Titan aerosol analogs from aromatic precursors: Comparisons to Cassini CIRS observations in the thermal infrared

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Background

Since Cassini's arrival at Titan, ppm levels of benzene (C_6H_6) as well as large positive ions, which may be polycyclic aromatic hydrocarbons (PAHs), have been detected in the atmosphere.[1] Aromatic molecules, photolytically active in the ultraviolet, may be important in the formation of the organic aerosol comprising the Titan haze layer even when present at low mixing ratios. Yet there have not been laboratory simulations exploring the impact of these molecules as precursors to Titan's organic aerosol.

Observations of Titan by the Cassini Composite Infrared Spectrometer (CIRS) in the far-infrared (far-IR) between 560 and 20 cm^{-1} (~18 to 500 μm) and in the mid-infrared (mid-IR) between 1500 and 600 cm^{-1} (~7 to 17 μm) have been used to infer the vertical variations of Titan's aerosol from the surface to an altitude of 300 km in the far-IR [2] and between 150 and 350 km in the mid-IR [3,4]. Titan's aerosol has several observed emission features which cannot be reporoduced using currently available optical constants from laboratory-generated Titan aerosol analogs [5,6], including a broad far-IR feature centered approximately at 140 cm^{-1} (71 μm).

Analog Studies

There is a need to revisit the infrared spectrum of laboratory-produced aerosol, particularly in the far-IR. We speculate that these features may be a blended composite that can be identified with low-energy vibrations of two-dimensional lattice structures of large molecules, such as PAHs or nitrogenated aromatics. We have found that such structures do not dominate the composition of analog materials generated from CH_4 and N_2 irradiation.

We are performing studies forming aerosol analogs via UV irradiation of several aromatic precursors – with and without nitrogen heteroatoms – to understand how the unique chemical architecture of the products will influence the observable aerosol characteristics. The optical and chemical properties of the aromatic analog will be compared to those formed from CH_4/N_2 mixtures [7,8], with a focus on the as-yet unidentified far- and mid-IR absorbance features. These studies show that the aerosol formed from aromatic precursors have distinct chemical composition as compared to previously studied analogs, which has implications for the optical properties of Titan's aerosol.

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