ACETYLENE ON TITAN'S SURFACE.

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Introduction

Saturn's moon Titan possesses a thick atmosphere mainly composed of N_2 (95%), CH_4 (4.9%) and less than 1% of minor species of hydrocarbons [1]. According to photochemical models, the dissociation of N_2 and CH_4 forms acetylene (C_2H_2) along with other hydrocarbons and nitriles in the atmosphere and exists under their solid form at the surface. Over the geological time scale, few hundred meters of thick layer of solid C_2H_2 could have formed on the surface of Titan [2]. The detection of some of these compounds with the Visual and Infrared Mapping Spectrometer (VIMS) of the Cassini mission have been reported [2]. Although predicted to be among the most produce hydrocarbons in the atmosphere, and therefore probably one of the most abundant at the surface, acetylene has not been detected so far using VIMS data on Titan's surface.

In this study we report the finding of acetylene at the surface of Titan in the 1.6 µm atmospheric window wit VIMS data, where one of the deepest acetylene absorption band (1.55 µm) occurs and can be used for identification. Acetylene has one major absorption band at 4.85 µm, which cannot be identified using VIMS data as it occurs just pass the shorward side of 5 µm Titan atmospheric window.

Methods

In order to detect acetylene on Titan, we selected data with the highest signal to noise ratio. The viewing conditions of the surface include high phase, incidence, and emission angles. Therfore we focused on the equatorial region of Titan. We selected regions of eastern Shangri la, Tui Regio, and Fensal-Aztlan/Quivira depending on the terrain types (bright and dark).

The search of acetylene reied on absorption band depth calculation at 1.55 µm [Fig.1]. Any variations from the surface are expected to define spatially coherent units in VIMS observations. On the other hand, the absence of variations would be ambiguous, as it could be associated to a systematic absorption, possibly from the atmosphere, or to an instrument artifact.

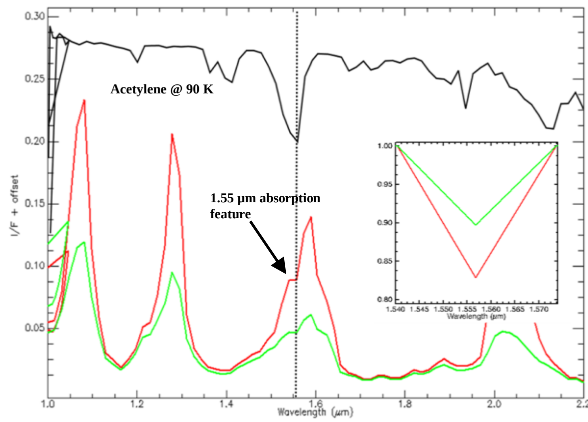

Figure 1: Average spectra of the selected (ROI) indicating absorption feature at 1.55 µm compared with laboratory spectrum [4].

To check if acetylene at the surface can be detected by VIMS using the absorption feature at 1.55 µm , we performed a simulation with a Radiative Transfer (RT) model [3]. We used the geometryof illumination and observation of VIMS observations and performed an inversion using radiative transfer model with a uniform surface albedo (i.e., which includes only the atmospheric absorptions iof methane).

Using calculation from RT model for surface albedo of 0 and 1, figure 2 shows that the 1.55 µm absorption band of acetylene is present in the spectra and is not produced by atmospheric compounds.

Results/Discussion

According to the band depth calculation the band depth seems to increase where the surface albedo is lower [Fig. 3]. Althoughvariations are small, they define surface units that are spatially coherent. A bright surface component such as acetylene mixed with other possible Titan aerosols with an absorption band at 1.55 µm could explain the observation.

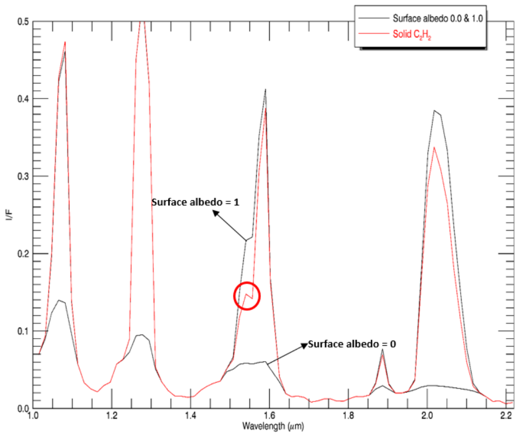

Figure 2: Simulation from RT model for constant surface albedo of 0 and 1, and solid acetylene. The red circle shows the absorption feature due to acetylene with negative slope

On simulation of a surface covered with acetylene (the red spectrum) illustrates the 1.55 µm absorption band of acetylene produces a local imimum in the spectrum, which is not the case if acetylene is not present on the surface.

In addition, the detection of the absorption at 1.55 µm seems quite independent of the viewing geometry if the angles of incidence/emergence are lower than 60 degrees, despite atmospheric absorption and scattering.

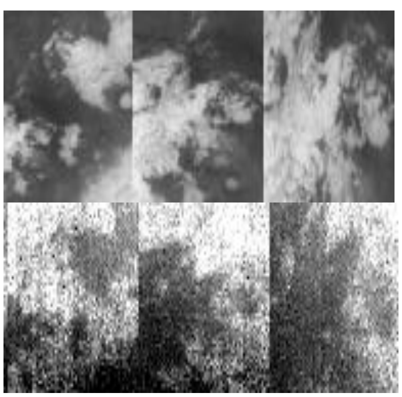

Figure 3: VIMS image of Fensal-Aztlan/Quivira at 2.0 µm (top) and absorption band depth at 1.55 µm (bottom). A clear evidence of anticorrelation with albedo.

Figure 3 shows the anticorrelation between the surface albedo and the absorption band depth at 1.55 µm for the Fensal-Aztlan/Quivira region, where the spectral diversity is remarkable for Titan. It comprises color units previously identified in VIMS data. A brown unit is correlated to the Fensal and Aztlan dune fields [5] ; a dark blue unit, is often encountered to the southeast of bright units such as Quivira or Sinlap crater [6], suspected to be enriched water ice with respect to the rest of Titan's surface [7]. The dark units (brown and dark blue) exhibit strongly positive detection of acetylene. VIMS spectra of the bright units show a mre weaker feature at 1.55 µm that we cannot interpret as surface acetylene. Therefore, according to our band-depth mapping analysis we conclude that C_2H_2 is present in most of the dark components in the dune fields.

Conclusions

We have successfully identified solid acetylene on the surface of Titan in the 1.6 µm atmospheric window. The band depths of acetylene at 1.55 µm appears significantly stronger in dark terrain than bright terrains, suggesting higher quantity of acetylene. C_2H_2 ice has bright albedo [4] and should appear bright in the VIMS data, and models suggest it should be found preferentially on topographic hights. The detection of acetylene in low albedo areas suggests that C_2H_2 is likely mobilized by surface runoff or aeolian processes and is transported toward low elevated regions of Titan. This distribution suggests also that C_2H_2 is mixed with Titan aerosols and other organic compounds which would darken the surface.

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