Europlanet TNA Report

PROJECT LEADER

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Date of TNA visit:	10/09/12 -- 10/12/12
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No. of days stay:	90
Host laboratory:	Molecular Physics laboratory, Physics department of the Open University
Reimbursed	Yes

Project Title –

Electron irradiation of interstellar ice analogs

Scientific Report Summary.
(plain text, no figures, maximum 250 words, to be included in database)

The objectives of this project were to explore, experimentally in an ultra-high vacuum surface scattering machine, the fundamental mechanisms involved in the synthesis of a key class of astrobiologically important molecules formed by irradiation of low temperature Solar System analogue ices. In particular we explored irradiation of ices consisting of simple precursor molecules and identify the key reactions and precursors, which drive the formation of more complex prebiotic molecules in the InterStellar Medium (ISM).

We have performed electron irradiation experiments of pure CH3OH, CH3OH:NH3 (2:1), and H2O:CH3OH:NH3 (2:1:1), at 15 K under ultra-high vacuum conditions. The resultant molecular synthesis was probed *on line* using FTIR spectroscopy.

These results obtained in this set of experiments were directly compared with previous work performed by Dr Escobar using X-rays. Product yields were compared and reaction rates estimated for the two different types of radiation.

Full Scientific Report on the outcome of your TNA visit

Approx. 1 page

Pure CH_3OH electron irradiation:

The features corresponding to CH_3OH decrease during electron irradiation. After irradiation new absorption bands appear, being assigned to CO_2 (2342 cm^{-1}) , CO (2137 cm^{-1}), H_2CO (1720 cm^{-1}), and CH_4 (1303 cm^{-1}), which are common in UV and X-ray irradiation. Irradiation with 1000 eV electrons is more effective in CH_3OH destruction and products formation, mainly due by their higher penetrability in the ice. The CH_3OH destruction and formation of new products displayed a clear electron energy dependence. The formation rate of CO_2, CO, H_2CO, and CH_4 is similar for 300 and 550 eV electron irradiation, while the formation rate is significantly higher for 1000 eV electron irradiation. The formation rate of all products increased with irradiation time except for H_2CO which reached its maximum formation rate in a very early stage of irradiation. These e- irradiation results are in contrast to those obtained with X-ray irradiation where the most effective product yields were with the 550 eV photons. However, the CH_3OH destruction is comparable at the same fluence for electron and X-ray radiation.

Electron irradiation of CH_3OH:NH_3 ice mixture:

In Figure 1 are plotted the difference spectra of irradiated and not irradiated CH_3OH:NH_3 (2:1) ice mixture for different irradiation times for 1000 eV energy electrons. During irradiation we observed the growing of different features at 2341 cm^{-1} (CO_2), 2163 cm^{-1} (OCN^-), 2139 cm^{-1} (CO), 1721 cm^{-1} (H_2CO), 1692 cm^{-1} ($HCONH_2$), 1587 cm^{-1} ($HCOO^-$), 1501 cm^{-1} (HCOOH), 1381 cm^{-1} ($HCONH_2$), and 1303 cm^{-1} (CH_4), which are common in both UV and X-ray irradiation. Irradiation with 1000 eV electrons is more effective in processing the ice, as was observed in electron irradiation of pure CH_3OH.

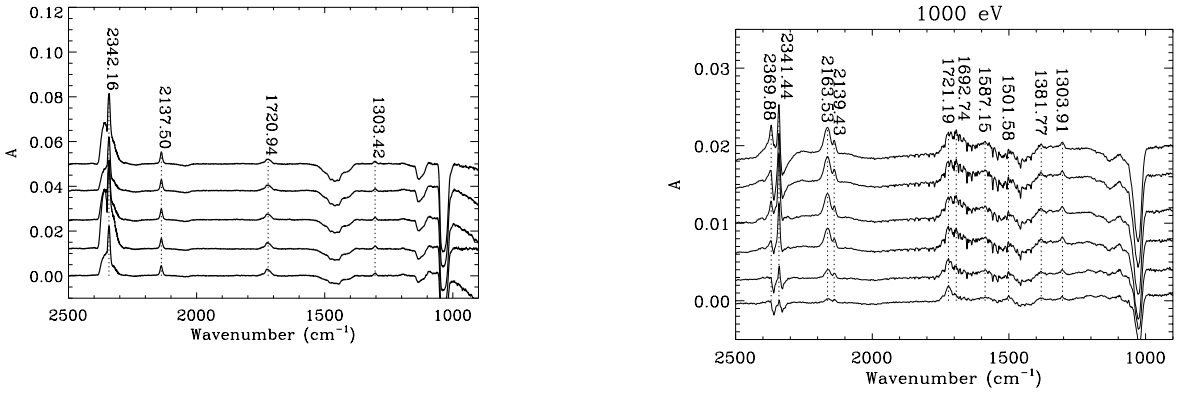


Figure 1. Infrared spectra of pure CH_3OH (Left) and CH_3OH:NH_3 (2:1) (Right) ice mixture at 1000 eV along irradiation.

The integrated area under the peaks of the CH_3OH, CO, OCN, H_2CO, and CH_4 was studied in this set of experiments to explore the formation of destruction of these compounds. The destruction rate of CH_3OH and the formation rate of CO, and OCN is similar for 300 and 550 eV electron irradiation, while the formation rate is significantly higher for 1000 eV e- irradiation.

Main conclusions.

Electron irradiation of pure CH_3OH and CH_3OH:NH_3 leads to the formation of the same irradiation products observed in X-ray and UV irradiation, although the former is more effective in inducing the observed chemical reactions

X-ray induced chemistry is strongly dependent upon the wavelength used during irradiation, ng 550 eV photons producing he largest yields form the photochemistry. The e- irradiation experiments show similar formation rates at 300 and 550 eV but evidence an enhanced product yield at 1000 eV (especially in CH_3OH:NH_3 ice mixtures), however the electron induced synthesis seems to be a similar mechanism to X-ray induced synthesis.

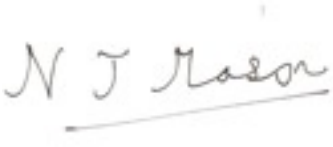
Please include:

- Publications arising/planned (include conference abstracts etc)

Jimenez-Escobar et al., 2013, in preparation.

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

I approve this report as an accurate account of this TNA



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