Towards the Development of Next-Generation Gaseous and Liquid Fuels: Shock Waves, Optical Diagnostics, and Reaction Kinetics

Alison M. Ferris
Stanford University

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As the world approaches consensus on the importance of curbing greenhouse gas emissions and reversing anthropogenic climate change, there is an urgent need for the development and deployment of low-carbon and carbon-neutral fuels, especially in energy sectors where electrification is impractical. Much scientific research is needed to identify viable alternative fuel options, develop efficient methods for fuel production, and characterize the oxidation behavior of these new fuels at conditions relevant to next-generation energy and propulsion systems. In this seminar, I will first introduce a subset of tools used by experimental kineticists to study fuel chemistry and flame behavior, including shock tubes, laser absorption spectroscopy, gas chromatography, and high-speed imaging. I will then present four novel applications of these tools to the analysis, design, and synthesis of conventional and next-generation fuels: (1) the use of a combined gas chromatography-laser absorption diagnostic to identify deficiencies in reaction rates used in low-temperature kinetic models; (2) a new experimental method for measuring laminar flame speeds at previously unexplored unburned gas temperatures in a shock tube; (3) an infrared (IR) spectrum-based, low-volume prescreening tool to aid in the design of sustainable aviation fuels; and (4) a new, shock wave-based approach for producing hydrogen from hydrogen-rich fuels like natural gas and ammonia. Finally, opportunities for future research and innovation will be discussed. Through this seminar, I will demonstrate that shock waves, optical diagnostics, and reaction kinetics form the basis of an exciting new frontier in fuel science.

Alison Ferris is a Research Scientist at Stanford University where she oversees multiple research initiatives in Professor Ron Hanson's Shock Tube and Optical Diagnostics Laboratory. Her research interests include using shock waves and optical diagnostics to study the design, chemical synthesis, and reaction kinetics of sustainable fuels for use in current and next-generation energy and propulsion systems. Alison received her Ph.D. in Mechanical Engineering from Stanford in 2021, focusing on the development of a high-temperature laminar flame speed measurement technique and a combined gas chromatography-laser absorption diagnostic for comprehensive, time-resolved species measurements behind reflected shock waves. Alison is a recipient of Stanford's Centennial Teaching Assistant Award, Zonta International's Amelia Earhart Fellowship, and Stanford's Justice, Equity, Diversity & Inclusion (JEDI) Service Graduation Award.

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