MEASURING EVAPORATION RATES OF LIQUID METHANE UNDER TITAN SIMULATED CONDITIONS

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INTRODUCTION

Evidences for liquid bodies have been found on Titan’s surface (Figure 1) [1, 2]. Titan’s atmosphere: nitrogen (N2) and methane (CH4).

Surface conditions: P = 1.5 bar, T = 90 - 94 K, close to the triple point of CH4 (Figure 2).

Methane cycle similar to water cycle on Earth [1, 3]: potential liquids on Titan’s surface [4, 5]. Evaporation of liquids: shoreline changes? (Ontario Lacus on Titan [6, 7])

NEED CONSTRAINTS ON EVAPORATION RATES OF LIQUID HYDROCARBONS

THE TITAN MODULE [8, 9]

- Temperature Control Box (TCB) to get Titan’s temperature
- Condenser to form liquid hydrocarbons
- Petri dish to collect the samples
- Balance for the mass recording
- Fiber optics to obtain FTIR measurements
- 2 digital cameras for a direct look inside the chamber

Figure 2: Schematic view of the Titan Module

Procedure:

- Purge by N2 to simulate Titan’s atmosphere (P=1.5 bar)
- Cooling of the chamber to Titan’s temperatures by flowing liquid nitrogen (LN2) into the coils surrounded the TCB.
- Cooling of the Condenser with LN2 to form liquid CH4 (111.6 K, TC 7 - 8).
- Pouring of the liquids into the Petri dish at T = 90 - 94 K

Figure 3: Simultaneous acquisition of mass and temperature data

MASS MONITORING OF EVAPORATION

The evaporation of methane is recorded as a loss of mass under steady Titan’s conditions (1.5 bar, 90 - 94 K).

1st approximation of evaporation rate: linear fit (Figure 4)

Result: 0.006 g/s, i.e. 2.79 mm/hr.

Figure 4: Empirical linear fit applied to the decreasing part of the mass data (Figure 2).

Comparison with theoretical calculations:

Theoretical calculations of methane evaporation rates using Ingersoll’s equation [10] (Figure 5).

First measurements of evaporation rates of methane under Titan’s conditions are close to the theoretical calculations.

Figure 5: Comparison between the methane evaporation rates measured under Titan’s conditions using the Titan Module (diamonds), and the methane evaporation rates inferred from Ingersoll’s equation (solid blue line).

FTIR MONITORING OF EVAPORATION

Nicolet 6700 FTIR Spectrometer to acquire IR spectra during the evaporation.

Wavelength range: from 1.0 to 2.6 µm.

Methane absorption bands:

1.16, 1.33, 1.41, 1.66, 1.72, 1.79 and 1.85 µm [11]

Figure 6: Two-way transmission spectra through liquid methane acquired during the evaporation of liquid methane at Titan’s pressure.

Methane absorption band depths computation:

Computation of methane absorption band depths based on the following formula [12]

Figure 7: Methane absorption band depths over the time.

CONCLUSION

- Experiments done using the Titan Module specially designed to reach Titan’s surface P,T conditions (1.5 bar, 90 - 94 K).
- First measurements of liquid methane evaporation rates in close agreements with theoretical calculations.
- Preliminary results of the FTIR experiment: methane absorption band depths decrease during the evaporation.

FUTURE WORK: Acquisition of evaporation data (mass, FTIR, Gas Chromatographer) of liquid hydrocarbons: methane, ethane and methane-ethane mixtures.

Crystallisation experiment of dissolved compounds implied in Titan’s lakes chemistry (acetylene...) [13] since Titan’s lakes morphologies suggest the presence of dissolution processes on the surface [14, 15].

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REFERENCES