A FACILITY FOR SIMULATING TITAN'S SURFACE ENVIRONMENT.

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Introduction: We simulate Titan conditions within our laboratory and subject relevant samples to experiments under those conditions. The properties of our facility for simulating Titan's environment are presented, including methodology, design, implementation, and results.

Saturn's largest satellite Titan, with its thick atmosphere, clouds, polar lakes, and fluvial morphologies, indicates a complex hydrological cycle. However, unlike Earth's hydrological cycle, which consists of one constituent, Titan's cycle may involve many constituents such as methane, ethane, propane and possibly other complex organic compounds [1,2,3]. The primary goal of this research is to experimentally determine the short and long term stability of light organic volatiles on the surface and shallow subsurface of Titan [4,5], and also obtain the *in situ* IR spectra of relevant liquids and ices (1.0 μm - 2.6 μm). Experiments on the evaporation rates of methane, ethane, etc., and mixtures thereof will characterize diffusion through the N_2 atmosphere near the surface as well as through the uppermost few centimeters of simulated regoliths.

Simulation Chamber: The concept of operation is straight-forward: determine methane (or other sample) evaporation rates by continually weighing the sample as it evaporates, while monitoring the evaporated gas concentrations in several locations within the chamber via a gas chromatograph (GC) fitted with a flame ionization detector (Fig. 1).

Our chamber, as previously used by Sears et al. (2005) and Chevrier et al. (2007) [6,7], is a stainless steel upright cylinder with an internal diameter of 61 cm and height of 208 cm. Access is through a hoist-operated lid. A 10 cm outlet at the bottom of the chamber leads to a Kinney KDH (83 CFM) vacuum pump. A chiller operates by flowing an ethylene glycol/water mixture via a GE 1.5 HP pump through 52 meters of 1.27 cm copper tubing surrounding the chamber. The chamber is wrapped in ~20 cm of fiberglass insulation and is encased in a 1.2 x 1.2 x 2.4 m aluminum cabinet.

Titan's environment is simulated within a removable module, which is lowered within the chamber via a hoist, along with ancillary tubing and electrical connections. Titan pressure is achieved by purging, then filling the chamber with nitrogen to 1.5 bar.
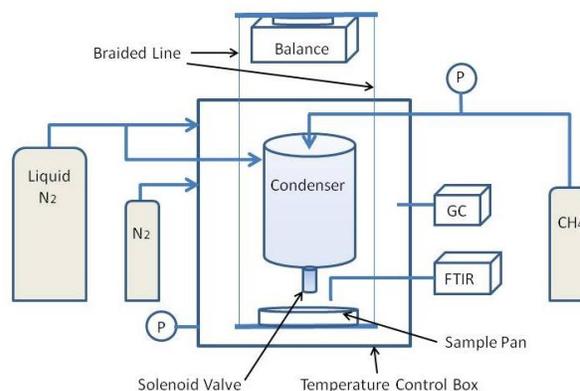

Figure 1. System schematic: The liquid sample is continuously weighed during evaporation; concentration of the evaporated sample is determined via a gas chromatograph.

The lower portion of the module is a cylindrical steel housing with a diameter of 53 cm and height of 53 cm. Contained within this housing is a temperature control box (TCB) with a diameter of 36 cm and height of 38 cm. It rests on a small platform within the module and is surrounded by fiberglass insulation. The TCB is surrounded by ~15 m of 0.95 cm diameter 318L stainless steel tubing through which liquid nitrogen (LN_2) is flowed. Residing within the TCB is a stainless steel Friedrich style condenser 8.9 cm in diameter and 28 cm in height. At the bottom of the condenser is a Valcor SV97 solenoid valve which, when opened, allows the condensed liquid sample to be poured into a pan where it is continuously weighed while it evaporates, thus determining the evaporation rate under the simulated conditions. This effective configuration yields a precise liquid sample mass and subsequent evaporation rate. The pan containing the liquid sample is located within the TCB, while the balance sits on a platform above the module's enclosure to prevent exposure to cryogenic temperatures. Braided line connects the pan to the balance above. By regulating the amounts of LN_2 in the condenser coils, and the amount of sample gas in the condenser, variable amounts of liquid can be condensed.

Data Acquisition and Control: The balance interfaces with the computer using LabView software. Temperatures are monitored via an Omega TC-08 eight channel USB data acquisition module utilizing type K thermocouples. The Watlow EZ-Zone PM temperature controller is operated via Specview software. All data is continuously collected by computer and subsequently analyzed utilizing Excel and MatLab. Infrared spectra are acquired *in situ* using a 15 meter fiber optic and recorded using OMNIC software, and then processed using IDL. The solenoid valve and all LN_2 and gas inputs are operated manually.

Discussion: Evaporation measurements are performed in both dry and humid atmospheres, with the gas chromatograph measuring the concentration of sample gas in the atmosphere. A dry atmosphere is achieved by continually flowing fresh N_2 through the chamber. Figure 2 shows the mass change for 6 g of liquid methane evaporating into a dry atmosphere over 25 minutes, which is equivalent to ~1.9 mm hr^{-1} for our 15 cm diameter Petri dish.
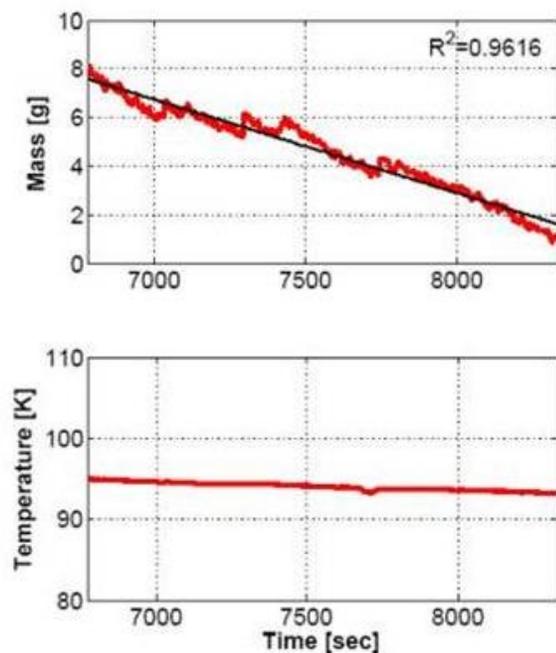

Figure 2. Liquid methane mass loss (top). Temperature ~ 2 cm above sample pan (bottom). Evaporation rate is calculated over a period of 25 minutes.

IR spectra of liquids and ices: Figure 3 shows an acetylene slurry poured into the sample pan within our chamber. The sample was subsequently frozen and IR spectra taken over a range of temperatures. IR spectra were also acquired during evaporation of liquid methane, ethane and their mixtures. Although the spec-

tra of pure substances have already been measured, we are mostly interested in the effect of relative concentrations on the reflectance spectra. This should help put constraints on the composition.

Figure 3. Acetylene slurry poured into sample pan (red arrow). Black arrow shows the fiber optic probe behind the output of the solenoid valve.

Figure 4 shows the IR spectra for liquid methane at a temperature of 93 K and pressure of 1.5 bar, and the spectra for acetylene ice at a pressure of 1 bar and temperature of 154 K.
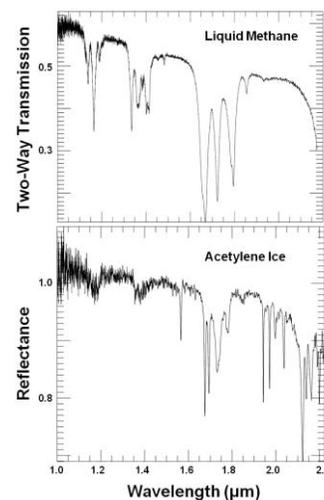

Figure 4. IR spectra of liquid methane at 93 K, 1.5 bar (top). IR spectra of acetylene ice at 154 K, 1 bar (bottom).

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