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# Size study of dust produced in a CCP RF discharge for the simulation of Titan's chemistry

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**Abstract.** A radio-frequency discharge in a N<sub>2</sub>-CH<sub>4</sub> gaseous mixture is used to reproduce Titan's aerosols. To understand the dust growth mechanisms, the effect of different parameters on their size is studied. It is shown that the tholins are bigger for a large amount of methane and for a lower gas flow in the plasma. The evolution of tholins' size with plasma duration is also presented.

**Keywords:** dusty plasma, light scattering, solid aerosols, Titan's atmosphere.

**PACS numbers:** 52.27.LW; 42.25.Fx; 96.30.nd.

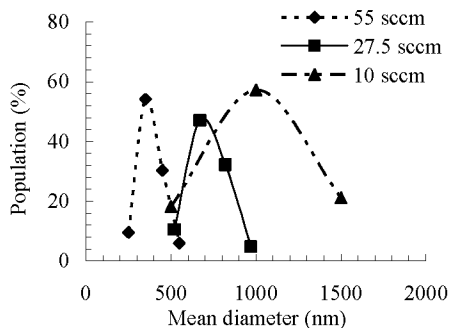
## INTRODUCTION AND EXPERIMENT

The atmosphere of Titan, the biggest satellite of Saturn, contains organic solid aerosols produced by the photochemistry of N<sub>2</sub> and CH<sub>4</sub>, the major gaseous atmospheric compounds. From measurements of solar light scattered by the aerosols, Tomasko et al. [1] showed that they are probably aggregates of 100 nm diameter monomers.

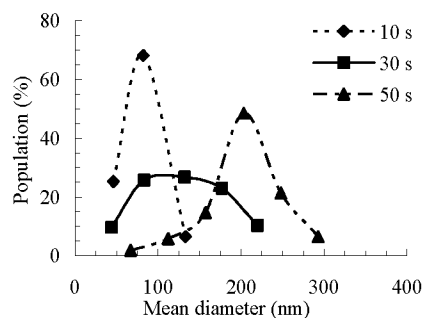
The experiment PAMPRE [2], a capacitively coupled radio frequency discharge, is used in a N<sub>2</sub>-CH<sub>4</sub> mixture, to produce analogues of Titan's aerosols named "tholins". These ones are quasi-spherical monomers [2]. The aim of this work is to study the effect of plasma working conditions on tholins' size. Four parameters are studied: the CH<sub>4</sub> amount in the discharge, the total gas flow rate, the absorbed RF power and the plasma duration. The produced dusts are collected outside the plasma for ex situ analysis: SEM-FEG (Sweeping Electronic Microscopy-Field Emission Gun) observations and light scattering measurements by the PROGRA<sup>2</sup> experiment on levitating particles [3].

## RESULTS AND DISCUSSIONS

From SEM-FEG images, "tholins" size distributions are deduced. In continuous working conditions, for given pressure, gas flow and RF absorbed power, the tholins' mean size increases with the CH<sub>4</sub> amount from 400 nm (2 % CH<sub>4</sub>) to 700 nm (10 % CH<sub>4</sub>). When the RF power decreases, the mean size of particles is reduced.



**FIGURE 1:** Tholins' size distributions of tholins produced at different gas flows.



**FIGURE 2:** Size distributions of tholins produced after 10, 30 and 50 s of plasma duration.

The effect of gas flow rate is studied, for given pressure (1 mbar), CH<sub>4</sub> amount (2 %) and RF power (30 W). Due to experimental constraints (pumping speed and gas flow control), gas flow range is limited between 10 and 55 sccm. The mean particles size increases when the total gas flow rate is reduced (Fig.1), varying from 350 nm (for 55 sccm) to 1000 nm (for 10 sccm). As reducing the gas flow induces a reduction of neutral gas speed into the plasma, this points out the major role of neutral gas drag force on dust particles growth. Even at a gas flow of 55 sccm, the particle mean size is still larger than Titan's ones.

In order to reduce the tholins' size, the plasma duration is reduced. As a cycle of formation of tholins lasts several seconds [4], plasma is generated at a gas flow of 55 sccm in pulsed mode, with durations varying from 10 to 50 s. Figure 2 shows, as expected, a growth of tholins with plasma duration. After 50 s, the mean size is about 200 nm, which is still smaller than tholins obtained in continuous working conditions (350 nm, see Fig.1). With 10 s of duration, we obtain tholins with 100 nm mean diameter, which is expected for Titan's atmosphere [1].

With the PROGRA<sup>2</sup> phase curves (i.e linear polarization as a function of scattered light direction) for 2 laser wavelengths (543.5nm and 632.8nm) are measured. The influence of CH<sub>4</sub> percentage is studied. The phase curves are well correlated to the tholins' size distributions obtained from SEM-FEG images.

## ACKNOWLEDGEMENTS

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## REFERENCES

1. M.G. Tomasko et al. *Nature* **438**, 765 (2006).
2. C. Szopa et al. *Planet. Space Sci.* **54**, 394 (2006).
3. J.B. Renard et al., *Appl. Opt.* **41**, 609 (2002).
4. M. Cavarroc, PhD thesis, University of Orleans, France (2007).