

**LIQUID HYDROCARBON EVAPORATION UNDER SIMULATED TITAN CONDITIONS** A. Luspay-Kuti<sup>1</sup>, F.C. Wasiak<sup>1</sup>, V.F. Chevrier<sup>1</sup>, W.D.D.P. Welivitiya<sup>1</sup>, L.A. Roe<sup>1</sup>, T. Cornet<sup>2</sup>, S.S. Magar<sup>1</sup>. <sup>1</sup>Arkansas Center for Space and Planetary Sciences, University of Arkansas (Fayetteville, AR 72701 USA; aluspayk@uark.edu), <sup>2</sup>Laboratoire de Planetologie et Godynamique de Nantes (2 rue de la Houssiniere BP92208, 44322 Nantes Cedex 3, France)

**Introduction:** The idea of stably existing liquids on the surface of Saturn's largest moon, Titan, dates back well before the arrival of the Cassini-Huygens mission. The fact that surface conditions are near the triple point of methane and ethane, and the detection of methane in Titan's atmosphere by Voyager [1], were suspect long before the actual mapping of the surface that large bodies of liquids may exist. The first definitive evidence for the existence of lakes on Titan was provided by [2]. They identified 75 radar-dark patches in the north polar region based on images obtained by the Cassini spacecraft, that were interpreted as surface lakes based on their low radar reflectivity. Cassini SAR images support the idea that the patches are indeed liquid, having a high emissivity and low dielectric constant.

These facts along with the identification of liquid ethane in Ontario Lacus using VIMS spectra [3] and methane moisture detected by Huygens GCMS in the near subsurface indicative of precipitation some time in the past, support that liquids (supposedly composed of ethane and methane to a large extent [4]) exist on the surface of present-day Titan.

The area of the lakes varies between 10 km<sup>2</sup> to 400,000 km<sup>2</sup>. During the T38 flyby [3] identified absorption features characteristic of ethane in VIMS spectra in Ontario Lacus, probably present in liquid solution with CH<sub>4</sub>, N<sub>2</sub> and other low molecular-weight hydrocarbon species. However, the chemical composition of the lakes is still under debate and is a challenge to determine precisely, partially because of the strong atmospheric absorption of CH<sub>4</sub>. [4] proposed that the lakes are indeed composed of CH<sub>4</sub> to a large extent (~5-10%), following C<sub>2</sub>H<sub>6</sub>.

Here we present our preliminary experimental results on the evaporation characteristics of pure ethane, as well as an ethane-methane mixture under Titan surface conditions. These and similar experimental results will be essential in determining the short and long-term stability of liquids on Titan.

**Experimental:** In the past we have conducted several experiments in our Titan simulation facility aimed at studying the evaporation of pure methane [5], [6], [7] therefore the same experimen-

tal setup was used for condensing ethane and measuring its mass loss over time. A detailed description on the simulation chamber and the experimental methods can be found in [6] [7], [8]. A methane-ethane mixture, which better approximates the hypothetical composition of the Titanian lakes than just pure methane or ethane, is created by condensing ethane into a petri dish at slightly higher temperatures than those characteristic on the surface on Titan. Then, liquid methane is poured on top of the liquid ethane. The condensed liquids in the pan exert an additional cooling effect on the surrounding simulated N<sub>2</sub> atmosphere, and once Titan-relevant temperatures are reached, the mass loss over time is used to calculate the evaporation rate. Hydrocarbon concentration in the module's atmosphere is monitored with a gas chromatograph equipped with a flame ionization detector.

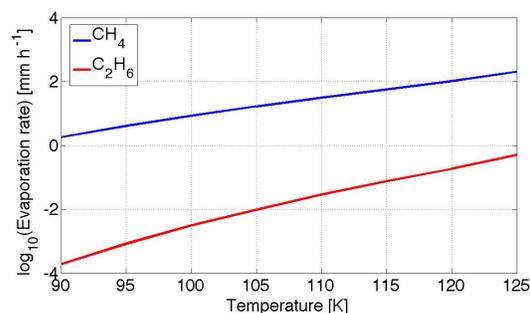


Figure 1: Evaporation rates of methane and ethane, calculated from equation  $E = 0.17D_{CH_4/N_2}\Delta\eta \left(\frac{\Delta\rho}{\nu z}\right)^{\frac{1}{3}}$

for methane and  $E = D\frac{\Delta\eta}{\Delta z}$  for ethane, where  $D_{CH_4/N_2}$  is the interdiffusion coefficient,  $\Delta\eta$  is the density difference between the evaporating surface of the liquid and away from the surface,  $\nu$  is the kinetic viscosity, and  $\Delta z$  is the height within which diffusion occurs.

**Results:** The relative mass over time and the corresponding temperatures for two runs are shown in Fig. 2. For ethane, the average evaporation rate calculated over the linear portions of the curves is 0.192 g min<sup>-1</sup>, which corresponds to 1.19 mm hr<sup>-1</sup>.

In Fig. 3., the evaporation of a mix of ~10 g ethane and ~16 g methane can be seen. Note that the plot differentiates into two distinctive parts.

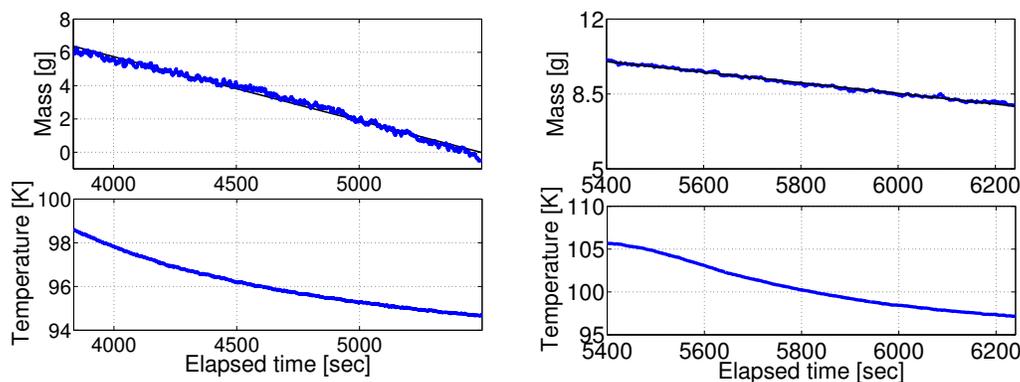


Figure 2: Mass (top) and temperature (bottom) over time for ethane, and the best fit line (black).

The first portion of the curve shows moderate decrease, characterized by an evaporation rate of  $0.234 \text{ g min}^{-1}$  ( $1.88 \text{ mm hr}^{-1}$ ) compared to the second portion, with an evaporation rate of  $0.414 \text{ g min}^{-1}$  ( $3.33 \text{ mm hr}^{-1}$ ).

**Discussion:** Even though these results are preliminary, compared to our previous results on methane, ethane's evaporation is slower than that of methane, as would be expected under Titan conditions. However, it is still higher than would be inferred in an  $\text{N}_2$  atmosphere and ethane's low saturation pressure (Fig. 1). One possible explanation is that the temperature of the liquid is higher than what is directly measured in the atmosphere. Currently, we do not measure the temperature of the liquids themselves, but will address this issue in the near future by putting thermocouples inside the pan as well.

The distinctive slopes in the case of the mixture are indicative of changes in the concentrations of the components as time progresses. Over the period of the first slope, the evaporation is larger than that of ethane, but slower than methane ( $\sim 2.7 \text{ mm hr}^{-1}$ ) [6]. This, in a first order estimate, is consistent with the presence of a large amount of ethane along methane, which is expected to dampen the evaporation as opposed to pure methane. Methane evaporates faster as it is buoyant in the  $\text{N}_2$  atmosphere, so a gradual decrease in this rate would be expected as most of the methane escapes the sample. Contrary, we see an increase in this rate. This could be caused by the fact that it is not the end of the curve shown in Fig. 3, but rather a middle section. There is still sample left in the pan, but the experiment had to be aborted for technical reasons. If this second part can in fact be considered as a middle portion of the run, it may be assumed that the part we see represents

the rapid evaporation when there is still a significant amount of methane present in the mixture.

Further experiments of both ethane and mixtures must and will be performed in the future in order to get a more established view on the behavior of these liquids, and thus the lakes on Titan.

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**References:** [1] J. I. Lunine, et al. (1983) *Science* 222:1229. [2] E. R. Stofan, et al. (2007) *Nature* 445:61. [3] R. H. Brown, et al. (2008) *Nature* 454:607. [4] D. Cordier, et al. (2009) *ApJ* 707:L128. [5] A. Luspay-Kuti, et al. (2012) in *43<sup>rd</sup> LPSC*, 2287. [6] A. Luspay-Kuti, et al. (2011) in *42<sup>nd</sup> LPSC*, 1736. [7] F. C. Wasiak, et al. (2011) in *EPSC-DPS* 548. [8] F. C. Wasiak, et al. (2011) in *42<sup>nd</sup> LPSC*, 1322.

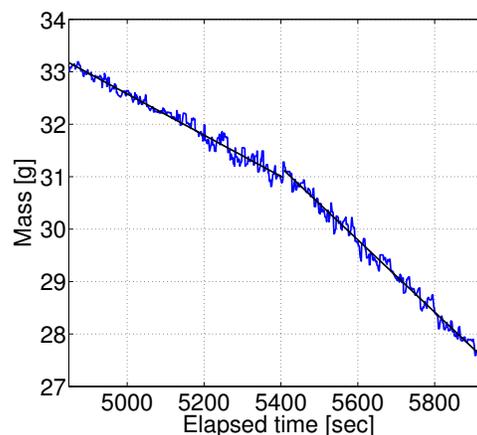


Figure 3: Mass vs. time for an ethane-methane mixture. The curve differentiates into two distinctive parts, with evaporation rates of  $1.88 \text{ mm hr}^{-1}$  and  $3.33 \text{ mm hr}^{-1}$ .