Influence of discharge kind on processes in Titan like atmosphere

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The aim of the presented work is the comparison of chemical processes initiated by different discharges (glow and spark) in the same gaseous mixtures at fixed geometric conditions. The nitrogen-methane gaseous mixture at atmospheric pressure was used at different methane concentration (0–2 %). The specially designed stainless-steel reactor [1, 2] operating in the flowing regime (200 Sccm of nitrogen) allowed simultaneous measurements of emission spectra emitted by the discharge and *in situ* acquisition of proton transfer reaction time of flight mass spectra of discharge products. The electrode system consisted of two stainless steel hemispheric electrodes (diameter of 10 mm) with the interelectrode distance of 1 mm. The DC and audiofrequency (10 kHz, rectangular pulses) power supplies were used for the discharge generation at similar applied energies. All arrangements were kept exactly the same for both discharges to be able fully compare discharge conditions as well as discharge produced compounds. Experiments were done in two series, for each power supply separately. The whole system was purged by nitrogen flow of 30 Sccm overnight to obtain oxygen free conditions (like in the Titan atmosphere). The background PTR-TOF spectrum was collected for 1 minute in pure nitrogen without the discharge. After that, the discharge was ignited and stabilized for 20 minutes. Then OES spectra of selected species (CN, N_2, N_2^+, C_2, H) were collected and simultaneously, the average PTR-TOF spectrum was evaluated for 5 minutes. The same cycle was repeated for added methane flows of 1, 2, 3, and 4 Sccm. Finally, the discharge was stopped and the whole reactor was cleaned by the pure nitrogen flow of 200 Sccm for 8 hours to remove all generated species.

The optical emission spectra showed huge difference between the used discharges. The main difference was that the emission of iron lines was observed in case of the pulsed AC discharge while nearly no emission of the C_2 Swan system was visible. Further, the CN systems emission was much weaker in this case (see Fig. 1-left) and its intensity was decreasing with the methane presence increase (in contrary to the DC discharge). On the other hand, a strong H-alpha line broadening was observed (see Fig. 1-right).

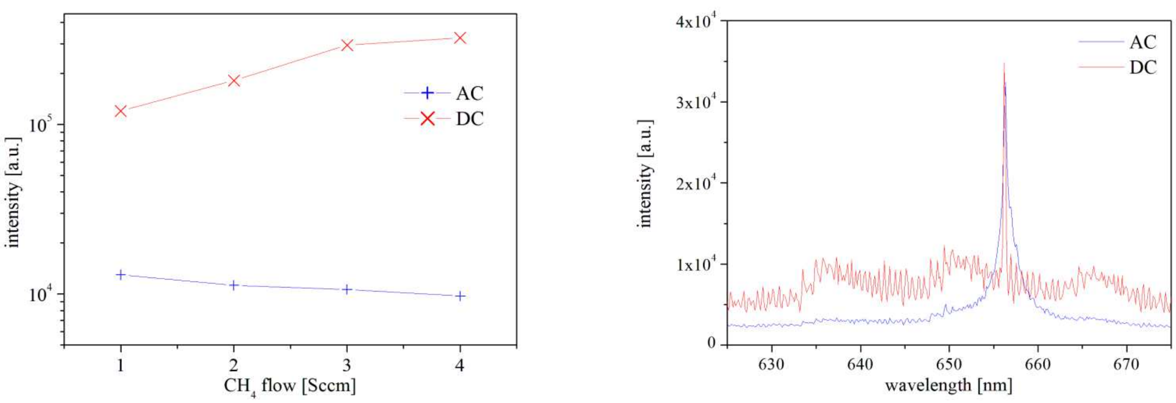

Fig. 1: Comparison of CN violet 0-1 band head intensity in both discharges (left); H-alpha line profile and CN red system emission in both discharges at methane flow of 4 Sccm (right, DC intensity was divided by factor 5).

The nitrogen second positive system intensity was the same in pure nitrogen, but it was increasing in DC and decreasing in the AC discharge. Hydrogen emission was increasing in both discharges, but its dependence on the methane concentration was much sensitive in the DC discharge.

Similar compounds with masses up to about 150 amu were formed by both discharges and majority of them has been already identified recently [1, 2]. In general, much higher products concentrations were observed in case of the DC discharge. Examples of obtained concentrations are shown in Fig. 2. It is necessary to note, that concentrations in the DC discharge with the higher methane addition were underestimated because the ionization precursor (H_3O^+) was consumed too much by the discharge products.

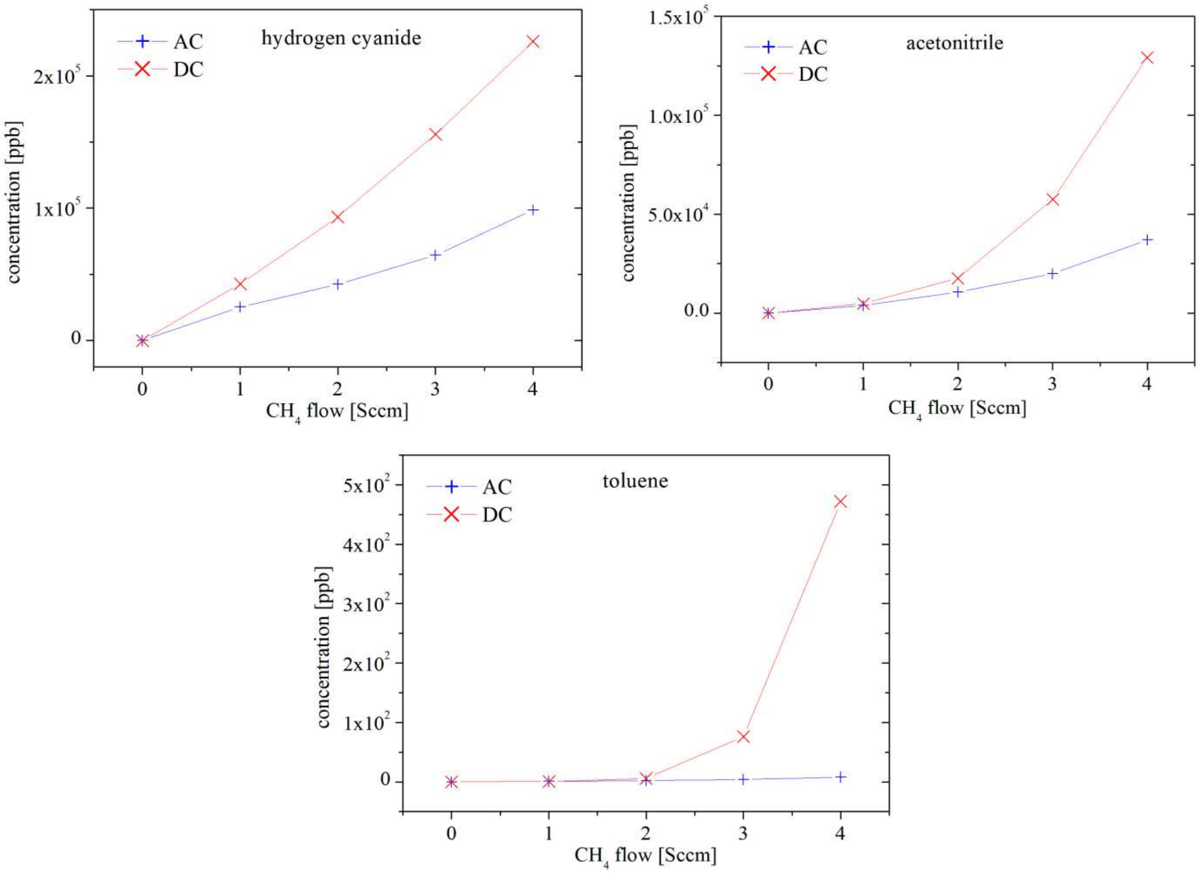

Fig. 2: Concentrations of selected compounds in dependence on methane addition in both discharges.

The presented results show a strong dependence of the synthetic processes in the Titan like atmosphere on the discharge kind. Next experiments will be focused on the DBD discharge under the same conditions; however, a modified electrode geometry will be used because the same geometry will be impossible to keep.

References

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

[2] S. Chudják, Thesis, FCH BUT 2023