

# Photochemistry of condensed species on Titan's aerosols analogues

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## Abstract

The formation of the aerosols of Titan starts in the upper layers of the atmosphere at about 1000 km. Then, they aggregate and sediment to the surface. Despite the intense work made on the comprehension of the aerosols formation, their chemical evolution during their sedimentation through the stratosphere and the troposphere remains unknown. In this work we investigate how the aerosols can interact with condensed species present in these atmospheric layers and chemically evolve when irradiated by UV solar photons.

## 1. Introduction

Titan, the largest satellite of Saturn, has a dense atmosphere made of molecular nitrogen (98 %) and methane (2 %) [1]. Dissociation and ionization of  $N_2$  and  $CH_4$  in the ionosphere of Titan at about 1000 km, by VUV solar photons and energetic particles from the Saturn's magnetosphere produce heavy organic molecules [2]. This chemistry initiates the formation of the brownish haze surrounding Titan. Then, the particles aggregate and sediment to the ground.

The measurement of the temperature profile in Titan's atmosphere by the HASI instrument onboard the Huygens probe shows a drop of temperature in the lower atmosphere with a minimum about 70 K at 44 km of altitude [3]. These low temperatures allow a possible condensation of photochemical products on the aerosols surface during their sedimentation through the stratosphere and the troposphere [4]. Different emission bands in the far infrared have been observed by the IRIS instrument of the Voyager spacecraft and by the CIRS instrument of the Cassini spacecraft and attributed to condensed species [5] [6].

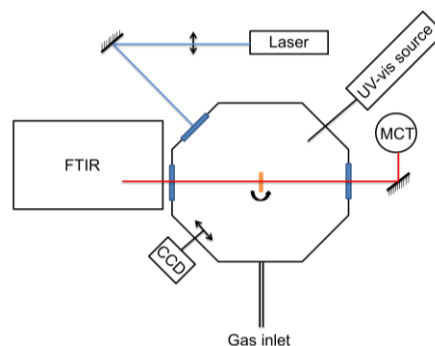
If high-energy solar photons initiating the organic chemistry in the ionosphere of Titan's have been significantly absorbed at the altitude where species can condense, photons with longer wavelengths are still present at altitude as low as 100 km. A chemical evolution of aerosols can then be initiated by the reactivity of aerosols coated with condensed species and irradiated by solar photons in the UV-visible range.

Here we present a first experimental study of the aging processes of Titan's aerosols coated with condensed species and irradiated by UV-visible solar flux in the lower atmospheric layers of Titan.

## 2. Material and methods

To study this phenomenon, we irradiate condensed species coated on a blank sapphire window or coated on thin films of Titan's aerosols analogues, named tholins, with a UV laser.

The analogues are produced by subjecting a  $N_2$ - $CH_4$  mixture to a radio-frequency discharge [7].



**Figure 1:** Scheme of the Acquabella experimental setup at the JPL's Titan Organic Aerosol Spectroscopy and chemisTry (TOAST) laboratory.

A blank sapphire window or a tholins sample is mounted in the Acquabella experiment [8].  $C_2H_2$  is deposited at 50 K to form an ice film on the top of the tholins sample.  $C_2H_2$  is one of the most abundant species in the atmosphere of Titan's with a mixing ratio about 2 ppm<sub>v</sub> as measured by the CIRS instrument at 120 km [9] and solid  $C_2H_2$  has been observed in Titan's stratosphere [10].

The acetylene consumption during the irradiation is monitored using absorption infrared spectroscopy. The evolution of the tholins sample, after the sublimation of the remaining ice, is monitored by absorption infrared spectroscopy.

### 3. Results

We conducted a series of experiments by depositing a thin layer of acetylene ice over the tholins film and subjected these samples to various solar spectra wavelengths using a tunable laser system. We found that while at longer wavelengths no significant chemistry was noticeable, but at shorter wavelengths, particularly 355 nm a significant amount of acetylene was depleted, indicating chemical bonding of acetylene to the tholins polymer.

Controlled experiments showed that a higher consumption of  $C_2H_2$  coated on a tholins sample occurred compared to the irradiation of  $C_2H_2$  ice film alone. Further experimental results and analysis of the data will be presented.

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### References

- [1] Flasar, F. M., et al., Titan's Atmospheric Temperatures, Winds, and Composition, *Science*, 308, 975-978 (2005)
- [2] Waite, J. H., et al., The Process of Tholin Formation in Titan's Upper Atmosphere, *Science*, 316, 870-875 (2007)

[3] Fulchignoni, M., et al., In situ measurements of the physical characteristics of Titan's environment, *Nature*, 438, 785-791 (2005)

[4] Lavvas, P., et al., Condensation in Titan's atmosphere at the Huygens landing site, *Icarus*, 215, 732-750 (2011)

[5] Coustenis, A., et al., Plausible condensates in Titan's stratosphere from Voyager infrared spectra, *Planetary and Space Science*, 47, 1305-1329 (1999)

[6] de Kok, R., et al., Condensation in Titan's stratosphere during polar winter, *Icarus*, 197, 572-578 (2008)

[7] Szopa, C., et al., PAMPRE: A dusty plasma experiment for Titan's tholins production and study, *planetary and Space Science*, 54, 394-404 (2006)

[8] Gudipati M. S., et al., Photochemical activity of Titan's low-altitude condensed haze, *Nature Communication*, 4, 1648 (2013)

[9] Vinatier, S., et al., Vertical abundance profiles of hydrocarbons in Titan's atmosphere at 15° S and 80° N retrieved from Cassini/CIRS spectra, *Icarus*, 188, 120-138 (2007)

[10] Khanna, R. K., Condensed species in Titan's stratosphere: Confirmation of crystalline cyanoacetylene ( $HC_3N$ ) and evidence for crystalline acetylene ( $C_2H_2$ ) on Titan, *Icarus*, 178, 165-170 (2005)