No possible conclusion

✓ Detection of at least four radical intermediary species from CO/H_2O VUV photolysis: **H•, H•CO, •CH$_2$OH**, and **HO•CO**.

✓ Two carboxilic acids can be formed in solid state by radical recombination:
H• + HO•CO ⟶ HCOOH (**FA**) & •CH$_2$OH + HO•CO ⟶ HOCH$_2$COOH (**glycolic acid**).

✓ Glyoxilic & oxalic acids could also be formed but more experiments are needed.

✓ Formic acid has been detected in the ISM [5] and interstellar ices [6]. Glycolic acid has not (yet) been observed, let's search for this molecule ☺.

PDF format — Poster Quizz

References

[1] K.-J. Chuang et al., *MNRAS*. **2017**, 467, 2552. **[2]** D. Skouteris et al., *ApJ*. **2018**, 854, 135. **[3]** A. Gutiérrez-Quintanilla et al., *MNRAS*. **2021**. **[4]** T. Hama and N. Watanabe, *Chem. Rev*. **2013**, 113, 8783. **[5]** B. Zuckerman et al., *ApJ*. **1971**, 163, L41. **[6]** A. C. A. Boogert et al., *ApJ*. **2008**, 678 (2), 985.