SOLUBILITY OF ACETYLENE IN LIQUID HYDROCARBONS UNDER TITAN SURFACE CONDITIONS.
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Introduction

Titan is the only body aside from Earth on which stable bodies of liquid have been found [1]. The exact composition of Titan lakes important question; various models have predicted the main constituents of the lakes are ethane and methane with several minor solid soluble components [2, 3]. Titan's atmospheric condition is near triple point of methane and allows only methane and ethane to be present in liquid state. To know the exact composition of lakes we need to understand the solubility of hydrocarbons ices in Titan liquids. However, current results lack data on the thermodynamic properties of these various molecules at Titan cryogenic temperatures. Acetylene (C_2H_2) is thought to be major component dissolved in Titan lakes [2, 4]. Dissolved solutes, such as C_2H_2 are of major interest to understand the possible biological potential of Titan, since it has been proposed that solid C_2H_2 may be possible energy source.

Our main objective of this study is to determine the solubility of solid C_2H_2 in CH_4 and C_2H_6 and also determine if they can be detected by conventional FTIR reflectance spectroscopy methods (Cassini VIMS). We focus on liquid methane and ethane because they are the major constituents of the liquid lakes [2, 6] and they might exhibit different behaviors with respect ti solubility [6]. This study will be used to understand the likely behavior of Titan lakes and their interaction with bedrock, sediments and for generation of karst terrain and evaporites.

Experimental Setup

The experimental facility used for the experiments is specifically designed for simulating Titan surface condition [5]. Pressure of 1.5 bar is maintained with N_2 gas and temperature of 90 -94 K is maintained with liquid nitrogen. Organics compounds are condensed from gas phase in the condenser, and then washed with liquid hydrocarbons (methane or ethane) during 20 mins before being collected in a Petri dish. The Titan chamber is also connected to a Nicolet 6700 FTIR that acquires *in situ* IR spectra of the sample (range pf 1 to 2.5 µm) via fiber optic. The sample mass is also continuously recorded to measure potential liquid mixture, evaporation processes [6].

Results

Fig. 1 shows the dissolution of C_2H_2 in pure methane. The pure acetylene features are shown (Fig. 1a) and the main absorption bands are centered at 1.40, 1.54, 1.89, and a negative slope at 2.0 µm [7]. Our results show that NIR signature of dissolved C_2H_2 has partially disappeared except for the absorption band at 1.54 µm and a negative slope at 2.0 µm. The C_2H_2 bands are barely visible in CH_4 mixture which, can be related to the amount of C_2H_2 present in liquid CH_4. The spectral features of C_2H_2 lie within the two largest VIMS atmospheric windows centered at 1.59 and 2.0 µm and can be potentially detected by VIMS. C_2H_2 band depth calculation shows that there is very little amount of C_2H_2 dissolved in CH_4. Several small absorption bands in the 1.6 – 1.8 µm region and beyond 2.1 µm are more likely due to traces of acetone present in our initial C_2H_2 sample.

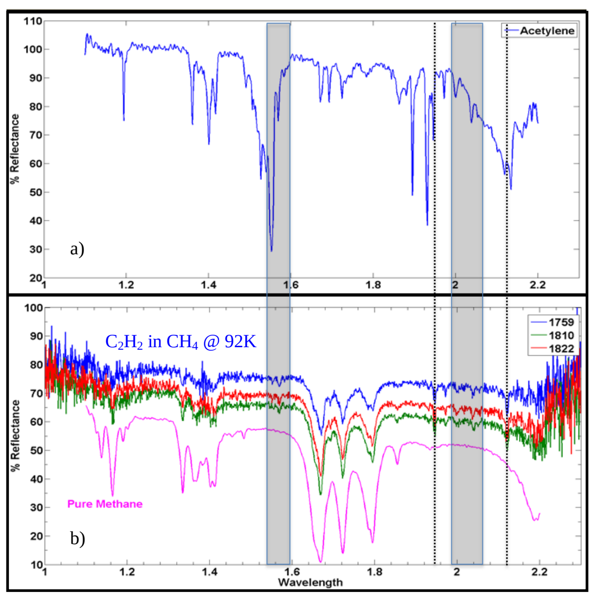

Figure 1: a) Acetylene spectra at 1.5 bar and at 90K. The shaded region shows the two VIMS atmospheric windows where C_2H_2 can be detected. b) The mixture of C_2H_2 and CH_4 over time and their comparison with pure CH_4.

In the similar type of experiment with same amount C_2H_2 in 10g of ethane shows different results. Fig. 2 shows the dissolution of C_2H_2 in liquid ethane. Comparing C_2H_2 dissolution in CH_4, the solubility of C_2H_2 in C_2H_6 is significantly larger. The mixture spectra of C_2H_2 and C_2H_6 show several different absorption bands with higher band depth values than C_2H_2 and CH_4 mixture spectra. The NIR signature of C_2H_2 in C_2H_6 is easily differentiable and the band depth calculation shows that C_2H_2 is more soluble in liquid ethane. The absorption band at 1.59 μm lies in the VIMS atmospheric window and is also visible in the NIR signature of C_2H_6 and C_2H_2 mixture. The C_2H_2 absorptions bands at 2.0 μm completely disappear and the band at 1.92 μm is easily distinguishable in ethane mixture compared to methane, which indicates higher C_2H_2 solubility.

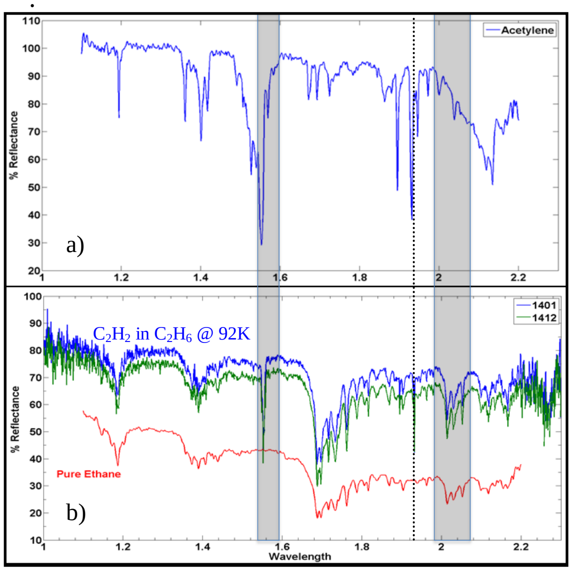

Figure 2: a) Acetylene spectra at 1.5 bar and at 90K. b) Mixture of C_2H_6 and C_2H_2 with comparison to pure Liquid ethane.

Conclusions

We have successfully conducted several different experiments of C_2H_2 in liquid hydrocarbons under simulated Titan surface conditions. Our solubility spectra show that C_2H_2 is far more soluble in liquid ethane than in liquid methane. To calculate the exact solubility values a spectra un-mixing model is being developed. This un-mixing model will provide the exact molar ratio of solute and solvent present in the mixture. Calculating the difference in band depth values of C_2H_2 in separate solvents will provide us the rough estimate of solubility. The spectral features seen at 1.59 μm and 2.0 μm region lie within two of the VIMS atmospheric windows. Therefore, the absorption features seen in laboratory spectra are large enough to be potentially detected in VIMS data, but only in the case of ethane-rich liquids. It is highly unlikely that C_2H_2 can be detected in CH_4 dominated liquids. The FTIR measurements used during these experiments will allow us to observe potential evaporites deposits of C_2H_2. The southern lakes like Ontario Lacus are very ethane rich [6, 8] could also contain a lot of C_2H_2, leading to possible C_2H_2 ice deposits after evaporation.

Acknowledgements

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