Influence of water vapor on electrical discharge-initiated processes in prebiotic atmospheres

M. Moravčík, F. Krčma

Brno university of technology, faculty of chemistry, institute of physical and applied chemistry, Brno, Czech Republic

The aim of the presented work is study of chemical process in extraterrestrial atmosphere and the synthesis of organic compounds formed in electrical discharges in gaseous mixtures at the atmospheric pressure and ambient temperature in the flowing regime. This study focuses on the influence of water molecules on chemical processes initiated by electrical discharges in probiotic atmospheres. This work is focused on the simulation of nitrogen-methane atmosphere and carbon dioxide atmosphere. These gases were chosen because they represent the main components of some known extraterrestrial atmospheres. The atmosphere of Titan, second largest moon of solar system, was mimicked by the gaseous mixture of methane (2-4 sccm) in 200 sccm of nitrogen. The second studied atmosphere was atmosphere of Mars that is based on the carbon dioxide. It was further enriched by small addition of nitrogen (2- 4 sccm) in 200 sccm of carbon dioxide. Water vapor with a flow rate of 0, 5,10, 15 and 20 sccm was gradually introduced into every gaseous mixture. A DC glow discharge was generated in a special reactor at atmospheric pressure [1].

The discharge formed products were analysed *in situ* using proton ionization mass spectrometry with a time-of-flight analyser. Huge number of simple aliphatic hydrocarbons, alcohols, aldehydes, and ketones was successfully identified. With increasing number of additives, more complex mainly aromatic substances were also formed as it can be seen in Figs. 1 and 2. In case of nitrogenous gaseous mixture, the most dominant detected gas products were ammonia, followed by hydrogen cyanide and acetonitrile. In case of carbon dioxide gaseous mixture, the most dominant detected species were ammonia or methanimine, with other additives high presents was confirmed for hydrogen cyanide or acetonitrile. Water and water dimer at molecular mass 37 are contamination, that were present in pure CO_2.

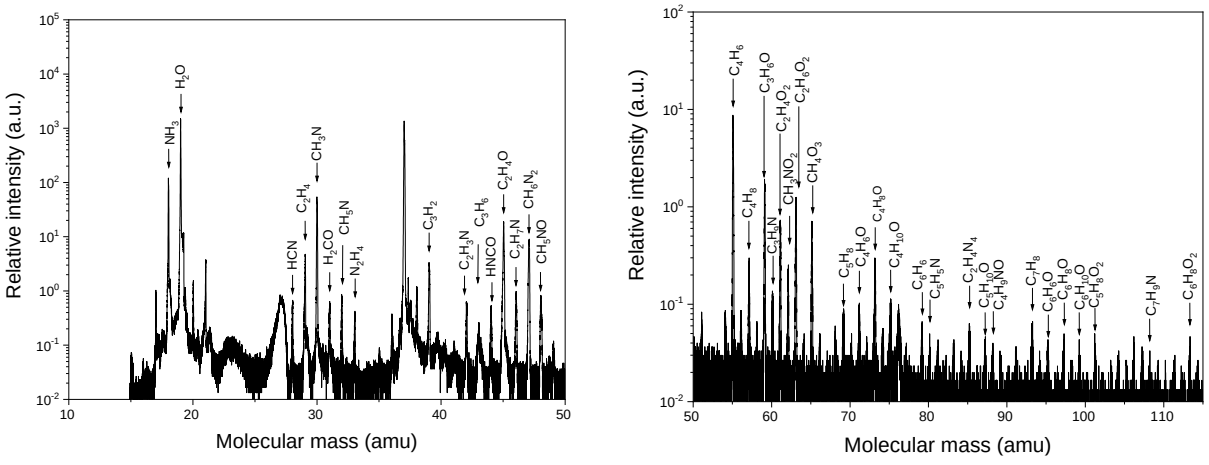

Fig. 1: The identified PTR-TOF mass spectrum of gaseous product in the discharge at nitrogen flow 4 sccm and water vapor flow 20 sccm in 200 sccm of carbon dioxide.

Simultaneously with PTR-TOF spectra acquisition, plasma diagnostics was carried out using optical emission spectroscopy. The lines of C and O together with CO Angstrom bands were identified in the pure CO_2, Hydrogen lines and bands of N_2, CN, CH and OH were identified with all admixtures. All

these groups were also presented in the compounds identified by PTR-TOF. Their changes in intensity were corresponding to the intensities of the mass spectrometry determined species.

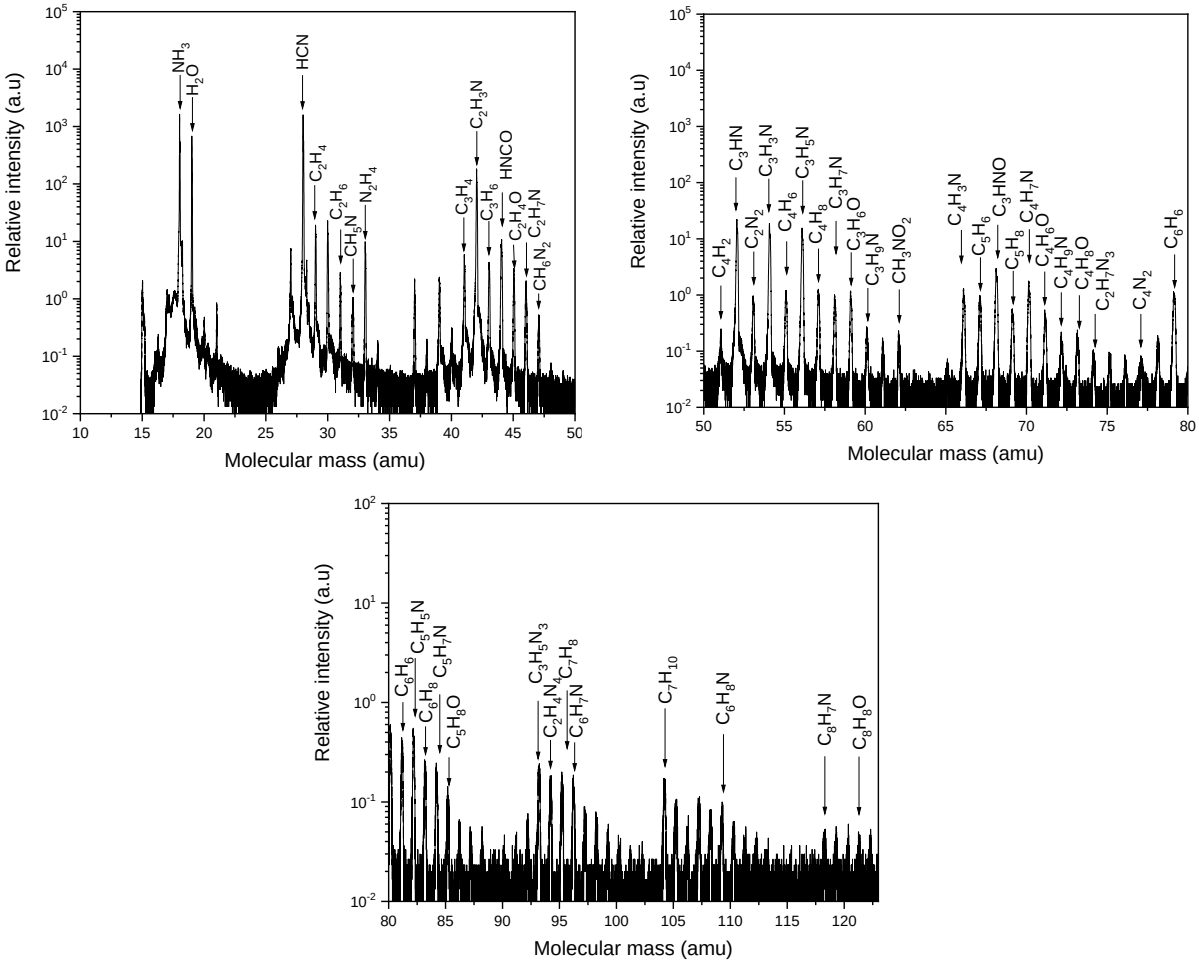

Fig. 2: The identified PTR-TOF mass spectrum of gaseous product in the discharge at methane flow 4 sccm and water vapor flow 20 sccm in 200 sccm of nitrogen.

In case of nitrogen-based mixture, the most dominant detected gas products were ammonia, followed by hydrogen cyanide, acetonitrile [2]. Significant increase of oxygen containing compounds was observed if water was added. One of the most important compounds formed is such case was formamide that is known as a precursor of uracil formation. This molecule is one of the nuclear acids bases. The OES spectra confirmed presence of C and H lines and CN, CH, NH, C_2 and N_2 spectral bands, if water was added also oxygen lines and OH bands were detected.

The substances detected in this work agree with the available literature and also with substances detected *in situ* in Mars's and Titan's atmospheres.

References

[1] S. Chudják, Z. Kozáková, F. Krčma, *ACS Earth Space Chem.,* **5** (2021) 535-543

[2] S. Chudják, Thesis, FCH BUT 2023