EVOLUTION OF AEROSOLS IN TITAN’S IONOSPHERIC PLASMA
An Experimental Simulation

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INTRODUCTION: EVOLUTION OF ORGANIC AEROSOLS IN PLASMA ENVIRONMENT

Titan is a moon of Saturn where climate and surface phenomena are governed by the presence of organic aerosols. Cassini spacecraft, which observed Titan from 2004 to 2017, discovered that aerosols start forming above 1200km, in the ionosphere. At this altitude the atmosphere is a N2-CH4-H2 dusty plasma (in respective proportions 98.4%-1.4%-0.2%). Aerosols cross the entire ionosphere when falling down to the surface of Titan. In such a reactive environment, these organic grains are likely to evolve, physically and/or chemically, through interactions with electrons, ions, radicals and excited species. Here we experimentally simulate the exposure of Titan’s aerosols to plasma and characterize the evolution of the sample in situ IR transmission spectroscopy.

SAMPLE: TITAN THOLINS

PAMPRE: Analogs of Titan’s aerosols (“tholins”) are formed in the reactor PAMPRE at LATMOS under conditions described in [1]. Pellet: Tholin grains are then pressed with KBr under 5 tons pressure to obtain thin pellets not totally opaque in IR.

PHYSICAL EROSION

With naked eyes
Pellets become whiter and rougher:
- preferential erosion of the brown organic material
- stronger erosion with H2

With scanning electron microscopy (SEM)
- black organic material is removed from the surface contrary to bigger KBr grains.
- at low pressure: some tholins are left and appear rougher.

CHEMICAL EVOLUTION: BY IR TRANSMISSION SPECTROSCOPY

CN bands (2060 – 2260 cm⁻¹)

After normalization on the maximum, relatively:
- disappears quickly
- appears progressively
- is less important without H2

CH bands (2430 – 3020 cm⁻¹)

- evolution of bands
- modifications of chemical environment
- toward aliphatic and saturated functions
- to compare with Cassini measurements in Titan’s stratosphere
- similarities in the aliphatic part
- but aromatics do not seem formed by N2-H2 plasma processes

NH bands (2400 – 5600 cm⁻¹)

- disappearance of the band at 3600 cm⁻¹ (-OH) in less than 5min
- quick deoxidation of tholins
- ratio ‘CH / ‘NH + OH’ bands
  - first minutes: deoxidation
  - but maybe also small long-term growth of ‘CH’ bands relatively to ‘NH’ bands

CONCLUSIONS AND PERSPECTIVES

- physical and chemical modifications seen ⇒ tholins are altered by plasma (roughness, relative evolution of major bands, changes in unsaturated functions, complexification of chemical environment, deoxidation...)
- the addition of H2 in N2 intensifies the evolution of tholins (Higher erosion speed at 1-2min for CN and NH bands, β-unsaturated - CH band growth, stronger deformation of CH bands...)
- what to expect on Titan: same ionization ratio, pressure 10⁻³ lower, particles 100x smaller, timescale >1000 larger [2]: compensation? ⇒ possible erosive effect + chemical modifications induced by N2-H2 plasma species
- to go further: evolution of gas species after interaction with the aerosols

REFERENCES