Modeling Photochemistry on Saturn's Largest Moon

This report features the work of Yu-Jong Wu and his co-workers published in Astrophys. J. Supplement Series ***212****, 7 (2014).*

Astronomical physics and chemistry continue to attract the attention of scientists who seek our origins. Advanced telescopes and spectra measured with them increasingly enable the phenomena of space to be uncovered. Many large chemical species that scientists thought not to exist in space have also been identified. How they were formed and how they react become important in our quest to know more about the world beyond planet earth.

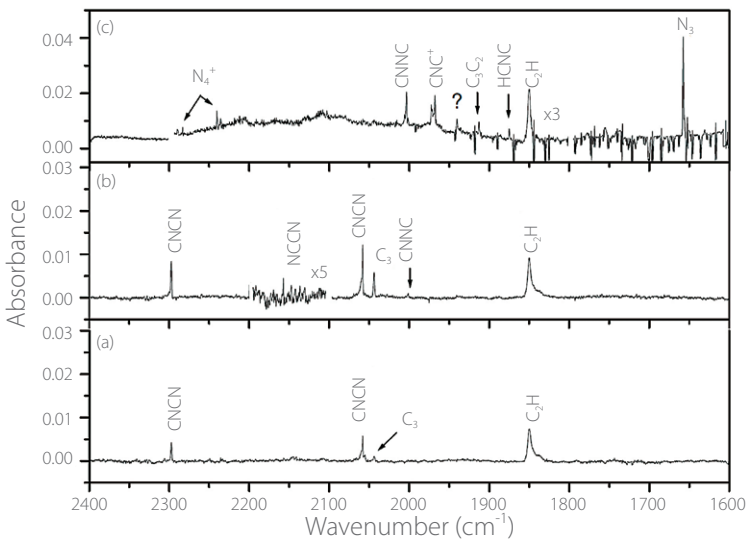

Fig. 1: Infrared absorption spectra recorded after irradiation of frozen samples of C_2H_2/N_2 (1/250) with light at wave lengths (a) 160 nm and (b) 121.6 nm, and with (c) 2-keV electrons, all for two hours. Lines pointing downward in trace (c) are due to interfering absorption by atmospheric water.[2]

The atmosphere of Titan, the largest moon of Saturn, comprises about 98.4% N_2, 1.6% CH_4 and trace gases C_2H_2, C_2H_4, C_2H_6, etc. These trace gases are likely formed from the electronic excitation of N_2 and CH_4 with successive fragmentation and chemical reactions. Yu-Jong Wu and his co-workers have measured the products formed on irradiation of CH_4 in an icy N_2 matrix; some of these products are nitrile derivatives.[1] The presence of large and complicated nitriles in Titan's atmosphere results from the polymerization of polyynes and cyanopolyynes; small unsaturated hydrocarbons, particularly C_2H_2 and C_4H_2, might prove crucial in chemical reactions, as they have been detected in appreciable mixing ratios at altitudes greater than 150 km. At this height, these molecules might absorb vacuum-ultraviolet photons or collide with energetic particles, then produce mainly highly reactive radicals C_2H and C_4H that are the building blocks of polyynes and their derivatives.

Wu noticed the key characters of chemical reactions of unsaturated hydrocarbons; he therefore took advantage of the tunable vacuum-ultraviolet radiation from **BL03A1** at the TLS to conduct the reactions of C_2H_2 in an icy N_2 matrix initiated on absorption of VUV photons or on electron impact.[2] Figure 1 shows infrared spectra of C_2H_2/N_2 (1/250) matrix samples irradiated with light at wave lengths (a) 160 nm and (b) 121.6 nm, and with (c) 2-keV electrons. Some nitrile products were accurately identified and complicated derivatives, such as CNNC and CNCN, were also detected. Further chemical reactions from these products might be the key sources of polyynes and their derivatives.

References

1. Y.-J. Wu, H.-F. Chen, S.-J. Chuang, and T.-P. Huang, Astrophys. J. **768**, 83 (2013).
2. Y.-J. Wu, S.-J. Chuang, S.-C. Chen, and T.-P. Huang, Astrophys. J. Supplement Series **212**, 7 (2014).