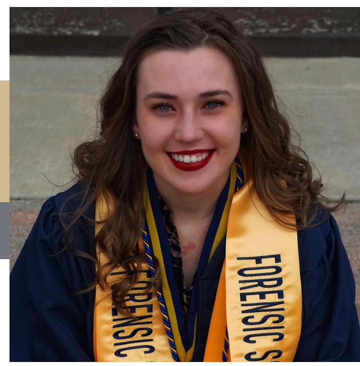
Physical Chemistry Seminar

"Characterization of Non-Equilibrium CN Formed Behind Strong Shock Waves in CH4-N2 Mixtures via TDLAS and OES Diagnostics"

Jennifer Vera

Goldstein Group
in Mechanical Engineering
Co-advised by Dr. Garth Simpson
Purdue University



The demand for an improved understanding of CN kinetics and spectroscopy has been driven by the abundance of CN formed during Titan atmospheric entry due to the fact that CN is a major source of radiation through its $A2\Pi \rightarrow X2\Sigma$ (red) and $B2\Sigma+ \rightarrow X2\Sigma+$ (violet) electronic systems. As a result, CN formation, decay, and radiation must be thoroughly understood for optimal design of thermal protection systems (TPS) used in Titan's atmosphere. Many experiments and simulations have been conducted to quantify and predict CN,although the agreement between experimental results and simulations has been unsatisfactory. Experimental measurements quantifying the state populations and internal temperatures of CN are therefore needed to improve the accuracy of theoretical predictions. A tunable diode laser absorption spectroscopy (TDLAS) diagnostic and an optical emission spectroscopy (OES) diagnostic have been developed to characterize the thermochemical evolution of non-equilibrium CN formed behind shock waves at Titan atmospheric entry conditions. The TDLAS diagnostic utilizes two time-multiplexed tunable diode lasers (TDLs) emitting near 1156.3 nm and 1180.3 nm to measure absorption lines of CN belonging to the $\Delta v = 0$ band of the $A2\Pi \leftarrow X2\Sigma$ electronic system. Scanned-wavelength direct absorption spectroscopy was used to provide measurements of CN's mole fraction and translational, rotational ($Trot(\nu" = 0)$ and $Trot(\nu" = 1)$), and vibrational temperatures at 100 kHz. The measurements clearly indicate that CN exhibits pronounced non-equilibrium rotational and vibrational state populations which is hypothesized to result from CN being produced in high vibrational or rotational states of $A2\Pi$ or $B2\Sigma$. The OES diagnostic uses a broadband (200 to 1100 nm) spectrometer with a 4096 pixel CMOS detector and a resolution of approximately 0.6 nm. This diagnostic serves to complement the existing TDLAS diagnostic to further elucidate the non-equilibrium and non-Boltzmannbehavior of CN in its $A2\Pi \rightarrow X2\Sigma$ and $B2\Sigma+ \rightarrow X2\Sigma+$ electronic systems, enhancing the understanding of the complex chemical processes that occur at these conditions.

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James Tarpo Jr. and Margaret Tarpo Department of Chemistry