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Laboratory Studies of Amorphous and Crystalline Cyanoacetylene Ices

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Cyanoacetylene (HC3N) was first detected in interstellar clouds nearly fifty years ago (Turner, 1971). Since then, HC3N has been observed in protoplanetary disks (Chapillon et al., 2012), comets (Bockelée-Morvan et al., 2000), Titan's stratosphere (Kunde et al., 1981), and possibly even Pluto's atmosphere (Lellouch et al., 2017). Given that HC3N has been observed in many different astrobiologically-relevant environments, it is important to study the structural and optical properties of this molecule in the condensed phase. Here we present absorbance spectra and optical constants of HC3N ice measured using the SPECtroscopy of Titan-Related ice AnaLogs (SPECTRAL) Chamber from the near- to far-IR (0.85 – 200 μm) spectral region (Anderson et al., 2018). Spectra were obtained at multiple temperatures between 30 and 120 K for relevance to different bodies in the outer solar system, with an emphasis placed on the formation of HC3N ice clouds in Titan's stratosphere as observed by Cassini's Composite InfraRed Spectrometer (CIRS). Experiments were performed by depositing HC3N vapor directly into its amorphous or crystalline ice phase, from which absorbance spectra were recorded and then the optical constants were determined. The results are compared with previous studies in the literature that measured the transmittance spectra and reported the optical constants of crystalline HC3N ice after annealing. In the annealing approach, however, there is an incomplete conversion to the crystalline phase, resulting in differences between the HC3N ice spectral features when compared with direct deposition of the vapor into its crystalline phase. Therefore, the optical properties presented here have more relevance to the CIRS-observed HC3N ice clouds residing in Titan's stratosphere. Such optical constants are critically needed to better understand the radiative properties and dynamics of Titan's atmosphere.