**HYDROCARBON ICES UNDER SIMULATED TITAN CONDITIONS.** M. Gainor[1,2], V.F. Chevrier[1], S. Singh[1], and A. Wagner[1]. [1]W. M. Keck Laboratory for Space Simulation, Arkansas Center for Space and Planetary Sciences, Fayetteville, Arkansas, 72701. [2]Department of Chemistry, Cooperative Developmental Energy Program, Fort Valley State University, Fort Valley, Georgia 31030. mgainor2@gmail.com.

**Introduction:** Saturn's moon Titan is the only body other than Earth where stable liquid has been identified on the surface. NASA Cassini RADAR discovered dark, lake-like features in the northern hemisphere of Titan [1]. Cassini-VIMS collected spectra of Titan's largest lake Ontario Lacus in the southern hemisphere of Titan. VIMS identified ethane as a major component of the lake using the 2µm atmospheric window [2]. Other hydrocarbons or nitriles may exist in liquid form in this lake, but spectra are hard to detect because of Titan's thick atmosphere [3].

Titan's atmosphere is composed of 95-98% nitrogen and 2-5% methane. Surface pressure is 1.5 bars, and the temperature is 90-94 K. Titan has a hydrological cycle driven by methane which can exist as gas, liquid, and solid ice on Titan [4]. We used FTIR to analyze ethane ice and the sublimation process of methane ice and to differentiate between liquid and ice spectra.

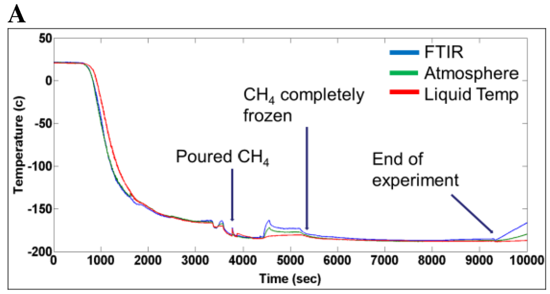
**Experimental:** The Titan simulation chamber is used to simulate Titan's atmosphere and surface conditions [5]. The chamber is purged with nitrogen gas before the experiment. Then, the gas is pressurized to build the atmosphere inside the module. Titan temperatures are reached by liquid nitrogen flowing through coils around the module. Once the chamber has reached relevant temperatures, methane or ethane gas is released into the condenser. We then open the condenser and allow the liquid to fall onto the petri dish. We then continue to cool the chamber until the liquid becomes frozen. The Titan simulation chamber is explained in greater detail in [5]. The temperature and mass are continuously recorded during the experiment.

We used the Nicolet 6700 Smart Diffuse spectrometer with nitrogen purge gas to collect infrared spectra from 1.0 to 2.5 µm with 4cm-1 spectral resolution. This allows us to cover five of the atmospheric windows at 1.19, 1.33, 1.4, 1.66, and 2.0 µm.

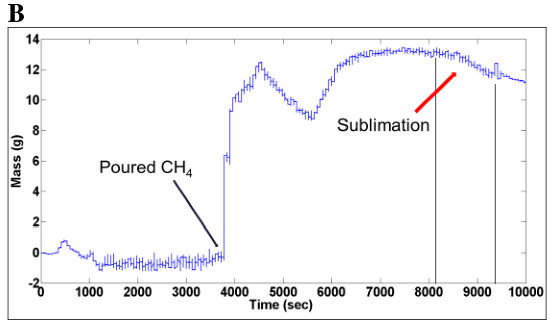
**Results:** A total of 7 Titan simulations of pure methane and pure ethane were run. Fig, 1 shows the temperature, mass, and FTIR spectra for a run of pure methane. At 3800 sec methane is added to the petri dish. At 5000 sec it begins to freeze and becomes completely solid at -183 C. The mass becomes stable at 6500 sec until it starts to decrease at 8200 sec. Spectra of methane were collected during the length of the experiment. The reflectance increased from 70% to about 75% during the phase change form liquid to solid ice. In this experiment we were able to collect spectra during the transition between phases. The spectra recorded during the solid phase shows the band depth is decreasing.

Fig. 2 shows the temperature, mass, and FTIR spectra for a run of pure ethane. There is a steady decrease in the temperature and it stabilizes until the ethane completely freezes. The ethane becomes solid ice is shown by the drop in temperature at 5000 sec. The temperature then stabilizes again until the end of the experiment. Ethane was dropped into the petri dish at 4000 sec, and the mass remains constant until the end of the run. In ethane spectra the shift in reflectance of the spectra correlates to the change from liquid to solid phase changes. The reflectance increases from about 67% to about 83%. However, unlike methane, the band depth in the ice spectra increases.

**A**




**B**




**C**

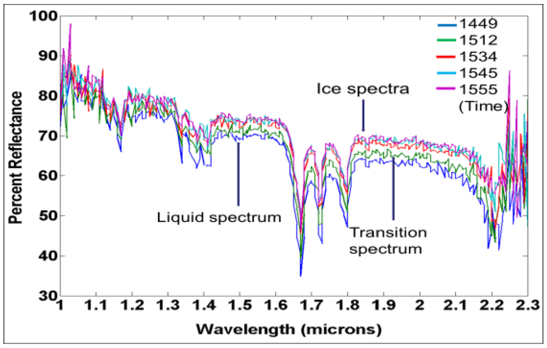



**Figure 1:** Temperature versus time (A), and mass versus time (B). Infrared spectra of methane during the course of the experiment (C). Methane peaks are observed at three of the atmospheric windows: 1.19, 1.33, and 1.66 microns.

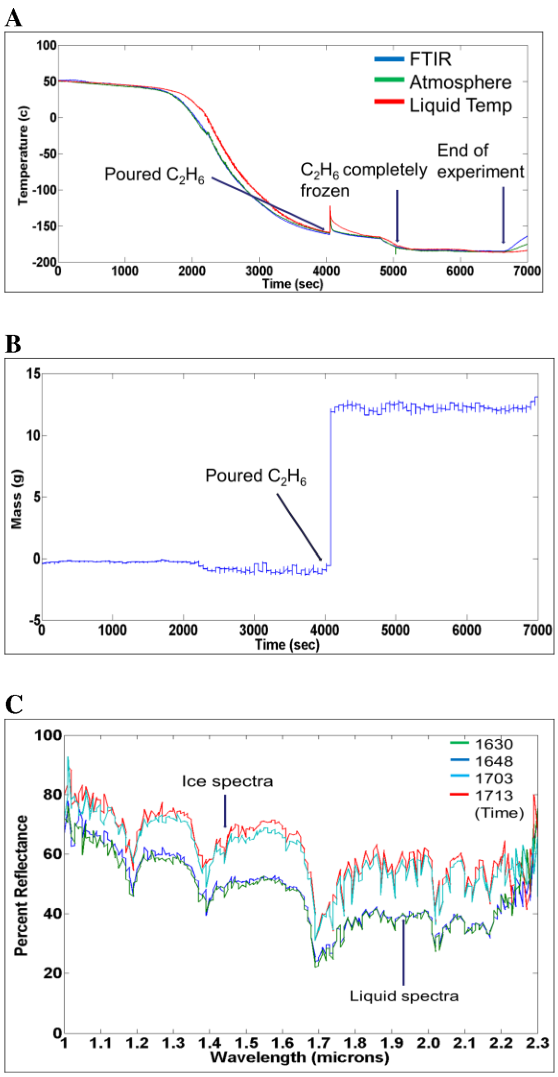



**Figure 2:** Temperature versus time (A), and mass versus time (B). Infrared spectra of methane during the course of the experiment (C). Ethane peaks are observed at three of the atmospheric windows: 1.19, 1.4, 1.66, and 2.0 microns.

**Discussion:** When analyzing the FTIR spectra from the runs we concentrate on two features: reflectance and absorption band depth. We then compare that with the temperature and mass data to ensure a direct correlation. In theory, as a substance changes form liquid to solid the reflectance should increase. In the liquid phase the particles are more spread out and the light is able to pass through and be absorbed more. When the substance is solid the molecules are more compact and don't allow as much light to pass directly through; instead the light is reflected. The shift is shown in the spectra of Fig. 1C and Fig. 2C. Both methane and ethane in the solid phase have a higher reflectance.

The absorption band depth is directly associated with the amount of substance present as discussed by Singh et al. [6]. Methane is an extremely volatile hydrocarbon. In Fig. 1C ice spectra the band depth decreases alluding to methane sublimating. The mass data (Fig. 1B) also shows a decrease in the amount of methane in the petri dish. In Fig. 2C ice spectra of ethane the band depths increase. Due to ethane being non-volatile, it does not sublimate so the mass stays constant.

Application to Titan. Studying methane ices will help to gain a better understanding of the hydrological cycle through evaporation/sublimation rates. Identification of the phase of the hydrocarbons can be interpreted by experimental data. Reflectance can be used to interpret light and dark features found on Titan's surface by Cassini spacecreaft.

**Conclusion:** From this study we have found that reflectance increases as the hydrocarbons change from liquid to solid ice. Methane is sublimating over time and ethane band depths increase over time.

Future Work: The sublimation rate of methane will be calculated. Also, there will be further sublimation experiments with hydrocarbon mixtures.

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**References:** [1] Stofan et al 2007 Icarus 185, 443-456. [2] R. H. Brown et al. Nature, 454:607– 610, 2008. [3] Moriconi et al. 2010, Icarus 210, 823-831). [4] A. Luspay-Kuti, et al. (2012) 43rdLPSC, 2408. [5] F.C. Wasiak et al. In 42nd LPSC, page 1322, 2011. [6] S. Singh, et al. (2013) 44thLPSC, 2056.