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Spectroscopic Study of the Decomposition Processes of Acetylene in the DC and Middle Frequency Nitrogen Plasmas

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The acetylene (C_2H_2) – nitrogen (N_2) low pressure plasmas were frequently applied to deposit the carbon nitride (CN:H) thin layers by the PACVD methods. Here, optical emission spectroscopy (OES) and actinometry techniques were employed to study the direct current (dc) and middle frequency (100 kHz) glow discharges, generated in the C_2H_2-N_2 mixture. The spectral diagnostics of generated glow discharges as well as the decomposition processes of acetylene were examined. Both plasmas were excited between two circular plane Armco - steel electrodes in a Pyrex glass chamber. High energy species, including CN, CH, H, C, N_2^+, N_2, N, were identified in plasma phase. The emission intensities of main species were measured versus various experimental parameters. Optical actinometry technique was applied to evaluate the relative concentrations of the species in the reactive mixture. The effect of pressure and working gas composition on the plasma processes were investigated.

The spatial distributions of the emission intensities of the species between two electrodes in the both glow discharges were recorded. The excitation, vibrational and rotational temperatures were determined to compare excitation conditions in the examined plasmas. Plasma processes and plasma non-equilibrium phenomena were discussed. Additionally, the FTIR and X-ray powder diffraction techniques were employed to analyze the structure of solid materials, resulted from the decomposition of acetylene in the nitrogen plasma.

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Transient Spark in $N_2/CO_2/H_2O/CH_4$ Mixtures at Atmospheric Pressure

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We have investigated a novel type of streamer-to-spark transition discharge named the transient spark (TS), operating above the liquid water in $N_2/CO_2/H_2O$ and $N_2/CO_2/H_2O/CH_4$ mixtures at atmospheric pressure. Although the applied voltage is DC, TS has a pulsed character with very short (~100 ns) high current (~1 A) pulses, with repetitive frequencies of some kHz. Thanks to the very short spark pulse duration, given by the small internal capacitance of the discharge system and the limiting series resistor, the plasma cannot reach LTE conditions.

The electrical and optical properties of TS were studied as functions of the frequency and the gas composition by electric measurements and optical emission spectroscopy. Infrared Absorption Spectroscopy was used to analyse gas samples, and solid deposits from

electrodes. Liquid samples were analysed by High Performance Liquid Chromatography (HPLC) and Proton-Transfer-Reaction Mass Spectrometry (PTR-MS).

The emission of N_2 2^{nd} and 1^{st} positive, N_2^+ 1^{st} negative, CN violet and red, OH (A-X) and NH (A-X) systems, as well as atomic N, O, H, and C lines was detected. The non-equilibrium character of TS was confirmed by comparisons with calculated vibrational (3000-4000 K) and rotational (500-1500 K) temperatures.

In $N_2/CO_2/H_2O$ mixtures, the most remarkable changes in the chemical composition of the treated gas were the decomposition of CO_2 and the production of CO as the main intermediate product. The production of CO was most probably crucial for the synthesis of organic species detected by PTR-MS and HPLC in the liquid samples.

In $N_2/CO_2/H_2O/CH_4$ mixtures, the CH_4 was quickly converted partially to various organic species, CO and CO_2. The amount of CO_2 increased with increasing input energy density. The production of organic species resulting from the partial oxidation of CH_4 was confirmed by all applied techniques.

These obtained results may help us gain a better understanding of the plasma chemistry induced by TS leading to the decomposition of CH_4 and other organic species (syn-gas production from $N_2/CO_2/H_2O/CH_4$ mixture or from real exhaust gases), as well as of the synthesis of organic species from inorganic $N_2/CO_2/H_2O$ mixtures. Formation of organic species in a completely inorganic $N_2/CO_2/H_2O$ atmosphere is a significant finding for the theory of the origins of life.

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Numerical Modelling of Dielectric Barrier Discharge in Nitrogen with Hydrogen Admixture

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Non-thermal discharge plasma at atmospheric pressure is widely used in multiple technological applications. The numerical modelling has very important role in understanding of the physical background of experiments. Numerical calculations of characteristics of the homogeneous dielectric barrier discharge in nitrogen at atmospheric pressure between parallel-plate electrodes were performed by means of one-dimensional fluid model. The hydrodynamic set of equations was solved using the fractional-step method. The modified second-order total variation diminishing scheme was used for treating of advection term. This algorithm allows the simulation with high gradient of particle density in reasonable time and it is easy to convert the algorithm to two-dimensional model.

The development of external quantities (i.e. external current, gap voltage) during the discharge is shown. The simulated data for ignition voltage are in very good agreement with measured data. Our simulations also give a qualitative explanation for discharge current profiles in pure nitrogen and in nitrogen with small admixture of hydrogen, however the