

LABORATORY UV PHOTOLYSIS OF PLANETARY ICE ANALOGS CONTAINING H₂O + CO₂ (1:1).

C. R. Richey¹, R. A. Underwood¹, and P. A. Gerakines¹, ¹Astro- and Solar-System Physics Program, Department of Physics, University of Alabama at Birmingham, Birmingham, AL 35294-1170.

Introduction: H₂O and CO₂ are important constituents of ices the Solar System [1]. They are two of the most abundant molecules found in the interstellar medium, out of which the Solar System formed [2,3]. H₂O and CO₂ are also found on many different satellites in the form of ices. By studying the IR spectra of these ices and the effects of UV photolysis we can obtain important information about their evolution. While there is an abundance of literature pertaining to the mid-IR spectra of photolyzed ices ($\lambda = 2.5\text{--}25\ \mu\text{m}$) [4], research in the near-IR ($\lambda = 1\text{--}2.5\ \mu\text{m}$) is slowly increasing. Part of this work is meant to complement previous studies of UV photolyzed H₂O+CO₂ ices [5,6].

The near-IR contains vibrational combination and harmonic modes, which are weaker than the fundamentals and therefore harder to detect. These features are important for planetary ices due to the fact that the Sun's radiation output peaks in the visible and it emits more photons in the near-IR than in the mid-IR. However, UV photons do not completely penetrate ices thicker than about 1 μm . Nevertheless, ices must be much thicker in order to possess strong near-IR absorption features (about 10 to 50 μm thick). In our experiments, we have created thick, UV photolyzed ices using three different methods, which are compared in the following sections.

Experiment: Gases to be studied were placed into a gas bulb in the desired mixing ratio via a separate gas manifold, and then deposited through a thin tube onto a substrate attached to the end of a rotatable cold finger, which can be cooled to 9 K and heated to 300 K with a resistive heater element. The vacuum chamber contains two IR transparent windows made of KBr and is situated inside the sample compartment of a Thermo Mattson Infinity Gold FTIR spectrometer. The UV-emitting microwave discharge H₂ flow lamp sits directly above the vacuum chamber and emits UV light onto the substrate through a MgF₂ window. The substrate may be turned to either face the spectrometer's IR beam or the UV lamp. A 1:1 mixture of H₂O + CO₂ was used in these experiments to optimize the production of H₂CO₃.

Methods: The first method was to deposit a thin layer of ice (0.1-1 μm) onto the substrate. Near- and mid-IR spectra of the deposited ice were measured, the substrate was turned, and the sample photolyzed for

256 m. This process was repeated for a total of ten layers for a combined time of 2560 m (42 h 40 m).

The second method examined in these experiments was to simultaneously deposit the ice while photolyzing it with the UV lamp. The method was stopped every two hours in order to obtain near- and mid-IR spectra to monitor development of photoproducts' absorption features. This experiment was performed for the same amount of time (2560 m).

The third method was a combination of the first two methods. The ice was simultaneously deposited while photolyzing for 30 m. The IR spectrum of the ice was measured, and the ice was photolyzed for an additional 2 h. The total duration of this experiment was 2550 m, with a total of 17 layers.

Results and Discussion: The simultaneous method displayed the highest rate of CO production ($8.2 \times 10^{15}\ \text{cm}^{-2}\text{s}^{-1}$), while the layering method appeared to be the slowest ($1.8 \times 10^{15}\ \text{cm}^{-2}\text{s}^{-1}$). The combination method displayed a CO production rate of $3.6 \times 10^{15}\ \text{cm}^{-2}\text{s}^{-1}$. We have used the CO/CO₂ ratio to compare the effectiveness of these three methods at producing photochemical changes per molecule deposited during the experiment. While the simultaneous method (CO/CO₂ = 0.045 ± 0.007) rapidly produced photochemical changes, it did not produce them nearly as effectively as the combination (CO/CO₂ = 0.10 ± 0.02) or layering methods (CO/CO₂ = 0.118 ± 0.006).

Acknowledgments: We acknowledge support from the National Science Foundation (NSF), Research Experience for Undergraduates (REU)- site award to the University of Alabama at Birmingham (UAB) under Grant No. DMR-0243640. Special thanks goes to everyone in the Astro- and Solar-System Physics Laboratory at UAB for all their help and advice.

References: [1] Roush, T. L. (2001) *JGR* 106, 33315-33323. [2] Gerakines, P. A., Whittet, D. C. B., Ehrenfreund, P., *et al.* (1999) *ApJ* 522, 357-377. [3] Gibb, E. L., Whittet, D. C. B., Schutte, W. A., *et al.* (2000) *ApJ* 536, 346-356. [4] Gerakines, P. A., Schutte, W. A., and Ehrenfreund, P. (1996) *A&A* 312, 289-305. [5] Gerakines, P. A., Moore, M. H., and Hudson, R. L. (2000) *A&A* 357, 793-800. [6] Wu, C. Y. R., and Judge, D. L. (2003) *JGR* 108, 5032, doi:10.1029/2002JE001932.