

Compared chemical compositions of grains and thin films produced in a CCP plasma

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Two sorts of solid organic samples are produced in a N₂-CH₄ CCP discharge: grains in the volume and thin films deposited on solid substrates on the grounded electrode in order to simulate Titan's atmospheric aerosols.

The aim here is to address if these two sorts of analogues are chemically equivalent or not. The chemical compositions of these both materials are measured by using elemental analysis, XPS analysis and Secondary Ion Mass Spectrometry. The main parameter probed is the CH₄/N₂ ratio to explore various possible chemical regimes. We find that films are homogeneous but significantly less rich in nitrogen and hydrogen than grains produced in the same experimental conditions.

1. Introduction

Since the Cassini space mission measurements in Titan's atmosphere, organic aerosols are known to be present and formed at high altitudes in the diluted and partially ionized medium that is Titan's ionosphere [1]. This unexpected chemistry can be further investigated in the laboratory with plasma experiments simulating the complex ion-neutral chemistry starting from N₂-CH₄ [2].

Two sorts of solid organic samples are produced in Capacitively Coupled Plasmas simulating Titan's atmospheric reactivity: grains in the volume and thin films on the grounded electrode. We expect that grains are more representative of Titan's atmospheric aerosols, but films can be used to provide optical properties in the IR and visible ranges who can be compared with Titan's in situ measurements.

The aim of the present study is to address if these two sorts of analogues are chemically equivalent or not, when produced in the same N₂-CH₄ plasma discharge.

2. Results

The chemical compositions of both these materials are measured by using elemental analysis, XPS analysis and Secondary Ion Mass Spectrometry.

Four experimental conditions are chosen in the plasma discharge to mimick the variability of atmospheric composition with altitude: 1, 2, 5 and 10% of CH₄-N₂ gas mixture (diluted in Nitrogen). The effect of the substrate is also studied, using both SiO₂ and CaF₂ substrates.

Table 1: Elemental analysis of both thin films and grains.

Samples	Thin films		Grains	
	N/C (XPS)	H/C (SIMS)	N/C	H/C
1%	0.4	~0.1	0.9	1.1
2%	0.3	~0.1	0.8	1.1
5%	0.2	~0.1	0.6	1.2
10%	0.1	~0.1	0.4	1.4

We find that films are homogeneous but significantly less rich in nitrogen and hydrogen than grains produced in the same experimental conditions. This difference in their chemical compositions is explained by the efficient etching occurring on the films, which stay in the discharge during the whole plasma duration, whereas the grains are ejected after a few minutes [3].

3- Conclusion.

The difference observed in the chemical composition of grains and films are due to differences in their production processes to be further studied.

4. References

- [1] Waite et al. (2009) Science, 316, p. 870
- [2] Alcouffe et al. (2010) PSST, 19, 015008
- [3] Carrasco et al. (2016) PSS, 128, p. 52