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Tholins produced by a RF plasma

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1. Introduction

Photochemistry by solar photons induces the formation of solid aerosols in the atmosphere of Titan. During the descent of the probe Huygens in 2005, a lot of data were collected. Among these data, the interesting ones for Titan's aerosols were produced by : i) the DISR experiment that provided optical data on the aerosols and on Titan's surface; ii) the ACP experiment, which provided compositional aerosols data [2]; iii) the HASI experiment [3] which measures the electrical properties of Titan's ground. Some properties of Titan's aerosols have been already deduced from Huygens data. However, a lot of data remains difficult to be interpreted without reference. These data do not allow to understand the formation of Titan's aerosols.

Laboratory simulations of the chemical-physics of Titan's atmosphere are thus of primary interest. The equivalents of Titan's aerosols produced in laboratory are named tholins. Up to now, most of tholins are produced as films deposited on solid surfaces. They do not reproduce the fractal form of Titan's aerosols, and solid substrate can influence the chemistry. The SA team has started to produce analogues of Titan's aerosols in laboratory, using a Radio-Frequency (RF) Capacitively Coupled Plasma (CCP). This kind of plasma produces solid particles in the gas phase. It also allows producing sufficient amounts of tholins which can be provided to laboratories collaborating in the field of planetology/astrobiology.

We present the correlations between the plasma conditions and tholins properties.

2. Experimental set-up

The experimental set up is described in [4]. The RF plasma is generated at 13.56 MHz and confined by a grounded metallic grid cage. Various proportions of nitrogenmethane are obtained by tuning gas flow of high purity N_2 and gas flow of a N_2-CH_4 (0.90-0.1) mixture. In the plasma, solid aerosols are directly produced from the gas mixture. They are maintained in levitation by electrostatic force and grow into the gas without any surface interaction. When their weight or the drag force due to gas flow dominate electrostatic force, they are ejected out of the plasma and collected in a glass vessel surrounding the cage. Tholins are then analysed and observed ex-situ.

3. Results

The collected tholins are observed by SEM and their elemental composition measured in terms of N, C, and H relative abundance. The influence of four parameters is studied: the amount of methane, the gas flow, the plasma duration, and the total pressure.

It is shown that the percentage of CH_4 in the gas mixture (0.5 - 10%) has an influence on the elemental composition of the tholins. Moreover, this CH_4 percentage changes also the tholins size distribution [5].

By changing the gas flow, we change the drag force. We observe the influence of this drag force on the mean size of produced tholins.

The third studied parameter is the duration of the RF plasma. As a matter of fact the cycle of formation of tholins (creation, growth and ejection) is known to last about a minute [6]. In typical working conditions, the produced tholins are bigger than 0.1 μm, which is expected in Titan's atmosphere [1]. Then, in order to reduce the tholins size, the RF discharge works in triggered mode with tuneable pulse duration. Thus, tholins are collected before they reach their maximal size.

Experimentations for different pressures are also done. As a matter of fact, in discharge plasma, the Electron Energy Distribution Function (EEDF) depends on the ratio E/n_0 where E is the electric field n_0 is the neutral gas density. The most efficient way to change it is to change pressure. Then, the tail of the EEDF is depopulated when pressure increases and the chemistry induced by electrons is changed [7].

With the presented work, we show that the RF CCP discharge is a very versatile device for the production of tholins with different elemental composition and size distribution.

4. Acknowledgements

SEM observations have been done at LISE (UPMC, Paris) and elemental analysis at the ICSN (Gif-sur-Yvette, France)

5.References

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