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Laboratory spectra of CO_2 in planetary ice analogs

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Abstract

CO_2 is a powerful diagnostic tool for analyzing remote IR data, as it has been detected on icy moons in the outer solar system. IR absorption profiles of CO_2 within ice mixtures containing H_2O and CH_3OH change with respect to temperature and mixture ratios. Laboratory analogs facilitate understanding of the interactions of CO_2 molecules with H_2O and CH_3OH. In this particular study, the CO_2 stretch mode around 4.3 μm (2350 cm^{-1}) is systematically observed in different mixtures with H_2O and CH_3OH in temperature ranges from 15 K to 150 K, as well as vibrational modes in the near-IR such as the combination bands near 2.7 μm (3700 cm^{-1}) and 2.0 μm (5080 cm^{-1}). These data may then be used to assist with interpretation of spectra from icy planetary surfaces.

1. Introduction

Previous studies have demonstrated the importance of laboratory-generated spectra in interpreting data from extraterrestrial ices (e.g., [4, 5, 7, 10]). While planetary surfaces in the outer solar system are known to contain solid H_2O, CO_2 has also been detected along many lines of sight [3, 8]. CO_2 IR absorption profiles in laboratory spectra of CO_2 ice mixtures have been shown to be sensitive to conditions of the ice, such as temperature and composition [6, 9, 11, 12]. These studies further prompted a systematic investigation of CO_2-containing ice mixtures.

In the new laboratory study described here, the IR spectra of ices bearing H_2O, CH_3OH, and CO_2 have been measured with systematically varying compositions and temperatures that span the range of the values expected on icy surfaces in the outer Solar System. The mid-IR spectra (λ = 2.5-25 μm) were measured for several different ice compositions at temperatures ranging from 15 Kto the sublimation temperature of CO_2 in the particular mixture. In addition, spectra in the range λ = 0.9-3.5 μm were studied to identify temperature and mixture ratio effects on the CO_2 com-

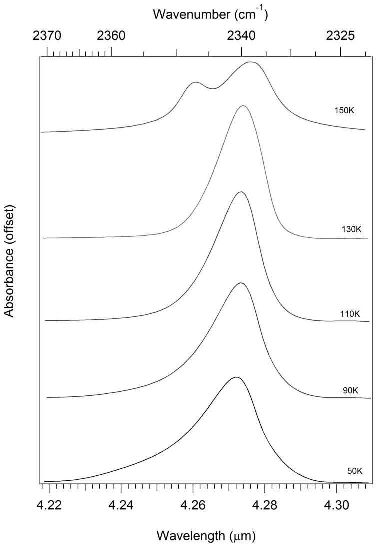

Figure 1: The 4.3 μm stretch mode of CO_2 in a H_2O + CH_3OH + CO_2 (10:1:1) mixture deposited at 50 K and warmed 2 K min^{-1}.

3. Tables

Table 1: Some mixtures and ratios investigated in this study.

Mixture	Ratio
H_2O + CO_2	20:1
H_2O + CH_3OH + CO_2	1:1:1
H_2O + CH_3OH + CO_2	10:1:1
H_2O + CH_3OH + CO_2	10:10:1
H_2O + CH_3OH + CO_2	100:1:1
H_2O + CH_3OH + CO_2	100:48:1
H_2O + CH_3OH + CO_2	1:10:1

4. Summary and Conclusions

Absorbance peak positions for the CO_2 stretch mode (e.g., Figure 1) and some of the combination modes in the near-IR were documented in all experiments. There appears to be a correlation between temperature and peak position, especially with the fundamental stretching mode feature. As temperature increases, some of the CO_2 vibrational modes split (Fig. 1) suggesting ice segregation, probably due to the formation of a type II H_2O-CH_3OH clathrate [1]. CO_2 was also present in mixtures deposited at temperatures above $50\,K$ in samples containing more than $50\,\%$ H_2O. This suggests that CO_2 may deposit on outer planetary surfaces with temperatures exceeding the sublimation temperature of pure CO_2. These data will be made available to the scientific community for use in interpreting spectra from extraterrestrial ices, pending publication [13].

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References

[1] Blake, D., Allamandola, L., Sandford, S., Hudgins, D., and Freund, F.: Science, Vol. 254, p. 548-551, 1991.

[2] Bernstein, M. P., Cruikshank, D. P., and Sandford, S. A.: Icarus, Vol. 179, p. 527, 2005.

[3] Cruikshank, D. P., Meyer, A. W., Brown, R. H., Clark, R. N., Jaumann, R., Stephan, K., Hibbitts, C. A., Sandford, S. A., Mastrapa, R. M. E., Filacchione, G., Ore, C. M. D., Nicholson, P. D., Buratti, B. J., McCord, T. B., Nelson, R. M., Dalton, J. B., Baines, K. H., and Matson, D. L.: Icarus, Vol. 206, p.551, 2010.

[4] Dartois, E., Demyk, K., d'Hendecourt, L., and Ehrenfreund, P.: Astronomy & Astrophysics, Vol. 351, p.1066, 1999

[5] Ehrenfreund, P., Kerkhof, O., Schutte, W. A., Boogert, A. C. A., Gerakines, P. A., Dartois, E., D'Hendecourt, L., Tielens, A. G. G. M., van Dishoeck, E. F., and Whittet, D. C. B.: Astronomy & Astrophysics, Vol. 351, p.240, 1999.

[6] Gerakines, P. A., Whittet, D. C. B., Ehrenfreund, P., Boogert, A. C. A., Tielens, A. G. G. M., Schutte, W. A., Chiar, J. E., van Dishoeck, E. F., Prusti, T., Helmich, F. P., and de Graauw, T.: The Astrophysical Journal, Vol. 522, p.357, 1999.

[7] Gerakines, P. A., Bray, J. J., Davis, A., and Richey, C. R.: The Astrophysical Journal, Vol. 620, p.1140, 2005.

[8] Grundy, W. M., Young, L. A., Spencer, J. R., Johnson, R. E., Young, E. F., and Buie, M. W.: Icarus, Vol. 184, p. 543, 2006.

[9] Öberg, K. I., Fayolle, E. C., Cuppen, H. M., van Dishoeck, E. F., and Linnartz, H.: Astronomy & Astrophysics, Vol. 505, p. 183, 2009.

[10] Salama, F., Allamandola, L. J., Sandford, S. A., Bregman, J. D., Witteborn, F. C., and Cruikshank, D. P.: Icarus, Vol. 107, p. 413-417, 1994.

[11] Sandford, S. A., and Allamandola, L. J.: The Astrophysical Journal, Vol. 355, p. 357-372, 1990.

[12] White, D. W., Gerakines, P. A., Cook, A. M., and Whittet, D. C. B.: The Astrophysical Journal Supplement Series, Vol. 180, p. 182, 2009.

[13] White, D. W., Mastrapa, R. M. E., and Sandford, S. A.: In preparation.