THE ORGANIC SOUP AT TITAN'S POLES INFERRED FROM CASSINI OBSERVATIONS. C. M. Anderson[1] and R. E. Samuelson[2], [1]NASA Goddard Space Flight Center, Planetary Systems Laboratory, 8800 Greenbelt Road, Greenbelt MD, 20771 (carrie.m.anderson@nasa.gov), [2]Department of Astronomy, University of Maryland College Park, MD 20742 (robert.e.samuelson@nasa.gov)

The Cassini spacecraft has unveiled a wealth of information relating to the physical and chemical conditions on Titan, Saturn's largest moon. Cassini's Ion and Neutral Mass Spectrometer (INMS) initially inferred the existence of large organic molecules at high altitudes near 1000 km [1]. Aerosol particles also reside at these altitudes as observed by Cassini's UltraViolet Imaging Spectrograph (UVIS) [2]. These observations imply that Titan's aerosol is composed of organic molecules that form at very high altitudes. Deeper down, in Titan's stratosphere, observations by Cassini's Composite InfraRed Spectrometer (CIRS) reveal the aerosol and many of the organic gases are non-uniformly mixed in latitude [3,4,5]. On the other hand, the spectral appearance of Titan's aerosol in the thermal infrared is found to be independent of latitude, as shown in figure 1. This suggests that almost all aerosol chemistry has ceased below Titan's stratopause (~300 km). This implies that Titan's aerosol chemistry is restricted to very high altitudes (very low pressures) on Titan. In contrast, laboratory aerosol analogs are mostly created at much higher pressures. This may be the reason that laboratory analog spectra in the thermal infrared are very different from Titan's observed aerosol spectrum [6].

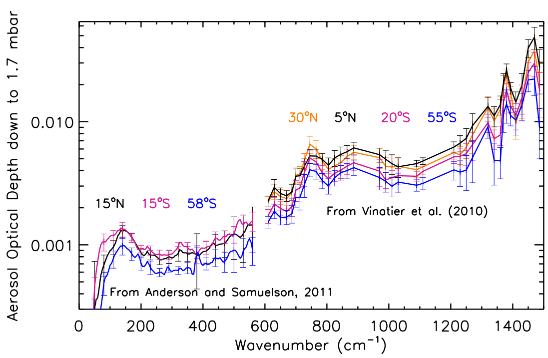

Figure 1 CIRS-derived aerosol optical depth integrated down to a pressure of 1.7 mbar during mid-to-late northern winter in the far IR [4] and early northern spring in the mid IR [5].

Titan's thermal infrared aerosol spectrum, derived from analyses of CIRS spectra, has emission features peaking at 140, 630, 745, 885, 1320, 1380, and 1470 cm^{-1} [4,5,6]. These features represent the presence of molecular bonds not presently evident in laboratory-created aerosol analogs that begin the experiments with CH_4 and N_2 mixtures. In particular, the low frequency feature at 140 cm^{-1} suggests possible low energy lattice vibrations of large planar molecules, such as polycyclic aromatic hydrocarbons (PAHs) or nitrogenated aromatics. Recent laboratory work finds aerosol analogs formed from nitrogen-containing aromatics to have similar broad emission features to that of the CIRS-observed 140 cm^{-1} aerosol emission feature [7].

For the temperatures observed by Cassini's Radio Science Subsystem (RSS), almost all organic gases are abundant enough to condense in Titan's lower stratosphere. Ice particles will form using aerosol particles as condensation nuclei. Titan's atmospheric meridional circulation pattern ensures that the organic ice/aerosol particle composites will subside preferentially in Titan's winter polar regions and be deposited on the surface at those locations. CIRS observations of both HC_3N and C_4N_2 ices in Titan's winter polar stratosphere tend to confirm this viewpoint [8,9]

Hydrocarbon lakes have been observed by Cassini's RADAR, Imaging Science Subsystem (ISS), and Visible and Infrared Mapping Spectrometer (VIMS) to exist primarily in Titan's polar regions [10,11,12]. The various organic ices and aerosols that have been deposited there will then be swept into these lakes by the CH_4 rivers observed on the surface. Water ice is the likely surface material that has been scoured out by the combination of liquid CH_4 and abrasive organic ice particles, and a sludge including aerosols, organic ice, and water ice will empty into the polar lakes. Thus the Titan polar lakes are swarming in an organic soup containing nitrogen, carbon, hydrogen and oxygen molecules that will be available to form biotic precursors such as amino acids once an effective energy source is available.

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