CO and N_2 differential depletion in prestellar cores: Experimental study of N_2 desorption induced by the CO presence on ices

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OVERVIEW

- I. Introduction
- II. Experiments
- III. Experimental results
- IV. Analysis and Discussion
- V. Conclusions

INTRODUCTION

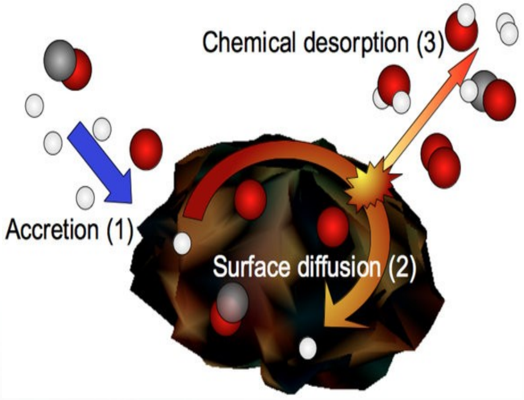
- CO and N_2 are two of the most abundant molecules and atoms in dark clouds.
- CO and N_2 molecules affect the abundances of many other molecules.
- The ability of a molecular or atom to freeze out depends on its binding energy and the temperature to the grain surface.
- The CO co-adsorption affects the N_2 desorption on the water ice morphologies.

EXPERIMENT

- All experiments are made through a machine named VENUS setup at LERMA laboratory in Cergy.

Mechanism:

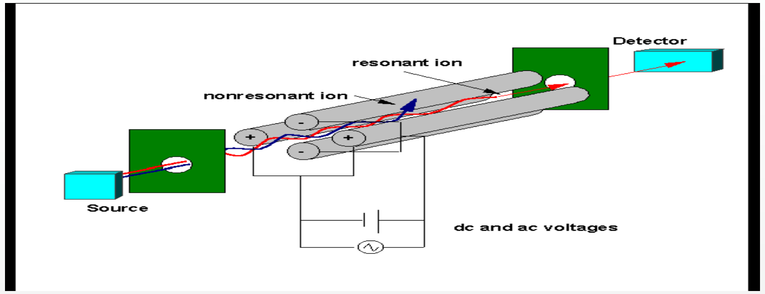
- The molecules or atoms come in contact with a surface before desorbing from the surface.



Dulieu et al. Nature Sci. Rep.2013

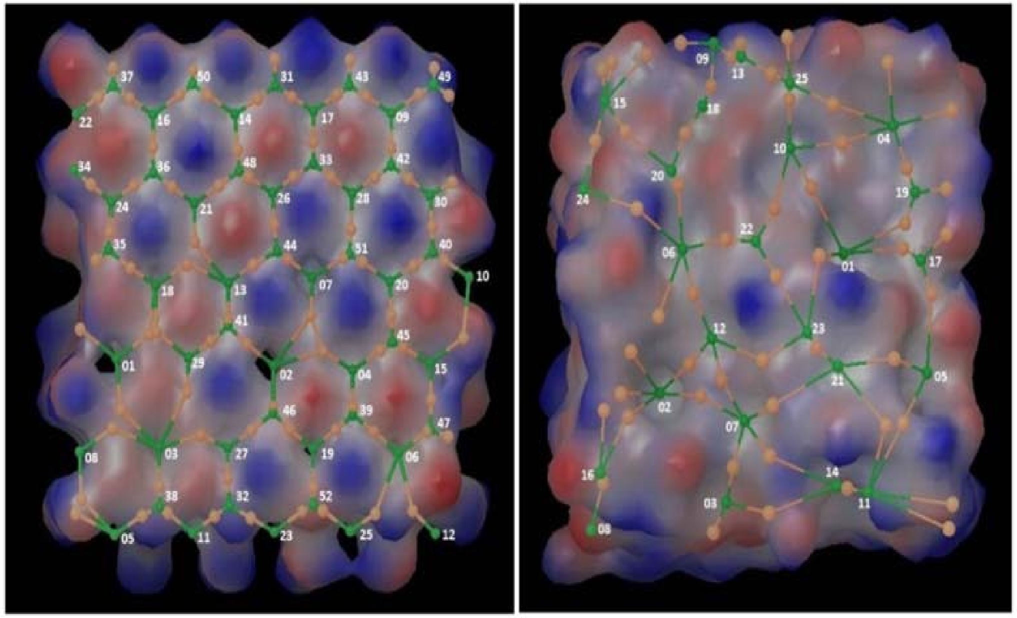
Detectors:

- Thermally Programmed Desorption (TPD).
- Quadrupole Mass Spectrometer (QMS).
- Infrared Spectroscopy.

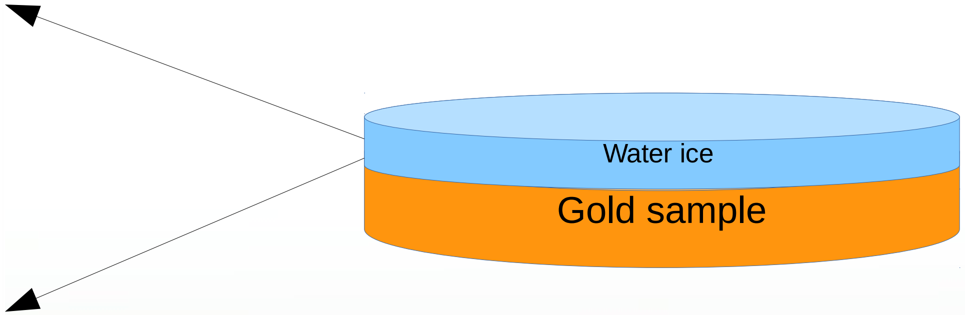


EXPERIMENT

- The water ice is deposited on the surface (compact amorphous solid water, porous amorphous solid water, and crystalline ice).



(c) Crystalline water ice (Surface) (d) Amorphous solid water (Surface)



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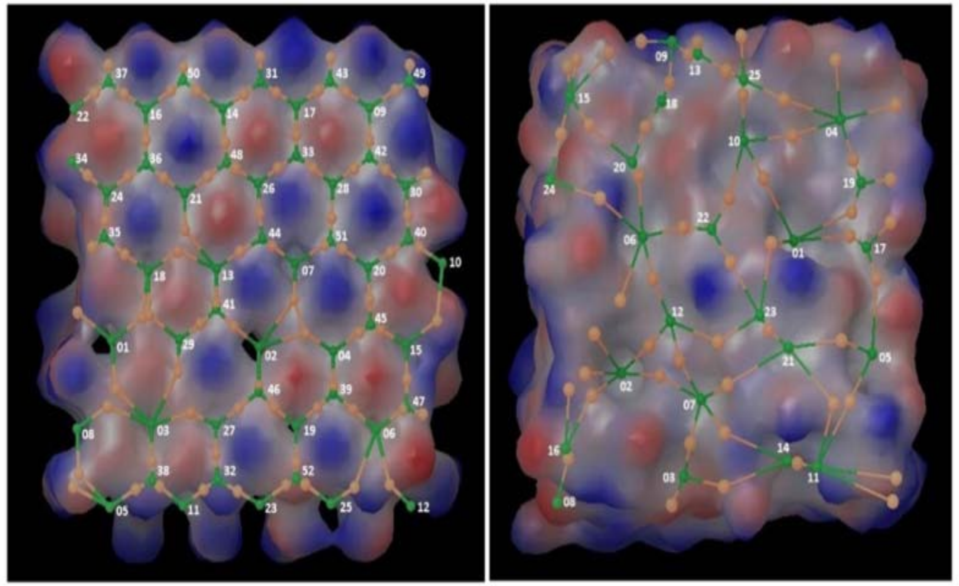
EXPERIMENT

- The water ice is deposited on the surface (compact amorphous solid water, porous amorphous solid water, and crystalline ice).
- The CO and N_2 molecules are deposited on the water ice surface at 10 K.
- The surface temperature is increased from 10 K annealing to 55 K.



(c) Crystalline water ice (Surface) (d) Amorphous solid water (Surface)

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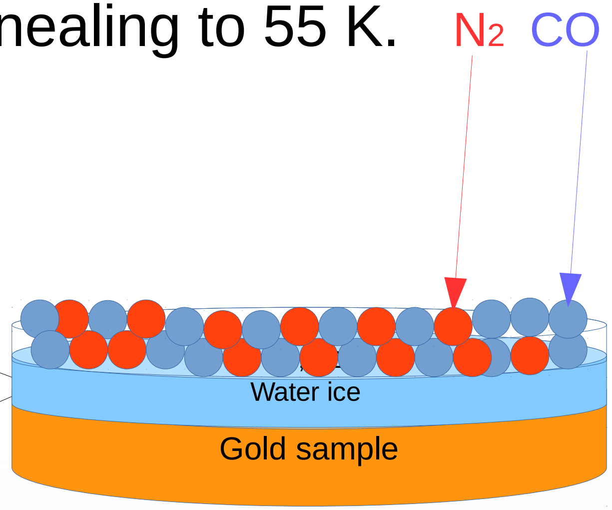
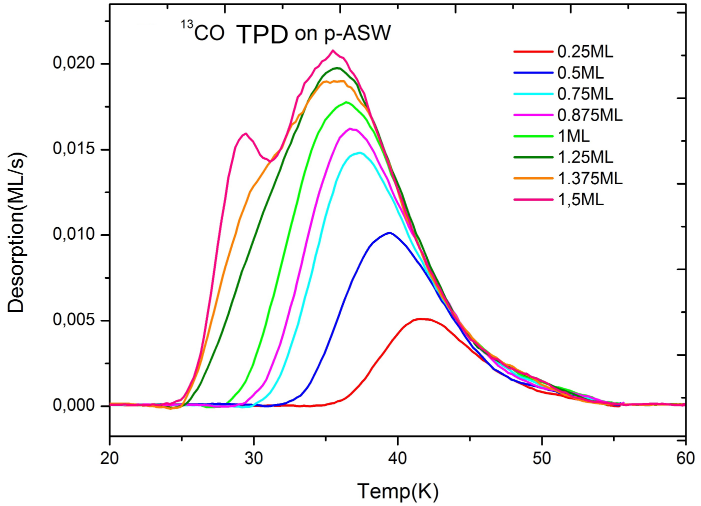
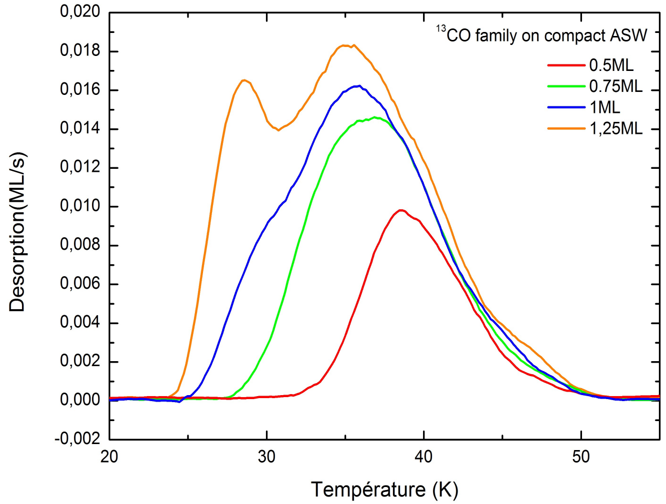


EXPERIMETAL RESULTS

- CO molecules are deposited on porous ASW and compact ASW.





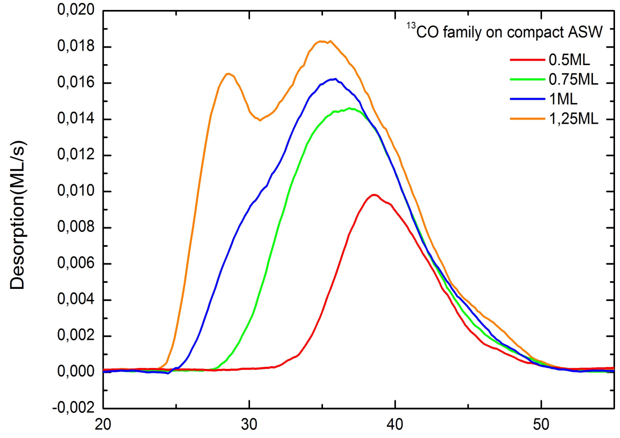
- The temperature shifts towards the lower values when the molecular doses increase on the surface.
- The surface density corresponds to 1 ML of $1.5*10^{15} molecules.cm^{-2}$ for porous ASW

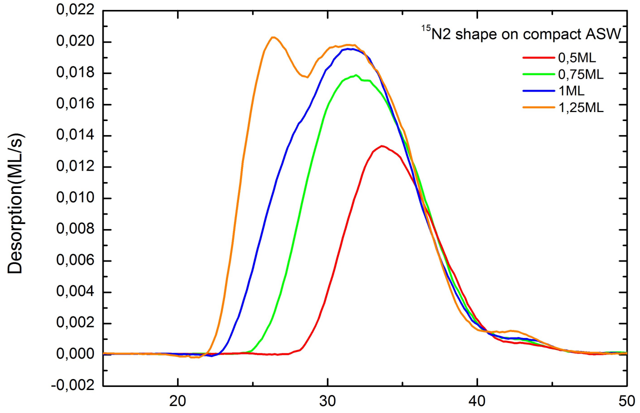
  Whereas it is $10^{15} molecules.cm^{-2}$ for compact ASW.

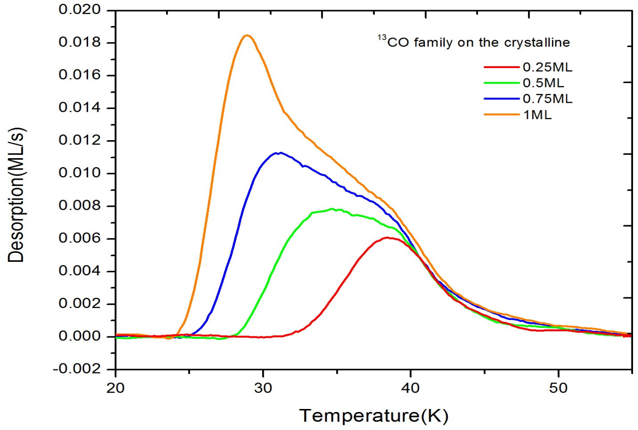
- The CO saturation on compact ASW appears earlier than porous ASW.

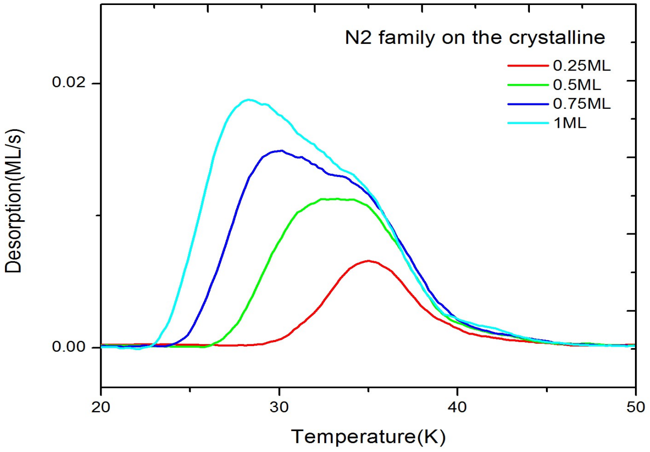
EXPERIMETAL RESULTS

- CO and N2 molecules are deposited on the compact ASW and crystalline ice .





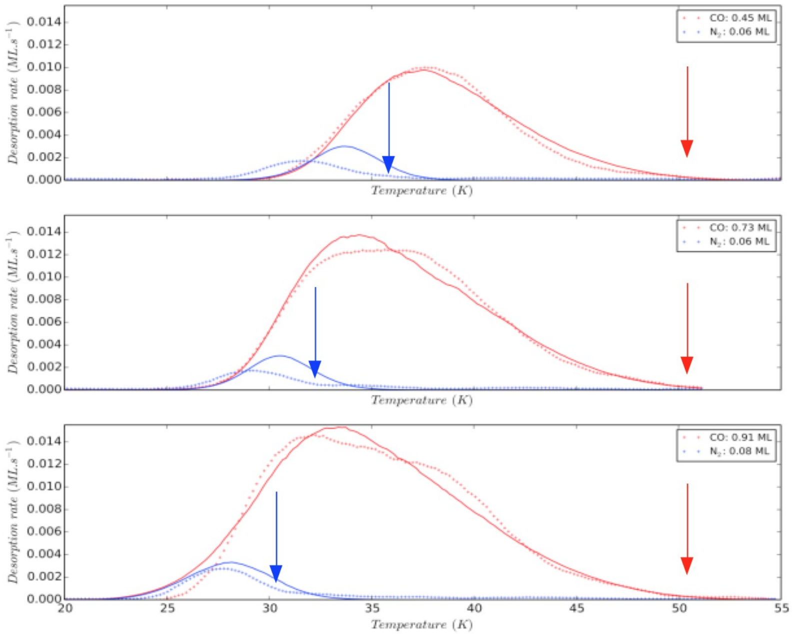




- N2 molecules start to desorb earlier than CO molecules .
- The CO and N2 desorption behaviors are affected by the water ice morphologies.

EXPERIMETAL RESULTS

- The desorption behavior of CO and N_2 mixture with the pressure ratio of 3:1



- CO desorption is not affected by the presence of N_2 whereas N_2 desorption temperature is lowered by CO co-adsorption.

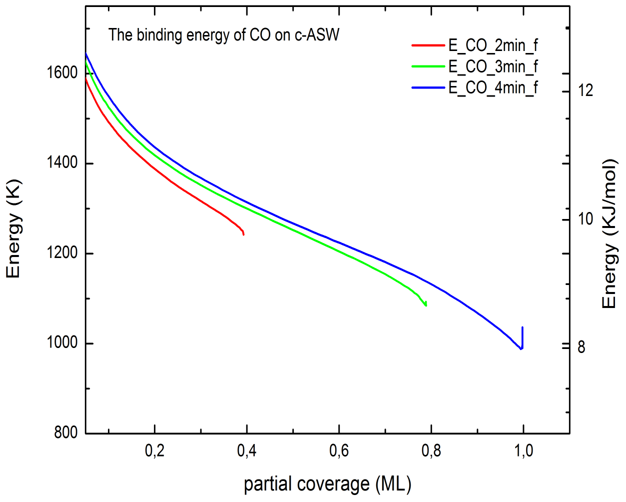
  ==> Binding energies of N_2 is reduced.

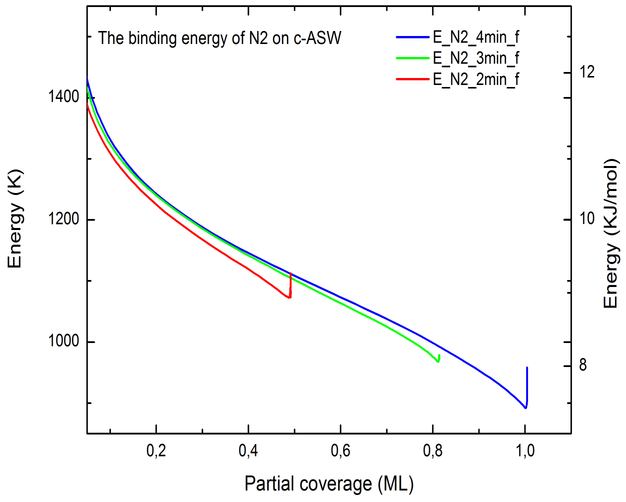
  => N_2 may form slightly later than CO.

ANALYSIS AND DISCUSSION

- The desorption rate is translated into the binding energy through the Polanyi – Wigner equation.

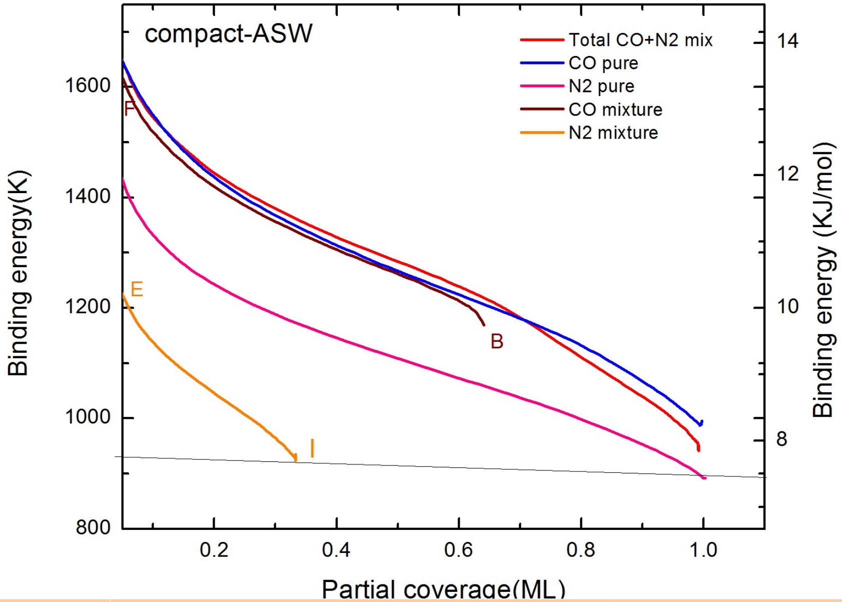
$$E_{des} = K_b T \ln\left(\frac{AN}{r}\right)$$





- The binding energy decreases with the coverage.
- The values range is from ~ 900 K to ~ 1630 K for CO pure and ~ 890 K to ~ 1430 K for N_2 pure corresponding to 1 ML.

ANALYSE AND DISCUSSION



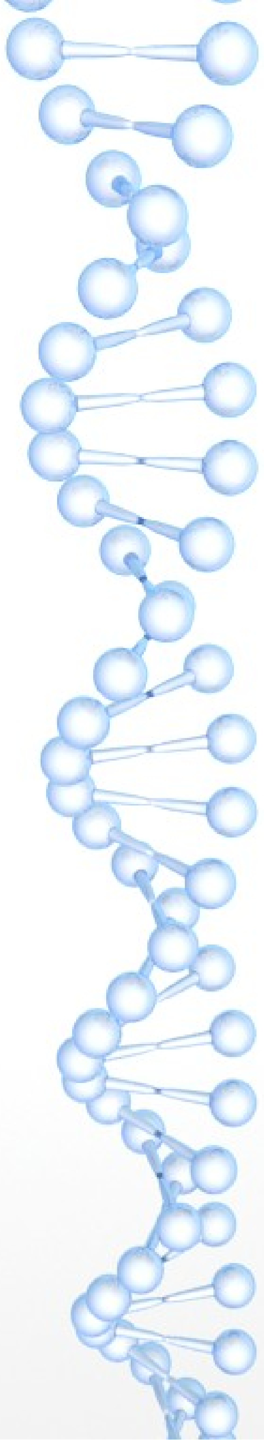
The mixture	N_2 (from I to E)	CO (from B to F)	N_2 + CO
E_{des}	~ 900 K - ~1200 K	~ 1200 K - ~ 1600 K	~ 900 K - ~ 1600 K

=> The CO desorption follows after the N_2 desorption.

=> The CO co-adsorption affects the N_2 desorption on the water ice surface.

CONCLUSIONS

- CO and N_2 are deposited on the water ice surface at 10 K.
- The CO and N_2 are affected by the water ice morphologies.
- The binding energy of CO and N_2 decreases with the coverage.
- The N_2 desorption is affected by the CO co-adsorption on the water ice surface : The N_2 first desorbs and is followed by CO.
- N_2 binding energy is always around the binding energy of multilayer (900 K) whereas CO binding energy range between 1600K (at low coverage) and 900 K for full coverage.



THANK YOU FOR YOUR ATTENTION!