

EuropaNet TNA Report

PROJECT LEADER

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Date of TNA visit:	15.06. – 15.08.2011
No. of days:	10
Host laboratory:	Department of Physics and Astronomy, The Open University, Walton Hall, MK7 6AA, Milton Keynes, United Kingdom
Reimbursed	Yes

Project Title – Physics and chemistry induced by N₂-CH₄ plasma discharges – similarities between discharges and Titan's atmosphere chemistry

Scientific Report Summary.

(plain text, no figures, maximum 250 words, to be included in database)

During the scientific mission a point-to-plane corona discharge fed by CH₄-N₂-CO₂ gas mixtures has been studied using Fourier Transform Infrared (FTIR) and Optical Emission Spectroscopy (OES). Experiments have been carried out in flowing regimes (25-50 sccm) at pressure 1.1 bar for wide range of discharge power. Energy balance was also estimated from Current-Voltage characteristics measured in the electrical circuit. Spectra showed that even a small admixture of CO₂ can change the electrochemistry of a CH₄-N₂ plasma, since beyond the dominant products such HCN, C₂H₂ and NH₃ a significant O-containing products were also formed in the discharge like CO and H₂O. These molecules have astrobiological importance for studies of Titan's atmosphere, because they provide explanations for synthesis of organic blocks needed for a formation of primitive life in planetary bodies.

Full Scientific Report on the outcome of your TNA visit

Approx. 1 page

Our scientific mission was focused on the chemical processes in negative point-to-plane corona discharge fed by various mixtures of CH₄, N₂ and CO₂. The point electrode was made of stainless steel and the plane electrode was made of a brass mesh. The distance between the electrodes was set to 5 mm. The study was carried out in two waves. In the first, the discharge was fed by different CH₄-N₂ gas mixtures (2, 3 and 4 % of CH₄), while in the second branch CO₂ was added to the CH₄-N₂ mixture (0,2 and 1%) . Experiments have been performed for wide range of discharge powers in flowing regimes (25-50 sccm) and at pressure of 1.1 bar.

For regulation of discharge current a 5 MΩ resistor was connected to the electrical circuit. Voltage was varied between 4 and 6,5 kV, by 0,5 kV steps. Above 7 kV corona was transferred to spark discharge. Energy balance was also estimated and plotted from Current-Voltage characteristics measured in the electrical circuit. With addition of 2% CH₄ in pure nitrogen the discharge current was reduced significantly. The same phenomenon happened in case of additional CO₂ to the CH₄-N₂ mixture which is explained by the presence of primary and generated electronegative species like HCN, CH₄ and CO₂.

Study of discharge products have been carried out using Fourier Transform Infrared (FTIR) and Optical Emission Spectroscopy (OES). The FTIR spectra recorded ex-situ in CH₄-N₂ discharge confirmed that increase in voltage and initial CH₄ content caused increase in concentration of detected dominant products (HCN, C₂H₂, NH₃ and C₂H₆). With addition of CO₂ to the CH₄-N₂ mixture, CO and H₂O appeared as new major products. Primary process of CO formation is the CO₂ dissociation that can be caused by electrons or/and excited nitrogen species. However, H₂O formation is a secondary step-wise reaction which depends on the density of atomic oxygen coming from CO₂ dissociation. Based on the experimental results a simplified empirical reaction model responsible for CO and H₂O formation was also suggested. Detection and analysis of minor trace products will be a subject of a future visit.

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Please include:

- Publications arising/planned (include conference abstracts etc)

- Oral presentation and abstract with title “*H₂O synthesis in CH₄-N₂-CO₂ discharges – Water formation in Titan’s atmosphere?*” - COST CM0805 meeting in Malta 2011 October

- Poster presentation at EPSC meeting in Nantes 2011 – “*Plasmas and Titan's atmosphere*”

- Host approval The host is required to approve the report agreeing it is an accurate account of the research performed.