



HAL
open science

On the influence of CO on a dusty N₂-CH₄ CCP RF discharge

Benjamin Fleury, Nathalie Carrasco, Thomas Gautier, Ahmed Mahjoub, Guy Cernogora

► **To cite this version:**

Benjamin Fleury, Nathalie Carrasco, Thomas Gautier, Ahmed Mahjoub, Guy Cernogora. On the influence of CO on a dusty N₂-CH₄ CCP RF discharge. ESCAMPIG 2012 (Europhysics Conference on the Atomic and Molecular Physics of Ionized Gases), Jul 2012, Viana do Castelo, Portugal. 2 p. hal-00741761

HAL Id: hal-00741761

<https://hal.science/hal-00741761>

Submitted on 15 Oct 2012

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

On the influence of CO on a dusty N₂-CH₄ CCP RF discharge

B. Fleury¹, N. Carrasco^{(*)1}, T. Gautier¹, A. Mahjoub¹, G. Cernogora¹

¹ *Laboratoire ATmosphère, Milieux et Observations Spatiales (LATMOS), University of Versailles Saint Quentin, 11 bvd d'Alembert, 78280 Guyancourt, France*

(*) nathalie.carrasco@latmos.ipsl.fr

In this work, we report the study of the effect of CO addition to a N₂:CH₄ RF CCP plasma. Results show that CO impacts some plasma properties such as the self-bias voltage and the methane consumption kinetics. CO introduction 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 N₂ and CH₄. 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 monoxide (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 N₂, premixed N₂+10% CH₄ 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 N₂-CH₄ plasma [3]. Surprisingly, no oxygenated species is detected in the gas phase, exception of carbon dioxide CO₂.

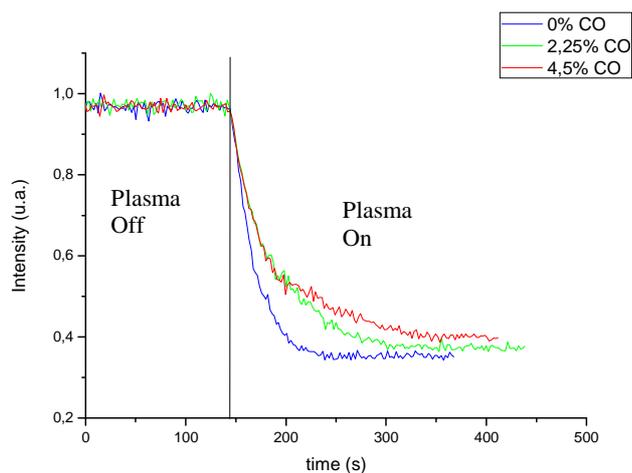


Fig. 1: Evolution of methane concentration in the discharge (arbitrary units) as a function of time. The blue curve corresponds to a pure N₂:CH₄ discharge, the green one includes 2.25% of CO and the red one 4.5% of CO. The vertical black line represents the ignition time.

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.

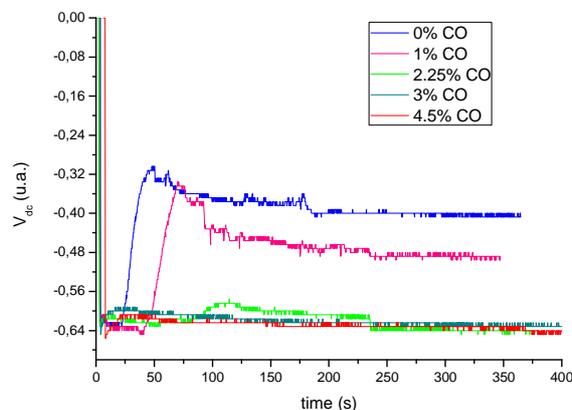


Fig. 2: Evolution of V_{dc} as a function of time for several CO concentrations (blue: 0%, pink: 1%, green: 2.25%, cyan: 3% and red: 4.5%)

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 monoxide 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

This work was financially supported by the ANR-09-JCJC-0038 contract.

References

- [1] G Alcouffe, M Cavarroc, G Cernogora, F Ouni, A Jolly, L Boufendi and C Szopa, *Plasma Sources Sci. Technol.* 19 (2010) 015008.
- [2] N. Carrasco, T. Gautier, E. Es-sebbar, P. Pernot and G. Cernogora, *Icarus* (2012) accepted.
- [3] T. Gautier, Carrasco N., Buch A., Szopa C., Sciamma-O'Brien E. and Cernogora G. *Icarus*, 213 (2011), 625-635.