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On the infuence of CO on a dusty N_2-CH_4 CCP RF discharge

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In this work, we report the study of the effect of CO addition to a N_2:CH_4 RF CCP plasma. Results show that CO impacts some plasma properties such as the self-bias voltage and the methane consumption kinetics. CO introdution modifies slightly the chemical composition of the gaseous products but significantly increases the inclusion of O in dust produced in the discharge.

The atmosphere of Titan is mainly made of N_2 and CH_4. Chemical reactions, induced by solar irradiation and charged particles accelerated in Saturn's magnetosphere, lead to the production of an opaque layer of organic solid aerosols in the atmosphere. The composition and chemical production processes of these aerosols remain mainly unknown and provide a great challenge in planetary science. In order to better constrain the formation processes of these aerosols, we simulate the whole reaction chains with a laboratory Radio Frequency Capacitively Coupled plasma discharge (RF CCP) in a nitrogen and methane gas mixture. This leads to the production of laboratory analogues of Titan's aerosols, called Tholins [1].

In this work we investigate the influence on the plasma discharge properties of carbon monoxyde (CO), the most abundant oxygenated compound in Titan's atmosphere.

The experimental plasma set-up is described in details in [1] We give here the main characteristics of this experimental set up. The plasma is produced by a RF CCP discharge is confined by a metallic grounded grid. Gas are injected continuously trough the polarized electrode. Gas mixtures are adjusted with gas flow control from pure N_2, premixed N_2+10% CH_4 and pure CO. All results presented here are obtained for a pressure of 1 mbar and 30W of injected RF power.

Gaseous products are condensed in a cold trap cooled by liquid nitrogen, downstream between the plasma reactor and the vacuum pump. Then the trap is warmed up to the room temperature and connected to a Thermo Gas Chromatograph coupled with a Mass spectrometer (GC-MS). The GC-MS results show that the gas mixture is made of nitriles and hydrocarbon, as detected in a pure N_2-CH_4 plasma [3]. Surprisingly, no oxygenated species is detected in the gas phase, exception of carbon dioxyde CO_2.

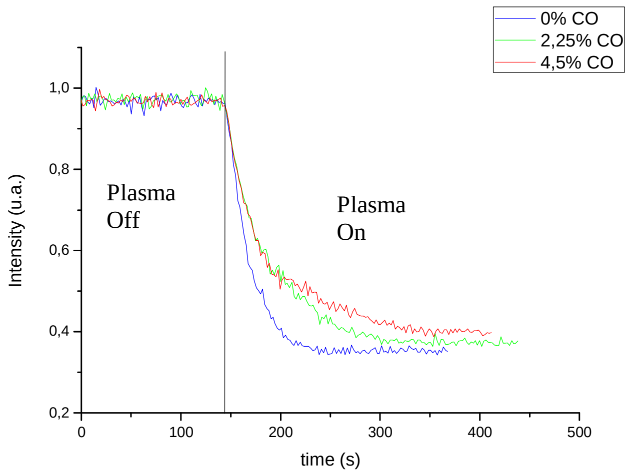

Fig. 1: Evolution of methane concentration in the discharge (arbitrary units) as a function of time. The blue curve corresponds to a pure N_2:CH_4 discharge, the green one includes 2.25% of CO and the red one 4.5% of CO. The vertical black line represents the ignition time.

The kinetic of methane consumption is monitored by *in-situ* mass spectrometry. The influence of CO concentration on this kinetic is shown in figure 1. This variation of methane consumption rate with

CO concentration is still not perfectly understood but might be linked to the time of dust apparition in the plasma.

The apparition of aerosols in the discharge is monitored using the evolution of the self-bias voltage (V_{dc}). The moment of apparition of dust in the plasma was monitored using V_{dc}. Indeed, when dust appears in the plasma, the self-bias increases [1]. The variation of V_{dc} as a function of the time for several CO concentrations is given in figure 2. The delay for dust formation increases with the amount of CO.

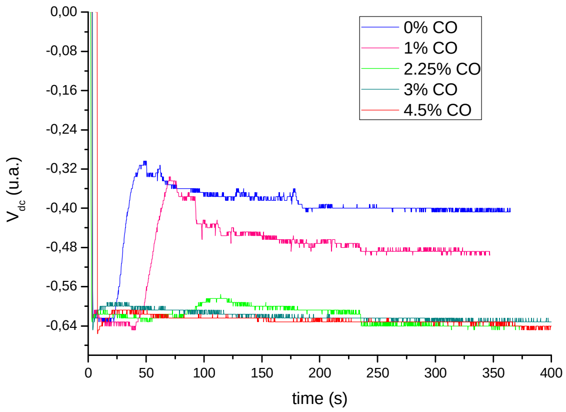

Fig. 2: Evolution of VdC as a function of time for several CO concentrations (blue: 0%, pink: 1%, green: 2.25%, cyan: 3% and red: 4.5%)

In a second time, we focused our study on the impact of CO on the tholins composition. We first recorded their infrared spectra. We did not detect any signature of oxygen related bond (e.g. C=O or O-H). This result significates that, if there is incorporation of oxygen in tholins, its amount should be low.

We then checked the global oxygen inclusion in tholins by elemental analysis. Results show a progressive increase (up to +5%) of oxygen content in tholins with increasing CO concentration.

As a conclusion, it is clear that the presence of carbon monoxyde can influence the plasma parameters. It can also delay the apparition of dust and modify dust properties. It is thus of great interest to further investigate the effect of CO.

Acknowledgments
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References

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