Pryolysis Measurements of Rocket and Jet Fuels and their Surrogates

Principal Investigator: Dr. Ronald K. Hanson

Research Associates: Dr. Jay Jeffries; Dr. David Davidson

Research Assistants: Megan MacDonald; Matt Liaw

Overview

We use the Aerosol Shock Tube to study the chemical kinetics of fuel decomposition. The tube is shown below from the perspective of the driver section in fig 1. Our primary fuels of interest are RP-1, RP-2, and JP-7. RP-1 is the standard US rocket kerosene, and RP-2 is a new rocket fuel, with a slightly different chemical composition than RP-1, intended to make it more stable as a coolant in regeneratively cooled rocket engines. JP-7 is a similar fuel, used primary in hypersonic vehicles. Since these are complex distilled fuels, containing hundreds of different hydrocarbons, we are also studying pure hydrocarbons that have similar chemical kinetic traits to these kerosenes. Our current surrogate for RP-1, RP-2, and JP-7 is dodecane, C12H26.

Figure 1: Aerosol shock tube

One application of this work is in the cooling channels of a regeneratively cooled liquid rocket engine. As the fuel absorbs heat from the engine, it can decompose, forming unwanted deposits on the cooling channel walls. This research will shed light on the chemical processes involved in this decomposition. We determine the pyrolysis characteristics of fuels, and then observe any changes when additives are included in the fuel. A group of molecules called hydrogen donors has been identified as a type of additive that slows decomposition of rocket and jet fuels.

We observe the pyrolysis of these fuels in an argon bathgas. The concentration of fuel throughout the decomposition process is monitored with a mid-infrared (3.39um) HeNe laser. This wavelength corresponds to one of the vibration modes of the C-H bond in the fuel. Since our fuels have many C-H bonds, they absorb readily at 3.39um.

We also employ a near-infrared diode laser that is not absorbed by the fuels. This nonresonant beam is therefore only scattered by the aerosol droplets, and its extinction signal will drop to zero when the aerosol is completely vaporized behind the incident shock. Figure 2 shows both the HeNe absorbance and the near-infrared extinction signals. It is clear that as the incident shock passes, the aerosol is vaporized, resulting in an RP-1 vapor. The reflected shock increases the temperature and pressure to that required for decomposition and the HeNe absorbance decreases as the fuel breaks apart.

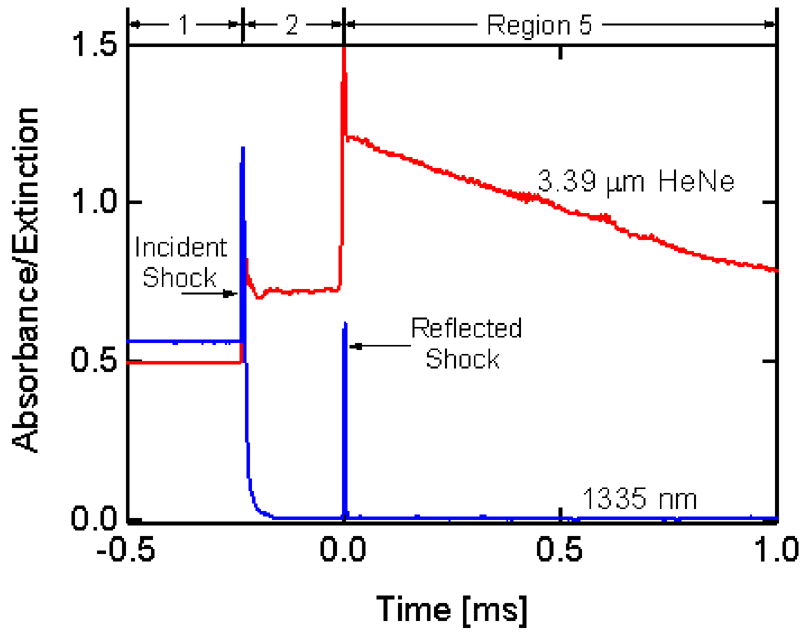

Figure 2: Sample data for an RP-1 shock

The end section of the shock tube can be seen below with the HeNe and diode lasers and their detectors.

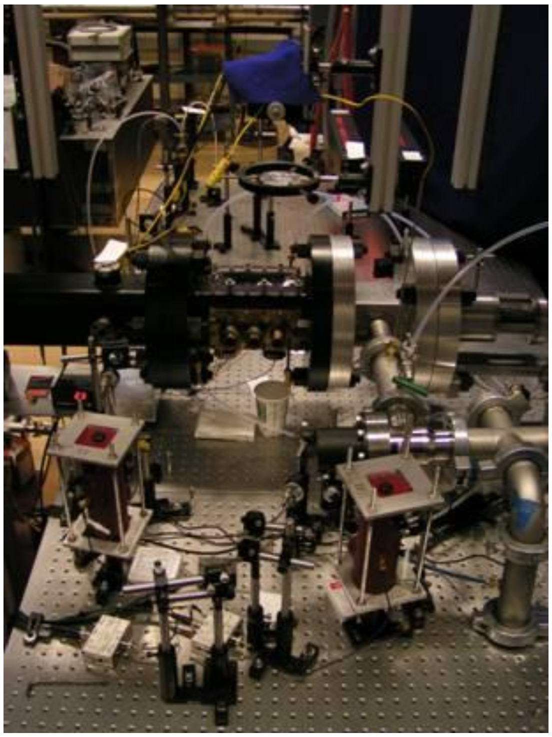

Figure 3: Test section of the aerosol shock tube