Titan's atmosphere: an optimal gas mixture for aerosol production?

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The intense photochemistry that takes place in Titan's dense atmosphere, mainly composed of N_2 and CH_4, leads to the production of complex organic molecules and to the subsequent formation of aerosols in suspension in the atmosphere. The CAPS and INMS instruments onboard Cassini have shown that these aerosols are not only formed in the neutral lower stratosphere but also at higher altitudes in the ionosphere, where an active chemistry between ion and neutral species occurs [1].

To try and understand this chemistry, we use a dusty plasma experiment that simulates the atmospheric reactivity on Titan [2]. This experiment, called PAMPRE, uses a radio frequency capacitively coupled plasma discharge, produced in a continuous gas flow, to induce the chemistry between N_2 and CH_4. More complex molecules are formed in the plasma and lead to the production of solid particles, analogues of Titan's aerosols, called tholins.

In a recent study [3], different nitrogen-methane gas mixtures (from 1% to 10% CH_4) have been used to study the influence of methane on the chemistry and on the subsequent production of tholins. From *in situ* mass spectrometry measurements, it has been observed that the methane concentration in the gas phase during tholin production (plasma steady state) is lower than the injected methane concentration. By varying the initial methane concentration, it has been found that tholins could be produced in methane steady state concentrations similar to Titan's atmospheric conditions (~1.5% CH_4) when injecting an initial CH_4 concentration of ~5%, as shown in Figure 1.

The tholin mass production rate has been quantified as a function of the initial methane concentration. The production was found to be the most efficient for a steady state CH_4 concentration in agreement with Titan's atmospheric CH_4 concentrations. The carbon gas to solid conversion rate has also been inferred for each gas mixture: the tholin carbon integration efficiency decreases when the initial CH_4 concentration in the gas mixture is increased.

We highlight, from the mass production rate measurements, two competitive chemical regimes controlling the tholin production efficiency: an efficient growth process which is proportional to the methane consumption, and an inhibiting process which opposes the growth process and dominates it for initial methane concentrations higher than ~5%. To explain these two opposite effects, we propose two mechanisms: one involving HCN patterns in the tholins for the growth process, and one involving the increasing amount of atomic hydrogen in the plasma as well as the increase in aliphatic contributions in the tholins for the inhibiting process. This study highlights new routes for understanding the chemical growth of the organic aerosols in Titan's atmosphere.

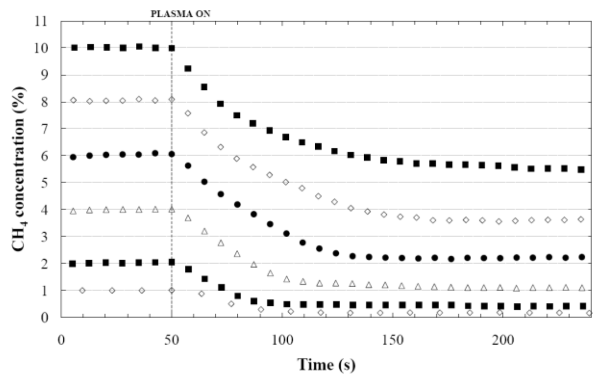

Figure 1. This figure shows the mass spectrum intensity at 15 u (i.e. the CH_3^+ fragment of methane) normalized to represent the CH_4 concentration in gas mixtures with 1%, 2%, 4%, 6%, 8% and 10% CH_4. The plasma was turned on after 50s and the steady state was reached after 150 s for all conditions, giving the steady state CH_4 concentration, which corresponds to the CH_4 concentration in the gas mixture during the tholin production.

References:

[1] Waite, J.H. Jr. et al. (2007) *Science*, 316, 870-875.
[2] Szopa, C. et al. (2006) *Planet. Space Sci.*, 54, 394–404.
[3] Sciamma-O'Brien, E. et al. *Icarus* (submitted).

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