

COMPOSITION AND DYNAMICS OF TITAN'S LAKES. A. Luspay-Kuti¹, V. F. Chevrier¹, S. Singh¹, E. G. Rivera-Valentin², A. Wagner¹, and F. C. Wasiake¹, ¹Arkansas Center for Space and Planetary Sciences, University of Arkansas (202 FELD U of A, Fayetteville, AR 72701. aluspayk@uark.edu), ²Brown University (324 Brook St. Box 1846, Providence, RI 02912).

Introduction: The *Cassini-Huygens* mission led to the identification of hundreds of hydrocarbon lakes on the surface of Titan. These lakes are mainly confined to the colder and presumably more humid polar regions, with more observed lakes in the north [1]. The primary components of the polar liquids are thought to be methane and ethane [e.g. 2]; however, little is known on the ratio of these hydrocarbons in the lakes. The predominance of methane-ethane mixtures has been confirmed by liquid-atmosphere equilibrium thermodynamic and geochemical models [2-4], but with contradictory results, spanning most of the mixture compositional range. The discrepancy in the various model results may be due to the absence of extended datasets at Titan-relevant cryogenic temperatures and pressure.

Here we report on experimental simulations of the evaporation of liquid ethane and methane-ethane mixtures, obtained at a temperature and pressure relevant to Titan's poles (~ 92 K and 1.5 bar N_2) for various methane-ethane mole fractions. We also propose a model to describe the measured binary mixture evaporation, and discuss the implications of our results to Titan's lakes. We suggest that such results, along with *Cassini* observations can be used to estimate the methane-ethane concentration of Titan's polar liquids.

Methods: The facility used for the experiments was specifically designed to simulate Titan surface conditions. Temperatures relevant to Titan's poles are reproduced via liquid nitrogen flow through coils at various locations inside the chamber, while a 1.5 bar atmosphere is maintained with pressurized N_2 . A detailed description of the simulation chamber can be found in [5].

The experimental protocol follows that of pure CH_4 experiments [6] to the most part. Before simulating CH_4 - C_2H_6 mixtures though, we ran controlled experiments on pure C_2H_6 . Ethane gas is introduced into the condenser maintained at 110 K, then the condensed liquid is drained into a petri dish connected to a scale, and the mass change is continuously recorded. This step is followed by introducing methane on top of ethane when simulating mixtures, once the temperature in the condenser reaches ~ 94 K. Using gas injection times and fluxes we can control liquid masses of these different hydrocarbons based on the desired concentrations to be simulated. Evaporation rate is determined by a least-squares fit to various portions of the data depending on the simulated sample.

Results: Mass data as a function of time is shown for pure ethane (Fig. 1) and ethane-methane mixtures of selected concentrations (Fig. 2). We find that evaporation is negligible for pure C_2H_6 on the scale of our experiments (Fig. 1). The mixtures show time-dependent mass loss, exhibiting distinct behaviors dependent on methane concentration (Fig. 2). Evaporation rates for mixtures with various CH_4 - C_2H_6 compositions are shown in Figure 3.

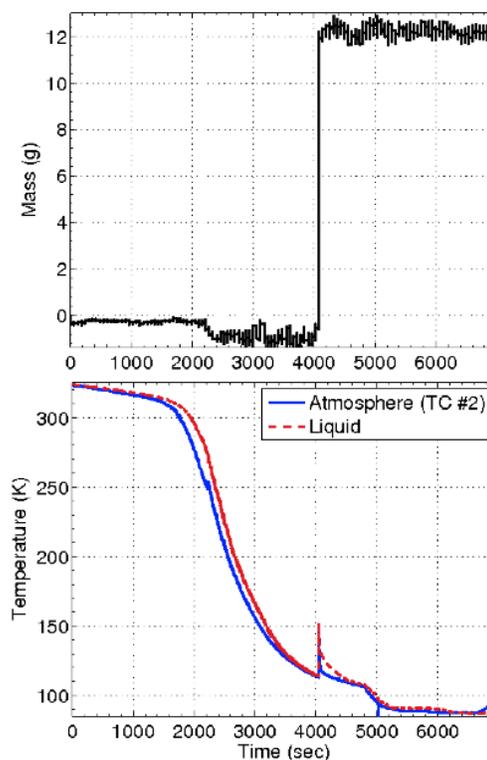


Figure 1. Mass vs. time for pure C_2H_6 and the corresponding atmospheric and liquid temperatures. The lack of mass loss over time indicates that ethane does not evaporate under Titan temperature and pressure conditions.

Model for Binary Mixture Evaporation: To understand the underlying evaporation processes we have developed a model based on mass loss through diffusion and buoyancy. The model used for pure CH_4 evaporation [6] has been adapted and modified for binary mixtures. Results from the model for dry and humid atmospheres are also shown in Figure 3.

Discussion: We show that the lack of pure C_2H_6 evaporation is due to its extremely low saturation pres-

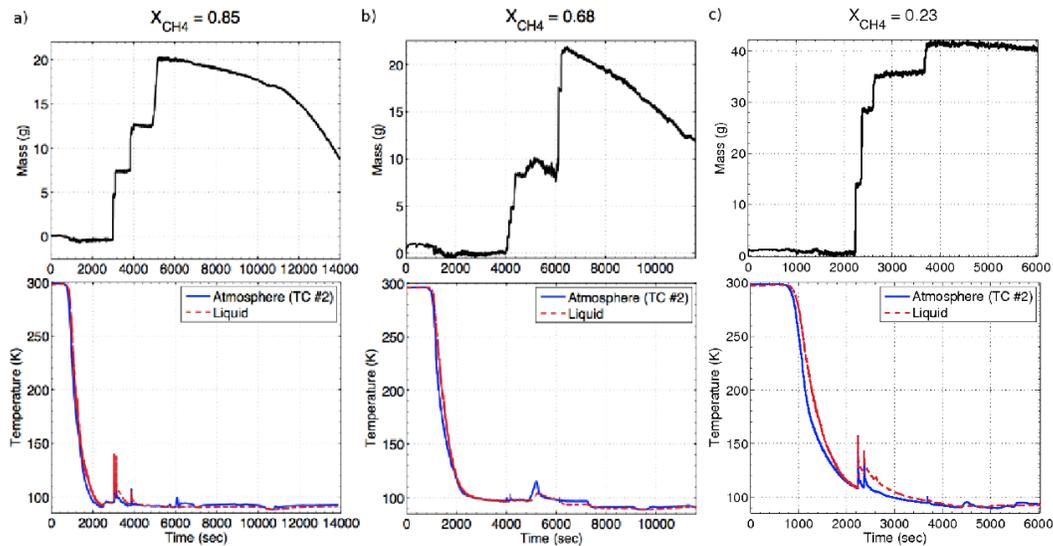


Figure 2. Mass vs. time (top) and temperature vs. time (bottom) curves for $\text{CH}_4\text{-C}_2\text{H}_6$ mixtures of different concentrations.

sure combined with the fact that it is not buoyant in a N_2 atmosphere. Mixture evaporation, however, increases nearly linearly with increasing CH_4 concentration, although at a lower rate than would be expected for a simple binary mixture. Indeed, methane is the only volatile phase, but early dissolution of N_2 in methane-rich environments results in a ternary mixture that further reducing evaporation. As our experiments show, this initial N_2 dissolution is only prominent for mixtures with CH_4 concentrations > 70 mol% (Fig. 2).

changes of Ontario Lacus [7] we approximate the methane content of Ontario Lacus to be 10-30%. This implies that it is primarily composed of ethane, hence it is most probably a residual lake that has incurred extensive methane evaporation. This method of combining *Cassini* observations of shoreline changes with our experimental evaporation data presented here provides a way to estimate the methane-ethane concentration of any polar lake on Titan.

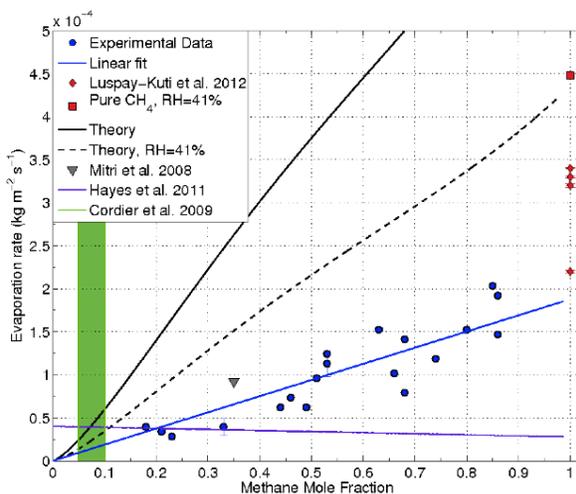


Figure 3. Evaporation rate as a function of methane mole fraction. Evaporation rate results from previous models and observation are also shown.

Implications for Titan: From our experimentally determined evaporation rate and the observed shoreline

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References: [1] Aharonson O. et al (2009) *Nature Geosci.* 2, 851-854. [2] Cordier et al. (2009) *ApJL* 707, L128-131. [3] Tan S. P. et al (2012) *Icarus* 222, 53-72. [4] Glein C. R. and Shock E. I. (2013) *Geochim Cosmochim Acta* 115, 217-240. [5] Wasiak F. C. et al. (2013) *ASR* 51, 1213-1220. [6] Luspay-Kuti et al. (2012) *GRL* 39, L23203. [7] Hayes et al. (2011) *Icarus* 211, 655-671. [8] Mitri et al. (2007) *Icarus* 186, 385-394.