Europlanet TNA Report

PROJECT LEADER

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Date of TNA visit:	25.5.2011-29.6.2011 And 7.9.2011-12.10.2011
No. of days:	10
Host laboratory:	Department of Physical Sciences The Open University Walton Hall Milton Keynes MK7 6AA United Kingdom
Reimbursed	Yes

Project Title – **SIMULATING TITAN`S ATMOSPHERE USING A NON-THERMAL PLASMA DISCHARGE**

Scientific Report Summary

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

During my visit at the Open University I performed at first Gas Chromatography with Mass Spectrometry analysis of products formed in methane-nitrogen-hydrogen gas mixtures from 1 up to 5% methane in nitrogen plus 1% hydrogen, with the gas flow rate of 100 and 200 sccm. The discharge current applied at the electrodes was set at constant value of 30 mA.

Second visit of mine was focused on experiments with different flow rates (50, 100, 150 and 200 sccm) in CH_4-N_2 gas mixtures and also in methane-nitrogen gas mixture plus 1% carbon dioxide. The discharge current applied at the electrodes were between 15 and 40 mA. The discharge gas products were analysed at the exhaust of the infrared cell with Fourier Transform Infrared spectrometry.

Full Scientific Report on the outcome of your TNA visit

Description of the work carried out during the visit

Gliding arc discharge

The trial visit was designed to perform the gliding arc discharge as a simulation of Titan's atmosphere. The main part of the project was focused on developing GC-MS analysis of the discharge gas products of the reactions between methane and nitrogen. The second part was orientated towards FTIR spectrometric analysis of the products of the reaction between methane and nitrogen gas. The gliding arc discharge reactor had the standard configuration, namely a pair of stainless steel holders was positioned parallel to the iron electrodes limiting the gas flow through the discharge zone. The electrical arc was gliding between the electrodes and expanded at the end of the electrodes. The discharge was powered by a homemade DC HV source. The GAD reactor was connected to an infrared gas cell equipped with KBr windows and placed in a Nicolet Nexus FTIR spectrometer. The simulated Titan like atmosphere was formed from a mixture of methane and nitrogen gas, the methane was varied from 1 to 5%. The measurements were carried out in a flow regime ranging between 100 and 200 sccm at atmospheric pressure and at room temperature. The total flow rate was regulated using MKS mass flow controllers.

Description of the main results obtained

A gas chromatography and mass spectrometry study of products formed in a gliding arc discharge fed by a varying mixture from 1 to 5% CH_4 in N_2 was carried out for various flow rates in the range 100 to 200 sccm, at atmospheric pressure and ambient temperature. The results from GC-MS analysis are shown in Figure 1. The major products identified in the GC-MS were: acetylene, hydrogen cyanide and acetonitrile. The FTIR detected ammonia but none was detected by GC-MS analysis, this may be due to the collecting method: in the case of FTIR measurements ammonia could be formed along the long pipe connecting the reactor with the FTIR cell, since ammonia formation is highly dependent on surface processes. However in the case of GC-MS analysis samples were taken directly from the reactor outlet. Minor products detected were: ethane, ethane, cyanogens, propene, propane, propyne, propadiene, butenyene, butadiene, butadiyne, acetonitrile, 2-propenenitrile and 2-propennitril, benzene and toluene. Many of these molecules have either been seen or speculated in Titan's atmosphere. The concentration of all compounds that were identified by GC-MS can be seen in Figure 2 a. and Figure 2 b. where the summed of hydrocarbons and nitrites increases for different concentrations of methane in nitrogen with 1% of hydrogen.

A FTIR spectrometric study of the products formed in the gliding arc discharge fed by a varying mixture of methane in nitrogen (1% of CH_4) was also carried out for various flow rates in a range from 50 to 200 sccm, at room temperature and atmospheric pressure. HCN was found to be the most abundant product at wavelength 1435 cm^{-1} (Figure 3). The other major products were NH_3 (966 cm^{-1}) and C_2H_2 (729 cm^{-1}). With the methane-nitrogen gas mixture with 1% of CO_2 were detected as products reaction carbon monoxide and water.

The product concentrations are strongly dependent on the compositions of the CH_4-N_2 and H_2 gas mixtures. Increasing the initial CH_4 content from 1 to 5% causes an increase in the total product yield. The dependence of product concentrations on the flow rate, and a gas mixture CH_4-N_2 plus H_2 give the same observed behaviour with respect to the major products, and

increases the concentration of lower hydrocarbons (C_2H_2, C_2H_4 and C_2H_6).

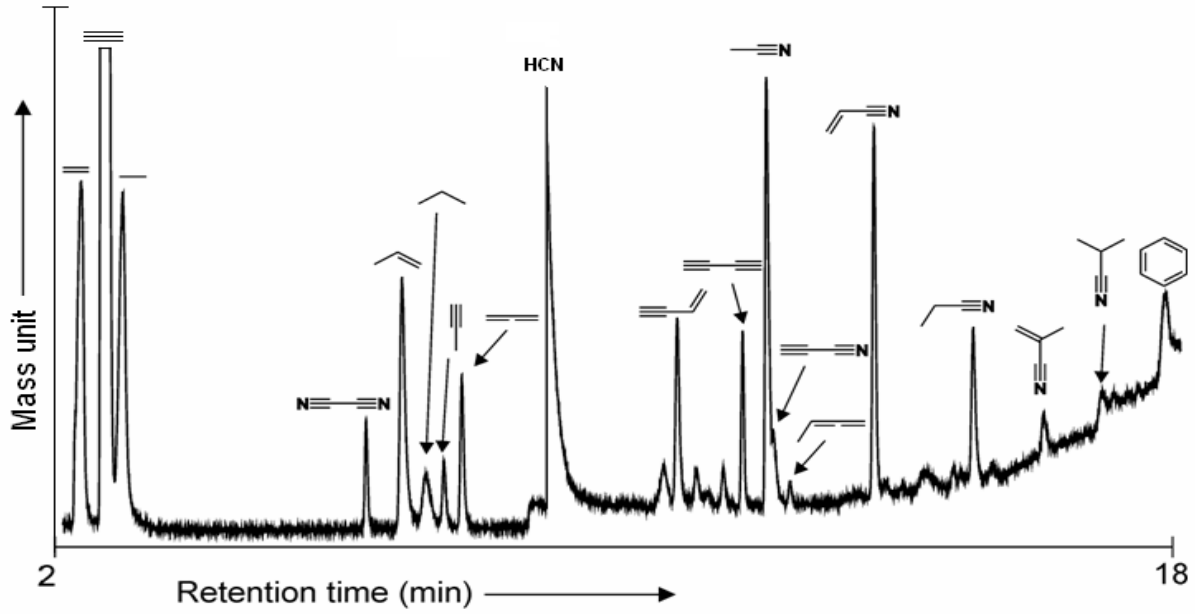

Figure 1. Sample chromatogram of analysed products formed in a gas mixture CH_4:N_2 = 2:98.

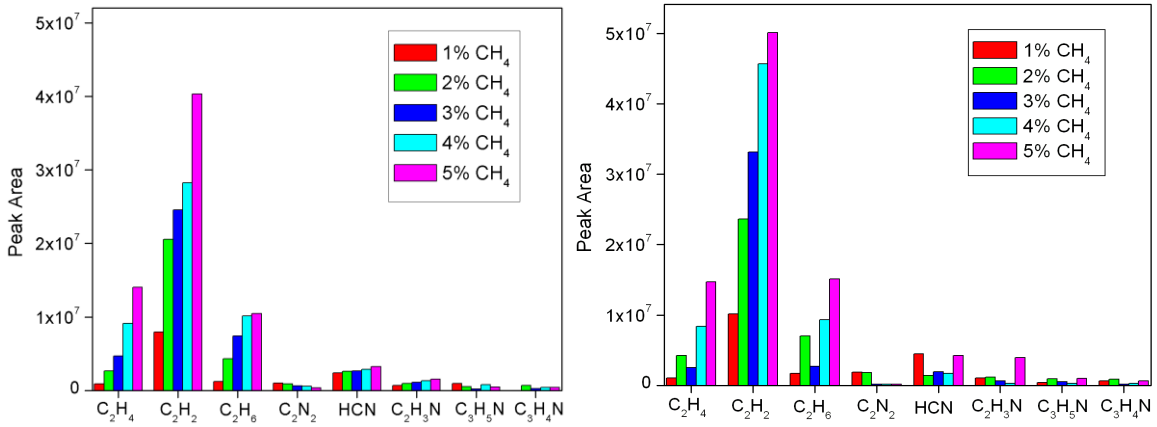

Figure 2a. and 2b. The dependence of product concentrations as a function of initial CH_4 concentrations **a**: 200 sccm flow rate and current 30 mA, **b**: 200 sccm flow rate and discharge current 30 mA, CH_4-N_2 gas mixture with 1% of hydrogen.

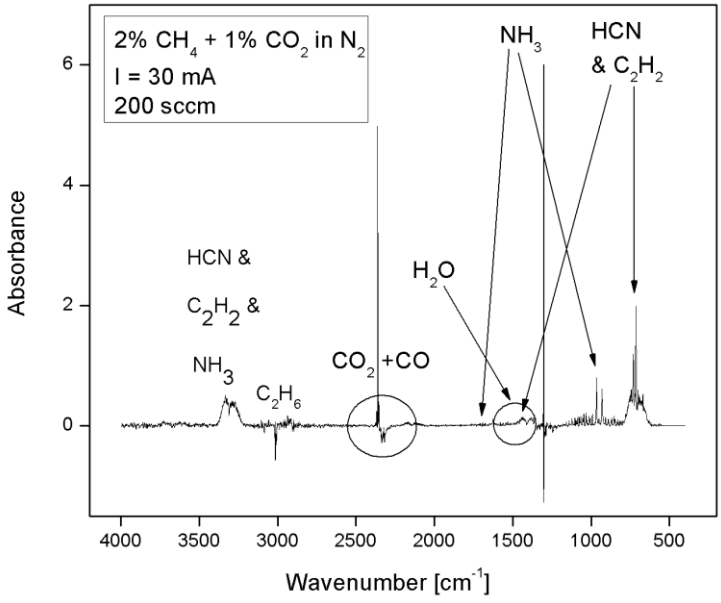

Figure 3. Sample spectrum of analysed products formed in a gas mixture 2% CH_4 + 1% CO_2 in N_2.

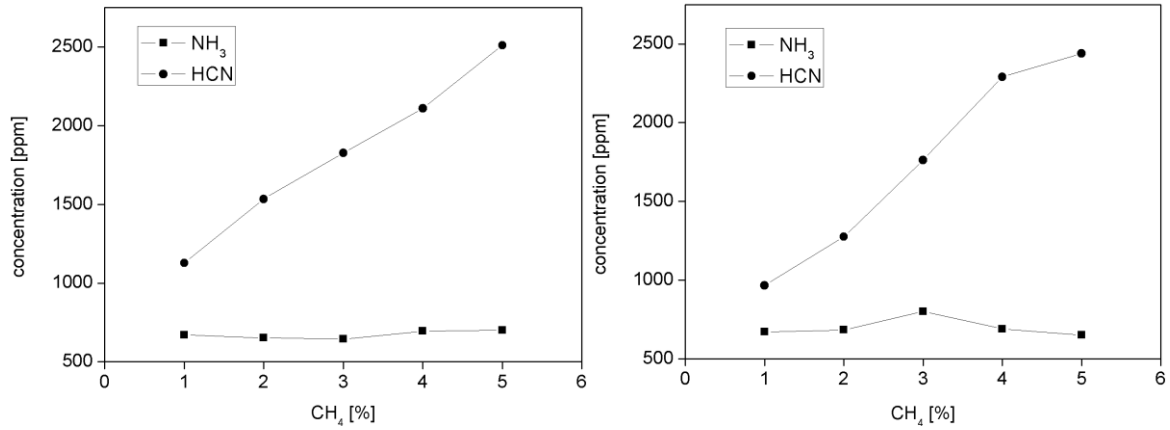

Figure 4a. and 4b. The dependence of products concentrations on initial CH_4 concentrations a: 200 sccm flow rate and discharge current 30 mA in N_2 plasma, and b: CH_4-N_2 gas mixture with 1% of hydrogen some experimental condition.

Please include:

- Publications arising/planned (include conference abstracts etc)

First results were published at The Chemical Cosmos conference being held in Malta.
Next results will be publish at The 18th Symposium on Atomic, Cluster and Surface Physics de l'Alpe d'Huez in France. The other results obtained in gliding arc discharge are planned to be published in PSST and EPJ-D journals.

- Host approval

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