National Aeronautics and Space Administration

FY24 R&TD Innovative Spontaneous Concepts (ISC)

Segregation of CO_2:CO mixtures in comet analogue ices

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Strategic Focus Area: Innovative Spontaneous Concepts

Objectives:

1. Demonstrate that CO_2:CO ice mixtures retain CO above the 40 K sublimation temperature of CO, and releases CO by segregation below the 80 K sublimation temperature of CO_2.
2. Measure the rate by which CO segregates out of CO_2 entrapment as function of temperature.

Background:

Comet nuclei have traditionally been thought to store their abundant CO within amorphous water ice and release CO during crystallization near 130 K. However, *Rosetta* measurements at Comet 67P/Churyumov-Gerasimenko suggest that CO might be stored within CO_2 ice, releasing CO through segregation at lower temperatures. The published literature does not contain CO_2:CO segregation-rate measurements needed in comet nucleus thermophysical models.

Approach and Results:

We deposit a CO_2:CO mixture at 12 K and perform Temperature Programmed Desorption (TPD) experiments while monitoring the ice mass and gas properties by a quartz crystal microbalance and a mass-spectrometer (Figs. 1-2). Segregation of CO below the CO_2 sublimation temperature is confirmed and we determine Polanyi-Wigner equation $dm/dt=-\nu\exp(-E/T)m$ parameters $\nu=10^8$ s^{-1} and E=1800 K (Fig. 3).

Significance/Benefits to JPL and NASA:

Our work enables novel ways of analyzing comet gas production rates to understand comet compositions. Better requirements can be placed on hardware needed during cryogenic comet nucleus sample return.

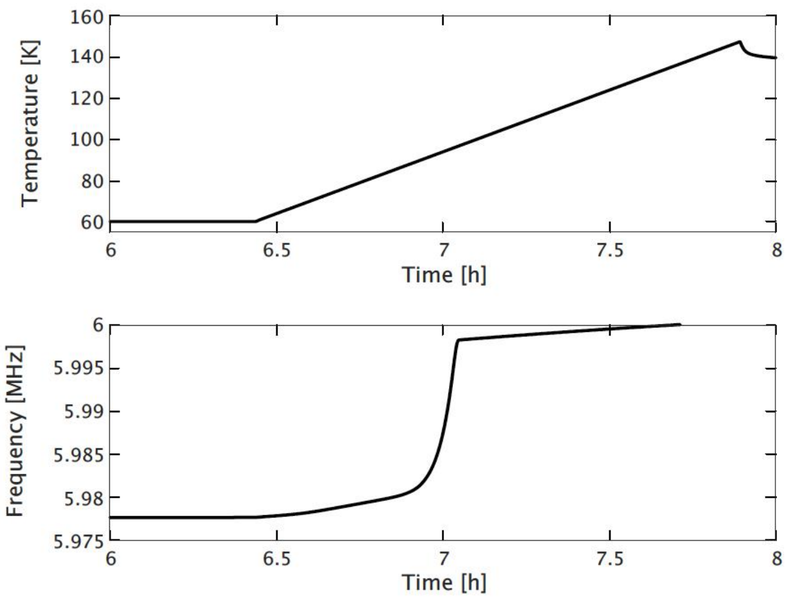

Figure 1: The temperature (top) is raised gradually to study the removal of ice from the substrate. The frequency of the quartz crystal microbalance (bottom) is used to determine ice mass.

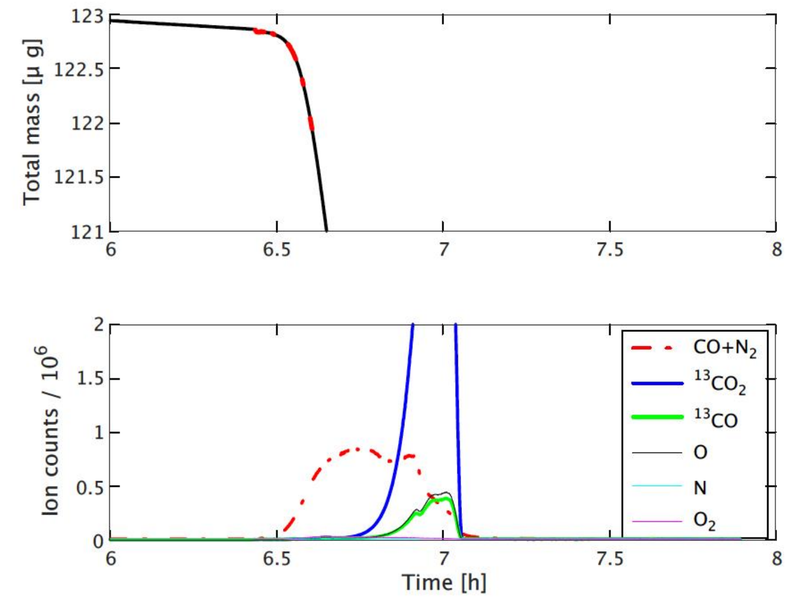

Figure 2: The total mass versus time (top), with the segment used for rate determination highlighted by the red dashed-dotted segment. The mass spectro-meter shows how CO release by segregation occurs prior to onset of CO_2 sublimation (bottom).

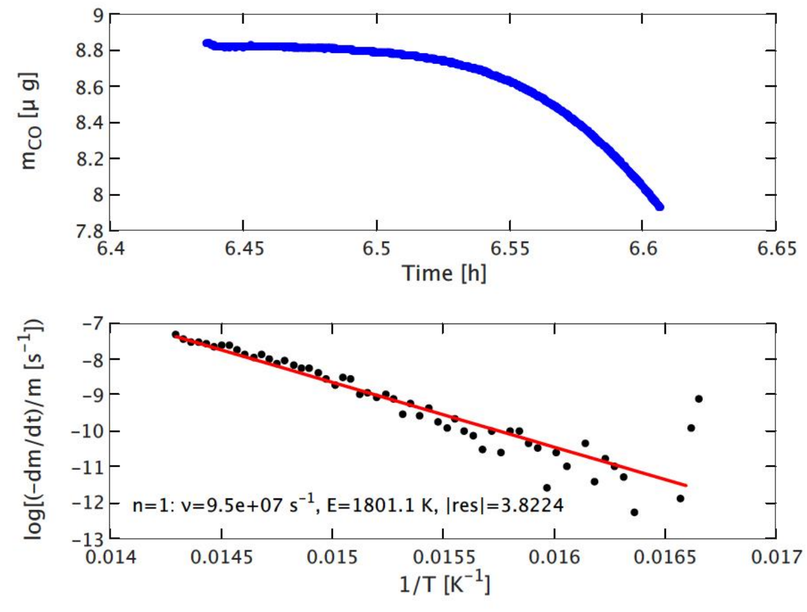

Figure 3: The CO mass during segregation versus time (top). That data is used to fit Polanyi-Wigner equation parameters for the segregation process (bottom).

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