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Chemical composition of Pluto's aerosols analogues

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Abstract

The discovery of haze in Pluto's atmosphere on July 14th, 2015, has raised lots of questions. To help understand the data provided by the *New Horizons* spacecraft, Pluto's aerosols analogues were synthetized and their chemical composition was determined by high-resolution mass spectrometry (Orbitrap technique).

1. Introduction

On July 14th, 2015, when Pluto was flown by the *New Horizons* spacecraft, aerosols were detected in its atmosphere, mainly composed of molecular nitrogen N_2, methane CH_4, with around 500 ppm of carbon monoxide CO [1,2,3]. These aerosols aggregate into several thin haze layers that extend at more than 350 km of altitude [4,5]. These aerosols may impact Pluto's atmospheric chemistry and climate [6,7]. To support these ideas, we have produced Pluto's aerosols analogues and analyzed their chemical composition by high-resolution mass spectrometry (ESI/Orbitrap technique).

2. Experimental setup

2.1. Pluto's aerosols analogues synthesis

We used the PAMPRE experiment [8] (LATMOS, France) to synthetize Pluto's aerosols analogues. PAMPRE is a Radio-Frequency Capacitively Coupled Plasma generated in a gas mixture representative of Pluto's atmosphere. For this study, the gas mixture was composed of variable proportions of molecular nitrogen and methane, with 500 ppm of carbon monoxide [2,3], at a pressure of 0.9 ± 0.1 mbar and at ambient temperature. Two types of analogues were produced (see Table 1).

Table 1: Types of Pluto's aerosols analogues produced with the PAMPRE experiment.

Composition of the gas mixture	Corresponding altitude on Pluto [2]
99% N_2 : 1% CH_4 : 500 ppm CO	400 km
95% N_2 : 5% CH_4 : 500 ppm CO	600 km

2.2. High-resolution mass spectrometry (HRMS) study

We analyzed the soluble fraction of Pluto's aerosols analogues, dissolved in a 50:50 (v/v)% methanol:acetonitrile mixture. The analytical instrument used was the LTQ Orbitrap XL (*ThermoFisher Scientific*). The ionization source was the ElectroSpray Ionization (ESI), in positive mode. The mass analyzer was the Orbitrap.

3. Chemical composition of Pluto's aerosols analogues inferred from ESI/Orbitrap analysis

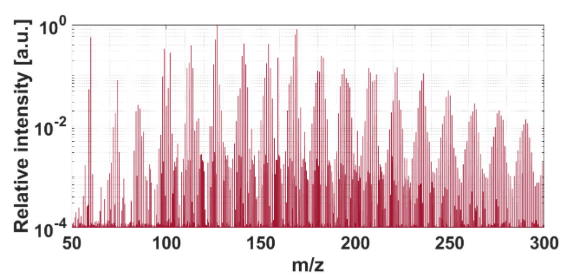

Figure 1: ESI+/Orbitrap mass spectrum of the soluble fraction of Pluto's aerosols analogues.

Our HRMS study has evidenced: (1) the molecules constituting Pluto's aerosols analogues are composed of a repetition of a co-polymeric $(CH_2)_m(HCN)_n$ pattern ; (2) nitrogen atoms are an important constituent of these molecules ; (3) oxygenated molecules represent a significant proportion of this complex molecules mixture ; (4) the CH_4 mixing ratio, and so the altitude of the aerosols formation, has an impact on the reactivity between N_2, CH_4 and CO, and especially a higher CH_4 mixing ratio results in a boosted incorporation of oxygen atoms in the molecules constituting Pluto's aerosols analogues.

4. Discussion and Conclusion

In our analogues, heavy unsaturated molecules have been detected. These molecules, likely very reactive, may interact with gaseous molecules and serve as condensation nuclei for clouds [6], impacting Pluto's climate. From *New Horizons* image dataset, seven Pluto's clouds candidates have been identified. These clouds could be due to the condensation of HCN, C_2H_2, C_2H_6, C_2H_4 or CH_4 [9]. The study of the interactions between our analogues and the previously mentioned gas molecules is needed to further refine Pluto's atmospheric models.

The presence of O-bearing molecules in our analogues being significant, we can hypothesize that Pluto's oxidized aerosols may influence Pluto's atmospheric thermal profile, by absorbing longer ultraviolet wavelengths [10]. This kind of radiative cooling may explain that Pluto's atmosphere, at about 400 km of altitude, is around 30 K colder than theoretically predicted [4,7]. Experimental study on the aerosols optical indices is of high need.

Acknowledgements

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