Mimicking Titan's upper atmosphere reactivity with a RF-capacitively coupled N_2-CH_4 plasma.

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Titan is the largest satellite of Saturn. Its upper atmosphere is well-known for the production of a phochemical organic smog. We simulate this ionospheric chemistry with a RF plasma setup. We present here the study of the gas phase composition, neutral and positively charged species, correlated with aerosol production efficiency.

Titan is the largest satellite of Saturn. It has a dense atmosphere of 1.5 bar at the surface mainly composed of nitrogen and methane. One of the most important results delivered by the ongoing Cassini space mission was to affirm that Titan's aerosols are synthesized in the upper atmosphere [1]. However, the Cassini mission has also highlighted the incompleteness of our knowledge on Titan's ionopheric chemistry, showing numerous unexplained species and *a fortiori* unknown processes coupling nitrogen and hydrocarbon chemistry, and involving neutrals, and positive and negative ions. The complex mechanisms leading to the production of the organic aerosols surrounding Titan remain thus mostly unknown. One way to study this reactivity is to reproduce in the laboratory the whole chain of reactions occurring in Titan's atmosphere.

Several experimental setups have been developed in order to reproduce Titan's atmospheric chemistry in the laboratory. Among them the RF-CCP device PAMPRE provided significant clues on the understanding of the polymeric chemical structure of the atmospheric aerosols [2-3]. The influence of the methane initial concentration on the aerosol production efficiency was studied, highlighting a surprising decrease of the aerosol production yield with the methane concentration [4]. In order to find some clues on the volatile products controlling the aerosol production, we performed an extensive study on the gas phase composition correlated with the aerosol production. The study of the gas phase organic products is focussed on its evolution with the initial methane amount $[CH_4]_0$ and its comparison with the aerosol production efficiency [5].

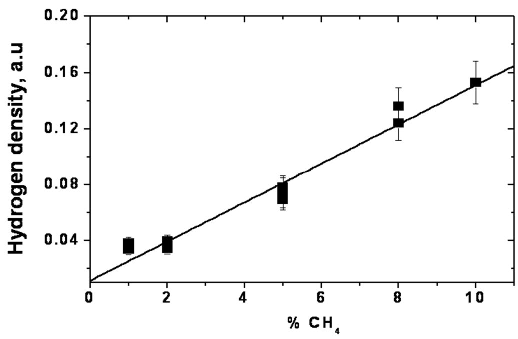

Fig. 1: Evolution of hydrogen atom densities as a function of % CH_4.

We quantified atomic hydrogen content (Fig. 1) by actinometry with in-situ optical emission spectroscopy, i.e. by measuring the ratio between emission lines intensities I(H) and I(Ar) populated by electron collisions, [Ar] being known:

$$[H] = A\frac{I(H)}{I(Ar)}\frac{k_{e-Ar}(T_e)}{k_{e-H}(T_e)}[Ar]. \qquad (1)$$

Methane consumption and stable gas neutrals production are monitored by in-situ mass spectrometry. We identify a change in the stationary gas phase composition for intermediate methane amounts: below $[CH_4]_0$=5%, the gas phase composition is mainly dominated by Nitrogen-containing species, whereas hydrocarbons are massively produced for $[CH_4]_0$>5%.

Moreover, two protonated imines are detected in the ion composition in agreement with Titan's Cassini-INMS measurements, and reinforcing the suspected role of these chemical species on aerosol production.

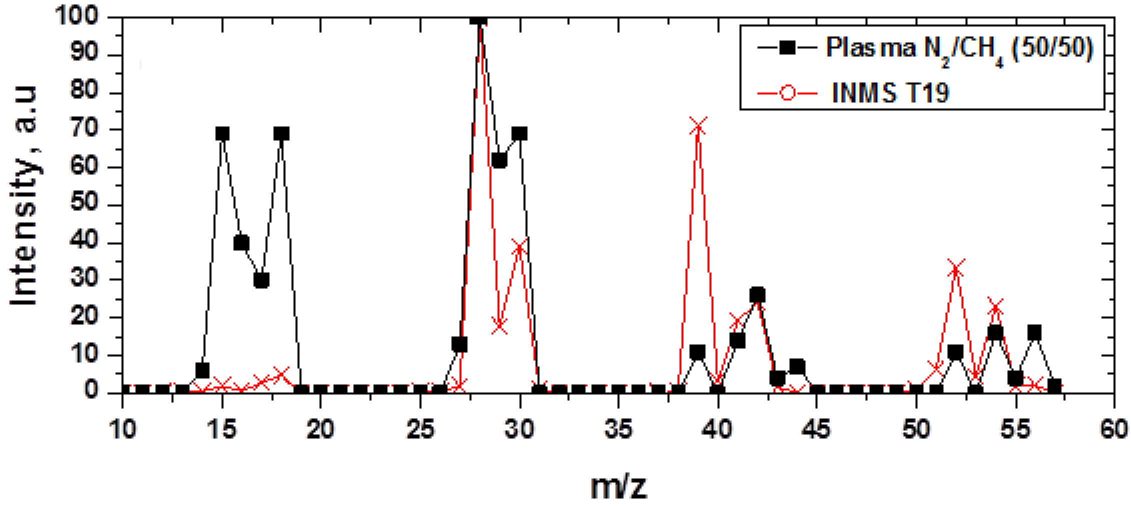

Fig. 2: Qualitative comparison of positive ion mass spectra observed in a N_2-CH_4 RF plasma [6] and in Titan's ionosphere (INMS T19), in arbitrary units and normalized at m/z 28.

Acknowledgments

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