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

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TITAN’S UPPER ATMOSPHERE

Titan is the biggest satellite of Saturn whose atmosphere is mainly composed of molecular nitrogen (N2) and methane (CH4) with an ratio of 98/2 %. [1]

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

Between 1000 and 600 km, the UUV 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.

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 UV RADIATIONS

METHOD

The analogues are produced as thin organic films deposited on Si substrates by submitting a 95-5% N2/CH4 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 1014 photons/s/cm² [6] while the DESIRS line provides a monochromatic flux of 1016 photons/s/cm².

The residence time of the aerosols in the thermosphere (between 1000 and 600 km) is about the duration of one Titanian day (104 s) [7]. So we counterbalance our higher photon flux by shorter irradiation times: 3h, 10h and 24h.

RESULTS

We can take only one reference for the blank substrates signature

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.

Kinetics at Ly-α

• Decrease of two bands:
  • C-H at 2950 cm⁻¹
  • C-N at 2180 cm⁻¹

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

References: