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# Evolution of Titan's atmospheric aerosols under high-altitude ultraviolet irradiation

S. Tigrine<sup>1,2</sup>, N. Carrasco<sup>1</sup>, A. Mahjoub<sup>1</sup>, B. Fleury<sup>1</sup>, G. Cernogora<sup>1</sup>, L. Nahon<sup>2</sup>, P. Pernot<sup>3</sup>, M. S. Gudipati<sup>4</sup>

<sup>1</sup>LATMOS, Université Versailles St. Quentin, UPMC Univ. Paris 06, CNRS, 11 Bvd. d'Alembert, 78280 Guyancourt, France, <sup>2</sup>Synchrotron SOLEIL, l'Orme des Merisiers, St Aubin, BP 48, 91192 Gif sur Yvette Cedex, France, <sup>3</sup>Laboratoire de Chimie Physique, UMR 8000, CNRS, Université Paris-Sud, Orsay, France, <sup>4</sup>Science Division, Jet Propulsion Laboratory, Science Division, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, California 91109, USA.

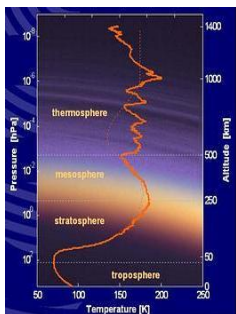


Figure 1: Atmospheric profile of Titan's atmosphere

## TITAN'S UPPER ATMOSPHERE

Titan is the biggest satellite of Saturn whose atmosphere is mainly composed of **molecular nitrogen (N<sub>2</sub>)** and **methane (CH<sub>4</sub>)** with an average ratio of 98/2 % [1]

The Cassini/Huygens mission revealed that the **interaction** between those **neutral molecules** and the **UV solar light** leads to a complex **photochemistry** that **produces heavy organic molecules**. When those molecules condense, they will then become the **solid aerosols** which are responsible for the **brownish haze surrounding Titan**. [2][3]

**Between 1000 and 600km**, the **VUV solar radiations** are still significant and will continue to **modify the physical, chemical and optical properties** of those grains. A change in these parameters can impact the radiative budget of Titan's atmosphere.



Figure 2 & 3: Titan seen by the Cassini's imager

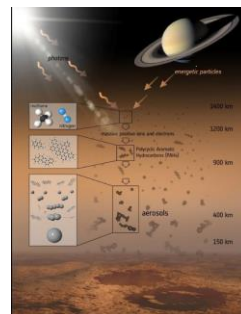


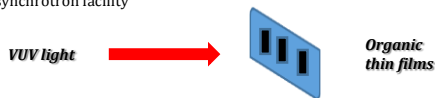
Figure 4: Aerosols' formation in Titan's upper atmosphere

Credits: NASA/ESA

**MAIN GOAL:** IDENTIFY AND UNDERSTAND THE PHOTOCHEMICAL EVOLUTION OF THE AEROSOLS BY ANALYSING THE IR SIGNATURES AND HOW THEY ARE MODIFIED AFTER BEING EXPOSED TO VUV RADIATIONS

## METHOD

The analogues are produced as thin organic films deposited on Si substrates by submitting a **95-5% N<sub>2</sub>-CH<sub>4</sub> molecular mixture to a radio-frequency electron discharge** [4]. **20 samples** have been prepared at the same time, by **45-min deposition**. Then, we estimate that their **thickness is about 300 nm** [5]. We irradiate the films of **Titan's atmospheric aerosols analogues** with VUV synchrotron radiations provided by the DESIRS beamline at the SOLEIL synchrotron facility



In Titan's ionosphere, the aerosols are exposed to the full VUV-solar spectrum, but we focus here on the **Lyman-α (121,6 nm)** wavelength as it is an important contribution.

The **solar VUV-UV photon flux reaching the top of Titan's atmosphere** is about **10<sup>14</sup> photons/s/cm<sup>2</sup>** [6] while the DESIRS line provides a **monochromatic flux of 10<sup>16</sup> photons/s/cm<sup>2</sup>**.

The **residence time of the aerosols in the thermosphere** (between 1000 and 600 km) is about the duration of **one Titanian day (10<sup>6</sup> s)** [7]. So we counterbalance our higher photon flux by **shorter irradiation times: 3h, 10h and 24h**.

## IR ANALYSIS

We checked that the films are **similar in size and composition** prior the irradiation experiment by **comparing their IR signatures**. We also made sure that they were **homogeneous** by recording their IR signatures on **different 400\*400 μm spots** of the same sample.

All the Infra-Red measurements have been performed with a Thermo Scientific Nicolet iN10 MX spectrometer at the **SMIS beamline** at the synchrotron SOLEIL facility. We used the highly sensitive **mercury cadmium telluride (MCT) detector** for a transmission analysis.

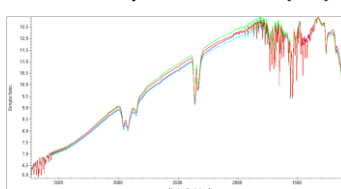


Figure 5: Spectrum of blank substrates. We compared substrates between them but also different positions on the same one.

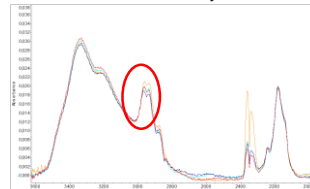


Figure 6: Comparison of different analog films. We notice some slight differences between some samples.

→ We can take only **one reference for the blank substrates signature**  
→ **BUT the analog samples are not exactly homogenous** between them

## RESULTS

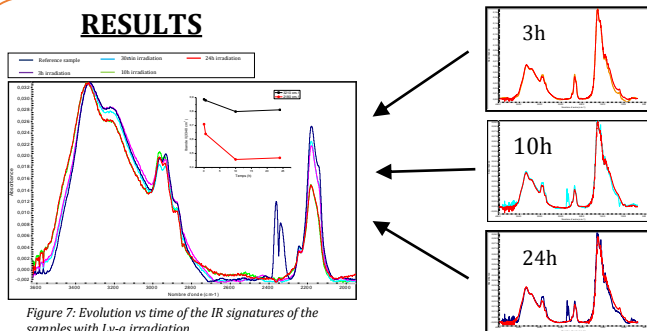


Figure 7: Evolution vs time of the IR signatures of the samples with Ly-α irradiation

## Kinetics at Ly-α

• **Decrease of two bands:**

- C-H at 2950 cm<sup>-1</sup>
- C-N at 2180 cm<sup>-1</sup>

→ **Are the samples too thick?**

• But the **decrease reaches saturation** after few hours

**To be Continued...**

- Test other wavelengths: **95 nm** (ionization effects?) or **190 nm** (soft UV)
- **Slimmer analog films**
- Gather data on the **absorption cross section** of the aerosol analogs

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