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Evolution of organic aerosols under conditions similar to Titan's ionosphere

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Abstract

Titan's ionosphere is a dusty plasma where complex organic aerosols are formed. As they have a strong prebiotic interest, we would like to understand how they are formed and how they interact with the surrounding plasma. Here we simulate this interaction dust-plasma in a DC reactor. We place analogues of Titan's aerosols in a N_2-H_2 discharge and follow their infrared absorption spectrum all along the exposure. The evolution of the surface state of the sample is also observed by scanning electron microscopy. First experiments indicate some modifications in the absorption bands and in the surface structure. Therefore, the organic aerosols seem to be physically and chemically altered by the plasma.

1. Introduction

Atmospheric aerosols play an important role in the climate of planets. Especially, Titan produces such a quantity of particles that its surface becomes invisible from above. The Cassini-Huygens mission discovered that this matter is created high in the atmosphere of the moon, where solar radiations and Saturn's energetic particles can ionize nitrogen and methane of Titan's atmosphere. This leads to complex chemical processes and the formation of organic nanograins in the ionosphere [1].

Laboratory simulations succeed in forming similar organic grains ("tholins") using RF plasma or UV light. Aerosols form in a few minutes and these first chemical steps are relentlessly studied. However, on Titan the particles cross the wide ionosphere during their descent and stay a while in a harsh plasma environment. Especially, the organic grains are likely to evolve physically and / or chemically. [2] recently studied the effect of UV radiations on tholins. Here we look at their evolution under plasma conditions.

2. Experimental setup

2.1 Sample synthesis

Samples are formed in the reactor PAMPRE [3]. A CCP RF discharge is ignited at 30W in a gas mixture of 95% N_2 and 5% CH_4 at 0.9mbar. In a few minutes it leads to the formation of organic grains.

Tholins are then diluted with 99% KBr and pressed in thin pellets.

2.2 Exposure in a plasma reactor

The pellets are exposed during several hours to a N_2-H_2 plasma. They are put in the middle of a DC glow discharge under a current of 20mA. A flow of 5sccm goes through the tube leading to an adjustable pressure of 1 to 3mbar. Methane is removed from the gas mixture to prevent the formation of new tholins.

2.3 Analysis of the sample evolution

The structure of the sample's surface is examined before and after exposure thanks to an Environment Scanning Electron Microscope (E-SEM) at LGPM (Quanta 200 from FEI).

Besides, the plasma reactor is adapted to fit inside the sample compartment of a FTIR (Bruker V70 with a 0.16cm-1 resolution). This allows direct *in situ* measurement through the pellet under direct plasma exposure. The evolution of tholins are then followed by infrared absorption spectroscopy, in transmission through the pellet.

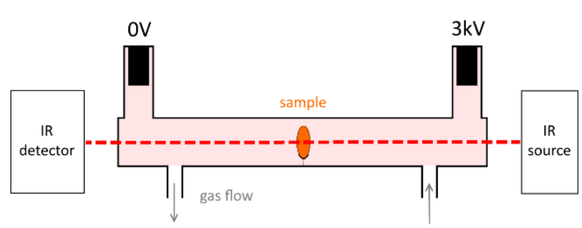

Figure 1: experimental setup

3. Results

3.1 Physical erosion

Pellets are quickly modified when the plasma is ignited. Plasma sputtering makes them whiter, rougher and eroded on the sides.

SEM pictures confirm the preferential erosion of organic material and the global formation of rough structures at the surface

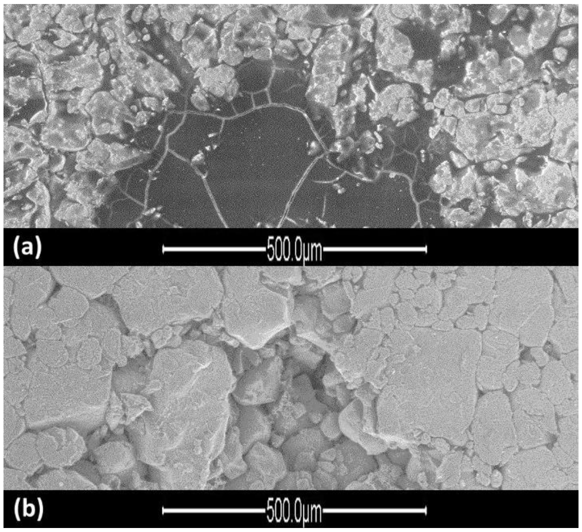

Figure 2: (a) Pellet with 1.5% of tholins in KBr. (b) Same pellet after 4h exposure to plasma at 3torr.

In addition, absolute IR absorbance of eroded pellets attests the loss of absorbing matter and the augmentation of diffusion with roughness.

3.2 Chemical modifications

After normalizing IR absorption bands to remove the effects due to physical erosion, we can notice some distortions in the spectra during plasma exposure.

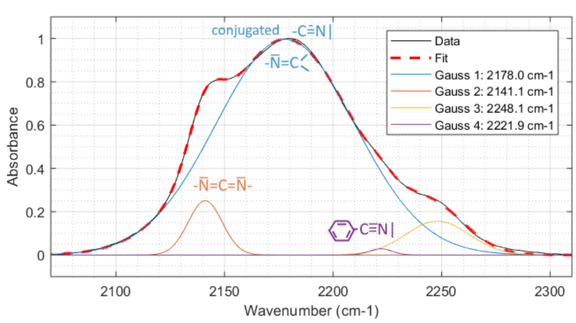

Figure 3: Deconvolution in Gaussians of the nitrile band before exposure

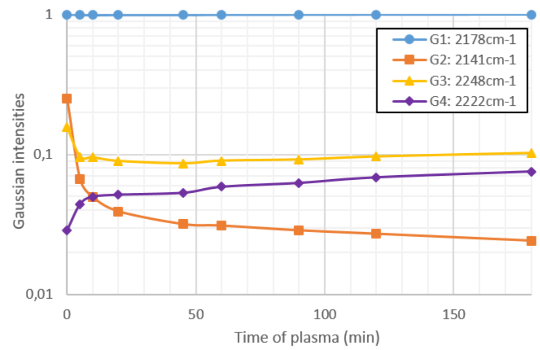

Figure 4: Evolution of Gaussian's amplitudes during exposure

4. Perspectives

Tholins are chemically changed by N_2-H_2 plasma conditions. The next logical step is to modify plasma parameters to understand the role of each species (electrons, ions, radicals…) in the evolutions seen.

Acknowledgements

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