

## Numerical study of Titan's atmosphere using a N<sub>2</sub>-CH<sub>4</sub> post-discharge

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Gas discharges (cold plasmas) in N<sub>2</sub>-CH<sub>4</sub> mixtures are recognized to be an important tool in laboratory simulation of Titan's atmosphere [1-3]. However, in these systems the electrons play a central role in determining the overall heavy species abundance, which is not the case of Titan's stratosphere and troposphere, where the electrons play only a minor role. Moreover, the typical temperature values in gas discharges have the order of 500-1000 K, whereas in the case of Titan's atmosphere the temperature is extremely lower.

The aim of this work is hence to present results from a numerical simulation realized in a common configuration set-up in the domain of low-temperature plasmas, in which the main active species produced in a flowing N<sub>2</sub>-CH<sub>4</sub> discharge enter in a downstream afterglow region, i.e. into a post-discharge, where the contribution of electron processes is negligibly small and the temperatures are close to the room temperature or even lower if specific care is taken into account (e.g. using liquid nitrogen).

Within this purpose, we have developed a kinetic model to describe the post-discharge of a microwave discharge at 2.45 GHz, in a N<sub>2</sub>-2%CH<sub>4</sub> mixture, for a wide range of pressures from 1 to 200 mbar, which are the conditions observed in Titan's stratosphere and troposphere at altitudes 180-35 km. Further, lower gas temperatures equal to 300 K and 150 K have been considered in the post-discharge. The model solves a time-dependent system of kinetic master equations for the most important heavy species produced in a N<sub>2</sub>-CH<sub>4</sub> mixture, using as initial conditions the results obtained in the discharge.

In order to simulate Titan's atmosphere, we have determined the concentrations of the

most populated species originating from methane dissociation, such as  $C_2H_2$ ,  $C_2H_4$ ,  $C_2H_6$ ,  $C_3H_4$  and  $C_3H_8$ , as well as other species produced in reactions with  $N_2$ , namely HCN,  $H_2CN$ ,  $C_2N_2$  and  $HC_3N$ . We have also determined the concentrations of  $N_2(B)$ ,  $N_2^+(B)$ ,  $CN(A)$  and  $CN(B)$ , which correspond to upper states of important radiative transitions observed in  $N_2-CH_4$  mixtures.

Our calculations show that HCN,  $HC_3N$  and  $C_2N_2$  are the most abundant nitriles, as also obtained in other Titan's atmosphere models [4,5], measurements from Voyager [6,7] and, more recently, from Cassini spacecraft [8]. In what concerns the species produced from methane decomposition, we obtain relevant abundances of  $C_2H_4$ ,  $C_2H_6$  and  $C_3H_4$ , but our model fails to predict the important concentrations usually measured for acetylene. In spite of this failure, our model allows to investigate the interplay mechanisms for production and destruction of the various species along the post-discharge for different values of pressure and two gas temperatures.

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