Experimental simulation of aerosols evolution in Titan's ionosphere

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EPSC Abstracts
Vol. 11, EPSC2017-594, 2017
European Planetary Science Congress 2017

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Abstract

Many recent studies on Titan are concerned with aerosols. In particular, questions are asked on how these complex organic molecules are formed and evolve in Titan's atmosphere. Here for the first time we experimentally study how harsh plasma environment simulating Titan ionosphere can affect these aerosols. Titan tholins are placed in a N_2-H_2 plasma reactor and sample signatures are measured by infrared transmission spectroscopy. First results show an evolution of the absorption bands. Therefore, plasma conditions seem to change tholin chemical structure.

1. Introduction

Observations by Cassini have revealed the formation of complex organic molecules in Titan ionosphere [1]. To better understand this complex chemistry, several experiments were conducted to reproduce analogs of Titan aerosols in laboratories [2,3,4]. These tholins appeared to be polymeric and nitrogenous molecules, and the influence of different parameters on the aerosol formation process has been studied [5,6].

However, a new issue might be addressed. Indeed, aerosols stay many years in Titan upper atmosphere, a dusty plasma where molecules are continuously bombarded by charged molecules. Consequently, tholins are likely to evolve in such an environment. The aim of this study is therefore to address this question by experimental simulation: we will analyze the effect of harsh plasma environment on tholins already formed.

2. Experimental device

2.1 Sample synthesis

Aerosols samples used are first formed in the plasma reactor PAMPRE at LATMOS, under conditions described in [6].

2.2 Plasma reactor

Samples are positioned at the center of a plasma reactor at LPP, where they are exposed to plasma during several hours.

The plasma reactor chosen is a DC glow discharge ignited in a 2 cm inner diameter tube with 23-centimeter length [7]. A 5 sccm flow of N_2-H_2 gaz mixture with 1% of hydrogen goes through the cell, and the pressure can be adjusted from 0.5 to 3.0 torr. The current is kept constant at 20 mA for this work. The effect of pure N_2 gas is also studied. The plasma reactor is adapted to fit inside the sample compartment of the FTIR, allowing for direct in situ measurement through the tholins sample under direct plasma exposure.

2.3 Analysis with IR spectroscopy

The evolution of these samples exposed to N_2-H_2 plasma is observed by infrared absorption spectroscopy, using a FTIR (Bruker V70 with 0.16 cm^{-1} resolution). Tholins are prepared in shape of thin pellets and placed in the middle of the plasma reactor, and centered on the FTIR beam to perform measurements in transmission through the pellet. However, pure tholins being too absorbent in IR to obtain satisfactory spectra, we diluted samples with 98.5% of KBr, transparent in the IR range studied.

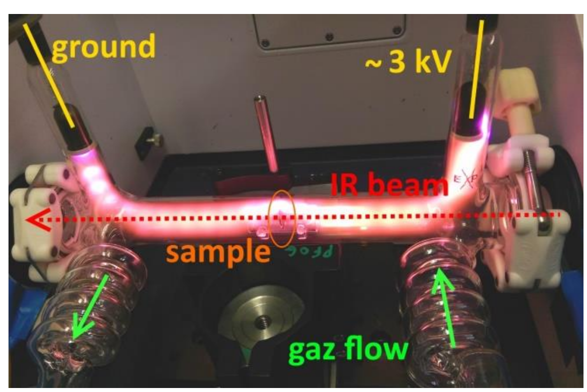

Figure 1: plasma reactor positioned in the FTIR

3. Results

We can observe changes on tholins even with naked eyes. Samples, at first brown, lighten and pellets become rough. Besides, IR spectra of tholin pellets are distorted after exposition to plasma.

3.1 Erosion of pellets

At first, we can note that pellets are eroded by plasma. Absorbance decreases to 40% of its initial value concerning the nitrile 2180 cm^{-1} band after an exposition of two hours at 1.9 torr. This value depends on various parameters, as pressure, exposition time or pellets concentration in tholins.

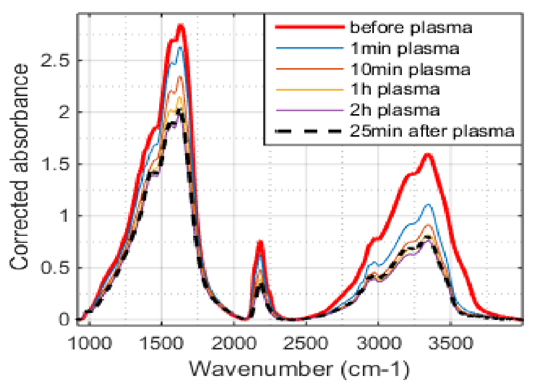

Figure 2: IR absorption spectra obtained by transmission through tholin pellets exposed to plasma at 1.9 torr during different times – with a corrected baseline

3.2 Chemical evolution

The normalization of individual peaks shows that IR absorption bands characteristic of tholins formed in PAMPRE are distorted during exposition to plasma. This witnesses changes in samples chemical structure.

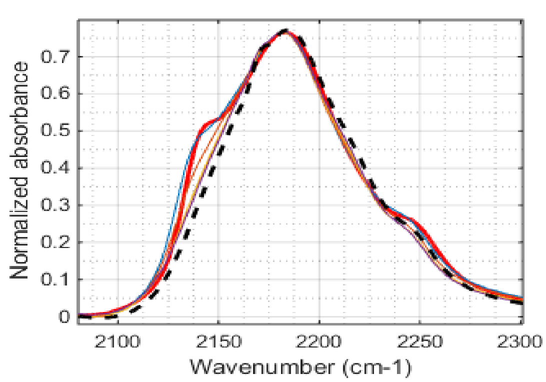

Figure 3: Same absorption spectra as in figure 2, normalized and zoomed on the nitrile band

4. Perspectives

These first results concerning evolution of Titan tholins exposed to N_2-H_2 plasma show that tholins seem sensitive to plasma conditions and structurally changed. An experimental compromise might be done in the choice of parameters to obtain notable structural modifications on tholins without totally eroding the pellets.

Besides, chemical analysis and study of surface state are the next steps to better characterize these changes.

Acknowledgements

AC is grateful to ENS Paris-Saclay for its training and financial support, and to David Yap for its explanations concerning the experimental setup.

NC acknowledges the financial support of the European Research Council (ERC Starting Grant PRIMCHEM, Grant agreement no. 636829).

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