



HAL
open science

Gaseous chemistry for a Titan's atmospheric plasma experimental simulation

Nathalie Carrasco, Thomas Gautier, Ella Sciamma-O'Brien, Cyril Szopa, Guy Cernogora, A. Buch, P. Pernot

► **To cite this version:**

Nathalie Carrasco, Thomas Gautier, Ella Sciamma-O'Brien, Cyril Szopa, Guy Cernogora, et al.. Gaseous chemistry for a Titan's atmospheric plasma experimental simulation. European Planetary Science Congress (EPSC2010), Sep 2010, Rome, Italy. EPSC2010-418 (2p.). hal-00665789

HAL Id: hal-00665789

<https://hal.science/hal-00665789>

Submitted on 22 Nov 2019

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.

Gaseous chemistry for a Titan's atmospheric plasma experimental simulation

N. Carrasco (1), T. Gautier (1), E. Sciamma-O'Brien (1), C. Szopa (1), G. Cernogora (1), A. Buch (2) and P. Pernot (3)
(1) LATMOS, Université de Versailles Saint Quentin, France, (2) LGPM, Ecole Centrale Paris, France (3) LCP, Université Paris Sud, France (nathalie.carrasco@latmos.ipsl.fr)

Abstract

We present the first study of gaseous composition monitoring for the PAMPRE experiment, which simulates Titan's atmospheric chemistry by radio-frequency N_2 - CH_4 plasma. Methane consumption is quantified for various N_2 - CH_4 gas mixtures. Moreover *in situ* mass spectrometry (MS) and *ex-situ* gas chromatography coupled with mass spectrometry (GC-MS) analyses reveal a large dominance of nitrile species in the gas phase chemistry.

1. Introduction

On Titan, the dissociation of N_2 and CH_4 by solar UV radiation and Saturn's magnetosphere electron bombardment induces a complex organic chemistry that results in the production of solid aerosols responsible for the orange haze surrounding Titan. These are the most complex extraterrestrial organic species detected in the solar system. Their chemical production mechanisms, initiated in the gaseous phase, remain mostly unknown and provide a great challenge in astrobiology. Several experimental setups have been developed in order to reproduce and study in the lab such a complex atmospheric system. Among them the plasma device PAMPRE provides recent significant clues on the understanding of the polymeric chemical structure of the aerosols [1], [2]. Here we present a first characterization of the gas phase composition obtained simultaneously with the aerosols formation in the reactive plasma.

2. Experimental Setup

In the PAMPRE experiment [3], different reactive N_2 - CH_4 gas mixtures are studied using a low pressure (~ 1 mbar) radiofrequency capacitively coupled plasma discharge. Solid aerosols are formed in suspension in the gas phase, and are collected and weighed at the end of several hours long run. The stable neutrals produced in the gaseous phase are

studied *in situ* by a Pfeiffer QME 200 quadrupole mass spectrometer. Moreover a cold trap connected to the extraction line of the experiment concentrates the volatile products which are further *ex-situ* analyzed with gas chromatography coupled with a quadrupole mass spectrometer (ThermoElectron).

3. Results

1.1 Methane consumption

Methane concentration is monitored by *in situ* mass spectrometry. Initial methane concentrations varying from 1 to 10% of the gaseous mixture lead to steady state concentrations from 0.2 to 5.5% after ~ 100 s of plasma discharge (see Figure 1) [4]. This shows an efficient consumption of methane feeding the formation of organic products both in gas and solid phases.

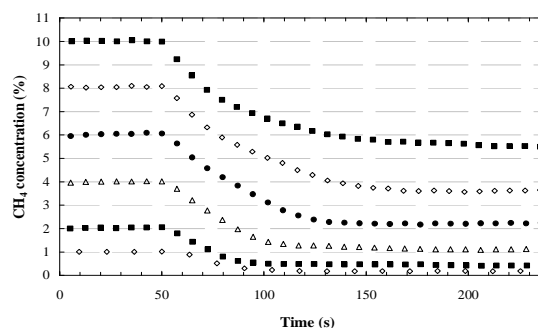


Figure 1: Evolution of the CH_4 concentration after plasma ignition (at $t=50$ s) with initial concentrations varying from 1 to 10%.

1.2 Gaseous products

Both *in-situ* mass spectrometry and *ex-situ* GC-MS analysis confirm the production of large amount of nitrile species in all the performed experiments, with a large contribution of hydrogen cyanide HCN and

acetonitrile CH_3CN . On the other hand hydrocarbon products are highly sensitive to the initial methane concentration: almost absent in low methane concentration gas mixtures, they become significant for mixtures with higher contents of methane.

Acknowledgements

We acknowledge the CNRS (PID OPV, PNP), the PRES UniverSud and the French National Research Agency (ANR-09-JCJC-0038) for their financial support. E.S.-O. thanks the PRES UniverSud and the CNES for her postdoctoral fellowships.

References

- [1] N. Carrasco, I. Schmitz-Afonso, J-Y. Bonnet, E. Quirico, R. Thissen, O. Dutuit, A. Bagag, O. Lapr vate, A. Buch, A. Giuliani, Gilles Adand , F. Ouni, E. Hadamcik, C. Szopa, G. Cernogora: Chemical characterization of tholins: Solubility, Morphology and Molecular Structure revisited. *J. Phys. Chem A*. 113(42), p.11195, 2009.
- [2] P. Pernot, N. Carrasco, R. Thissen and I. Schmitz-Afonso: Tholinomics - Chemical analysis of nitrogen-rich polymers. *Analytical Chemistry*. 82(4), p.1371, 2010.
- [3]. C. Szopa, G. Cernogora, L. Boufendi, J.-J. Correia, P. Coll: PAMPRE: A dusty plasma experiment for Titan's tholins production and study, *Planetary and Space Science*, 54(4), p.394, 2006.
- [4]. E. Sciamma-O'Brien, N. Carrasco, C. Szopa, A. Buch, G. Cernogora: Titan's atmosphere: an optimal gaz mixture for aerosol production ? *Icarus*. In press, 2010.