PTR-TOF analyzis of glow discharge products in Titan related atmosphere

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The glow discharge at atmospheric pressure was generated in the nitrogen-methane (1 to 5 %) gaseous mixtures related to the Titan's atmosphere. The discharge itself was monitored by optical emission spectrometry that confirmed presence of active nitrogen species and various radicals formed from methane. Besides them, the CN spectral bands were observed. Intensities of all light emitting species were studied in the dependence on applied power and composition of nitrogen-methane mixture. The stable discharge products were analysed by proton transfer time of flight mass spectrometry of the exhausting gas. Presence of huge number of amino and cyano compounds was confirmed as well as aliphatic and some aromatic hydrocarbons. Their relative concentrations were determined under the same conditions as optical emission spectra were collected.

1. Introduction

The laboratory studies of chemical processes initiated by electrical discharges in extra-terrestrial planetary atmosphere's gaseous mixtures started to be important during last years because of observing many exoplanets and search of potential exo-biology or even exo-life. The most studied exo-atmosphere is Titan's one because it was proposed that current Titan's atmosphere is similar \as Earth atmosphere before life formation.

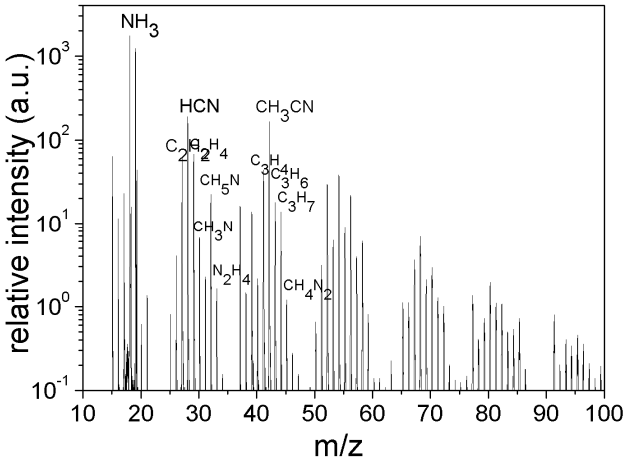
2. Experimental

The atmospheric pressure DC glow discharge at energy of up to 50 W was created between stainless steel electrodes in pure nitrogen containing 1-5 % of methane. The flow rate of gaseous mixture was fixed at 100 Sccm. Whole system was evacuated before measurement by rotary oil pump to minimize the gaseous mixture contamination by oxygen. The optical emission spectra of discharge were collected using Jobin Yvon TRIAX 550 spectrometer with CCD detector. The exhaust gas was analysed using proton transfer time of flight mass spectrometry allowing simultaneous detection of many stable discharge products without fragmentation.

3. Results

The nitrogen molecular second positive and first negative bands and CN violet CN bands were determined as the most intense in the discharge emission spectra. The hydrogen lines and C_2 Swan molecular bands were determined, too. Using these spectra, the rotational temperature of about 2000 K was calculated. This temperature is nearly independent on the applied power and slightly increases with the increase of the methane content in the gaseous mixture. The vibrational temperature obtained from neutral nitrogen molecule is also not dependent on the applied power but it increases nearly directly proportionally from 300 K (at 1% of methane) to 3600 K (at 5% of methane). In the contrary, vibrational temperatures obtained from nitrogen molecular ion and CN showed the same trend: temperature is decreasing with the increase of nitrogen in the gaseous mixture and they are increasing directly proportionally with applied discharge power. Both of them are significantly higher (up to 5700 K) than was calculated for neutral nitrogen.

An example of PTR-TOF spectrum is given on Fig. 1 there the main determined compounds are marked. Totally, 32 compounds were identified and their relative intensities were studied under the same conditions as were used for the OES measurements.



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