EXPERIMENTAL STUDY OF NITROGEN DISSOLUTION IN METHANE-ETHANE MIXTURES UNDER TITAN SURFACE CONDITIONS

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INTRODUCTION

In the past few years there have been significant advances in determining the composition of Titan’s lakes, using vapor-liquid equilibrium calculations with activity models [1], Regular Solution Theory [2,3] and Statistical Associating Fluid Theory [4]. Though, in the absence of relevant datasets at Titan temperature and pressure conditions, the thermodynamic and kinetic parameters are extrapolated values, thus carrying high uncertainty. Using our recent work on experimental measurements of evaporation rates of liquid methane-ethane mixtures [5,6], we present preliminary results on the solubility of N₂ in liquid mixtures under conditions relevant to Titan’s surface.

Experimental Protocol

- Titan simulation chamber
- Temperature: 92-94 K
- 1.5 bar N₂ atmosphere
- C₂H₆ then CH₄ condensation
- Mass loss measurements
- Continuous P, T, measurements

Initial Evaporation Results

- The plateau zone at the beginning of the experiment increases with increasing CH₄ concentration (Fig. 1).
- Steady-state slope correction removes the hydrocarbon evaporation (Fig. 2A).
- The residual mass increase is due to N₂ dissolution (Fig. 2B).

Results

- N₂ solubility is not detected at initial CH₄ mole ratio below 0.7
- Time to reach steady state decreases with increasing X_CH₄ (Fig. 3)
- Above X_CH₄ ~ 0.7 exponential increase of N₂ solubility (Table 1, Fig. 4).

N₂ solubility determination

Conclusions

- Solubility of nitrogen is strongly dependent on the liquid composition.
- Favored in methane-rich liquid ponds or lakes.
- May affect the freezing point of methane and act as antifreeze (Fig. 5).
- Should not affect ethane-rich liquids.
- The experiments provide values for thermodynamic models of lakes composition.

Future work

- Add more data to refine ternary diagram.
- Determine kinetics of N₂ solubility (is it limited by diffusion in the liquid or by solubility kinetics).
- Determine frost-point depression for processes like evaporative cooling and ice formation.

References


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