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Infrared Spectra, Index of Refraction, and Optical Constants of Nitrile Ices Relevant to Titan’s Atmosphere

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Abstract

Spectra and optical constants of nitrile ices known or suspected to be in Titan’s atmosphere are presented from 2.5 to 200 microns (4000 to 50 cm\(^{-1}\)). These results are relevant to the ongoing modeling of Cassini CIRS observations of Titan’s winter pole. Ices studied include: HCN, hydrogen cyanide; C\(_2\)N\(_2\), cyanogen; CH\(_3\)CN, acetonitrile; C\(_2\)H\(_5\)CN, propionitrile; and HC\(_3\)N, cyanoacetylene. For each of these molecules we report new measurements of the index of refraction, \(n\), determined in both the amorphous- and crystalline-phase at 670 nm. Spectra were measured and optical constants were calculated for each nitrile at a variety of temperatures including 20, 35, 50, 75, 95, and 110 K, in the amorphous- and crystalline-phase.

This laboratory effort uses a dedicated FTIR spectrometer to record transmission spectra of thin-film ice samples. Laser interference is used to measure film thickness during condensation onto a transparent cold window attached to the tail section of a closed-cycle helium cryostat. Optical constants, real (\(n\)) and imaginary (\(k\)) refractive indices, are determined using Kramers-Kronig (K-K) analysis. Our calculation reproduces the complete spectrum, including all interference effects. Index of refraction measurements are made in a separate dedicated FTIR spectrometer where interference deposit fringes are measured using two 670 nm lasers at different angles to the ice substrate.

A survey of these new measurements will be presented along with a discussion of their validation, errors, and application to Titan data.

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