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Gaseous chemistry for a Titan's atmospheric plasma experimental simulation

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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 ~100s 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.

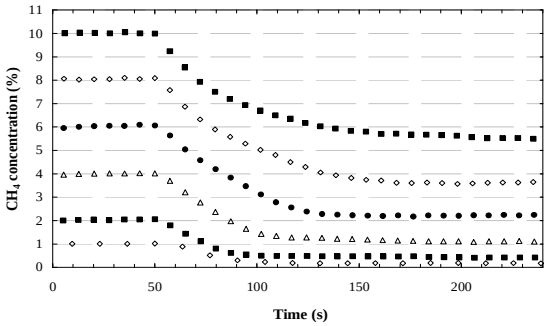

Figure 1: Evolution of the CH_4 concentration after plasma ignition (at t=50s) with initial concentrations varying from 1 to 10%.

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.

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