INFRARED SPECTRA OF EUROPA AND LUNAR POLAR RELEVANT HYDROCARBONS AND BRINES

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Introduction The surface of Europa is thought to contain both complex hydrocarbons and salty brines created in combination with the moon's surface composition and energy from radiation in Jupiter's magnetic field [1]. On the Moon, there are several lines of evidence that hydrocarbons and other organics may be an important volatile species: methane detected in lunar samples [2] and in the lunar exosphere [3]; dark lag deposits possibly composed of organic residues topping ice in Mercury's polar regions, which serve as analogs to lunar polar deposits [4]; carbon-hydrogen bonds detected in lunar glasses prepared to minimize contamination [5]; and organic detections by The Lunar Crater Observation and Sensing Satellite (LCROSS) that impacted a large projectile into the permanently shaded Cabeus crater near the lunar south pole [6].

Mapping Imaging Spectrometer for Europa (MISE) will have a spectral range 0.8-5 μm and 10-nm spectral sampling, capable of identifying "organics, salts, acid hydrates, water ice phases, altered silicates, radiolytic compounds, and warm thermal anomalies" on the surface of Europa [7]. For the Moon, the newly launched Chandrayaan-2 carries an infrared spectrometer that operates throughout the organic region near 3.4 microns and may have the sensitivity to detect these absorptions in shadowed regions indirectly illuminated by reflected sunlight. The Lunar Trailblazer mission will also carry a spectrometer similar to Chandrayaan-1's Moon Mineralogy Mapper that was used to detect ice in permanent shadow [8].

Data on the spectral reflectances of relevant simulant samples in the near to mid-infrared from frozen brines, hydrous minerals, and alcohols, will be useful for interpretation of data from these missions, and are currently being acquired at the University of Hawaii at Mānoa.

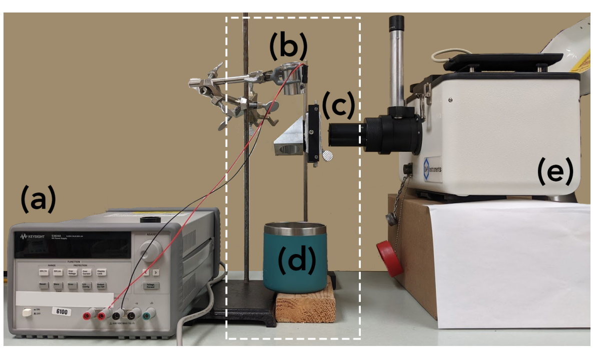

Figure 1: *The experimental setup consists of the following: (a) power supply, (b) IRS-001C Electro Optical Components infrared illuminator, (c) fold mirror, (d) LN_2 Dewar, (e) Designs and Prototypes portable infrared spectrometer. The geometry of the components is shown in Figure 2.*

Compound	*Concentration*
Methanol	99.99%
Ethanol	99.99%
2-propanol	99.99%
Ammonium Oxide	99.99%
NaCl $MgSO_4$	0.5M in H_2O
NaCl $MgSO_4$	1.0M in H_2O
Sodium Bicarbonate	2.0M in H_2O
Hydrogen Peroxide	3% in H_2O

Table 1: *Europa and lunar polar relevant samples.*

Methods Europa and lunar polar relevant liquid samples (Table 1) were passed through a Paasche VL#3 airbrush with 0.75 mm head into liquid nitrogen (77 K). Similar to previous techniques [9][10][11], this allows for the samples to freeze instantaneously upon contact with the liquid nitrogen, producing fine particulate ice and achieving similar spectral characteristics to materials at the surface of Europa and lunar poles.

To better constrain grain size, the frozen samples were passed through a liquid nitrogen cooled sieve to ensure particles were less than 75 μm, and placed onto a sample cup surrounded by liquid nitrogen. To ensure atmospheric water did not condense on the sam-

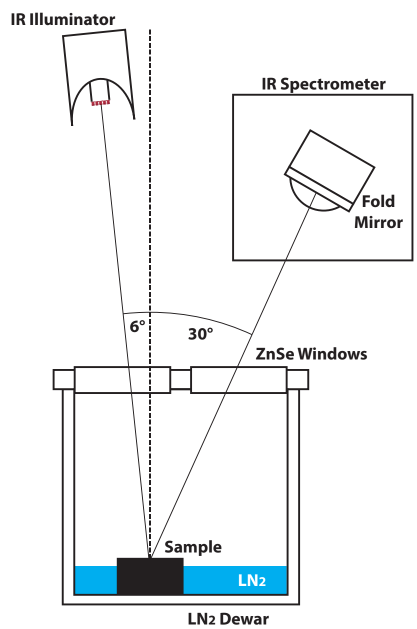

Figure 2: *Geometry of the experimental setup.*

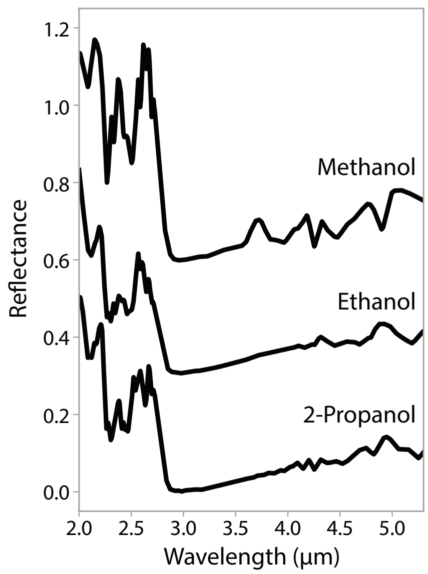

Figure 3: *Infrared reflectance spectra of selected alcohols, offset for clarity.*

ples, the Dewar containing the sample and liquid nitrogen was covered by a Zinc Selenide (ZnSe) window that maintained positive pressure inside the chamber from the evaporating liquid nitrogen. The samples were monitored until any remaining liquid nitrogen evaporated from the sample cup.

The measurement system consists of a Designs and Prototypes portable infrared spectrometer and a IRS-001C Electro Optical Components infrared illuminator (Figure 1). The illuminator is a filament operated at 1200 K with a 1" parabolic reflector to direct the beam. Data are normalized to a diffuse Infragold standard. The measurement incidence angle was 6 degrees and emission angle was 30 degrees, with an azimuth angle of 180 degrees, resulting in a 36 degree phase angle (Figure 2). The incident and emission light cones both subtended 6 degrees.

Results We obtained a series of infrared spectra of frozen hydrocarbons and salt brine solutions between 2 and 5.3 μm (Figures 3 and 4). The series of alcohols (Figure 3), show the combined effects of organics and hydroxyl, evidenced by the sharp drop in reflectance between 2.5-3 μm. They also show strong organic spectral features both in the 2 and 3-5 micron region as expected.

In Figure 4, ice features are apparent in the NaCL $MgSO_4$, sodium bicarbonate, and hydrogen peroxide solutions at shorter wavelengths, with spectra consistent with that of water ice. There is a possible sulfate feature between 4-4.5 μm in the NaCL $MgSO_4$ solution. The feature at 4.2 μm is due to imperfect removal of CO_2 in the test environment because the observations of the reflectance standard did not include the purged path of the sample chamber.

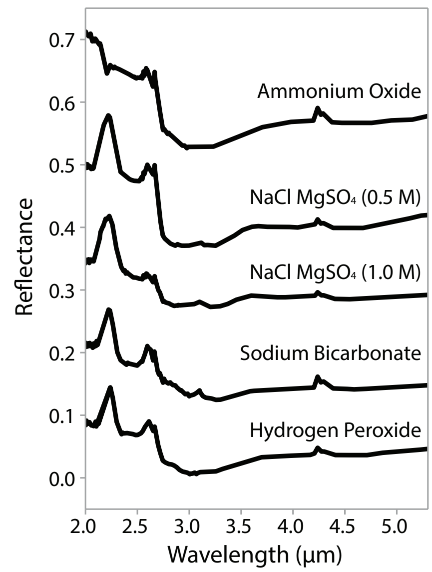

Figure 4: *Infrared reflectance spectra of selected salts and other volatiles, offset for clarity. The feature at 4.2 μm is due to imperfect removal of CO_2 in the text environment.*

Discussion We showed that our experiment can produce and detect samples relevant to Europa and lunar polar exploration, important for future mission characterization of surface frosts. Our next steps are to characterize further organic materials, such as various amino acids, and determine the minimum concentration of relevant solvents our system can detect.

Summary Bi-directional reflectance data of relevant simulant samples was measured in the near to mid-infrared, useful for interpretation of data from new and future missions like MISE, Chandrayaan-2, and Lunar Trailblazer.

References

[1] T. Hoehler. *Geobiology*, 2:205–215, 2004.
[2] P. I. Abell et al. *Proceedings of the 2nd Lunar Science Conference*, 2:1843–1863, 1971.
[3] P. I. Hodges Jr. *Geophys. Res. Lett.*, 43:6742–6748, 2016.
[4] D. A. Paige et al. *Science*, 339(6117):300–3, 2013.
[5] Y. Liu et al. *Nature Geoscience*, 5(11):779, 2012.
[6] A. Colaprete et al. *Science*, 330(6003):463–8, 2010.
[7] D. L. Blaney et al. *50th Lunar and Planetary Science Conference 2019*, LPI Contrib. No. 2132, 2019.
[8] S. Li et al. *Proceedings of the National Academy of Sciences*, 115(36):8907–8912, 2018.
[9] D. M. Hudgins et al. *Astrophysical Journal Supplement Series*, 86(2):713–870, 1993.
[10] T. M. Orlando et al. *Icarus*, 177:528–533, 2005.
[11] R. W. Carlson et al. *Europa, Europa's Surface Composition*. University of Arizona Press, 2009.