

Blowoff Characterization of Liquid Aviation Fuels

Nick Rock, Ben Emerson, Tim Lieuwen

1



THE DANIEL GUGGENHEIM
SCHOOL OF AEROSPACE ENGINEERING



Incentives for Alternative Aviation Fuels

- Mitigation of global climate change
- Improved air quality
- Cost
- Stable and diverse energy supply

Goal is to develop “drop-in fuels”, or fuels that can be used in existing engine hardware without modification.

Colket, M., 2016, “An Overview of the National Jet Fuels Combustion Program.” 54th AIAA Aerospace Sciences Meeting AIAA2016-0177.

Certification Challenges

- ▶ Jet fuel specifications are developed by government and industry based organizations.
- ▶ Alternative jet fuels are evaluated on 3 Figures of Merit:
 - Lean Blowout
 - Altitude Relight
 - Cold Start
- ▶ Current alternative jet fuel certification process requires 3-4 million dollars and 3-5 years.
- ▶ Combustion testing by Original Equipment Manufacturers (OEMs) is the most resource intensive aspect of the certification process.

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Overview of NJFCP

- Program Goal is to replace OEM testing with a methodology that leverages standard lab-scale experiments and models.
- Need improved knowledge of how fuel physical and chemical properties affect engine performance.
- Area 3 at Georgia Tech focuses on lean blowoff.



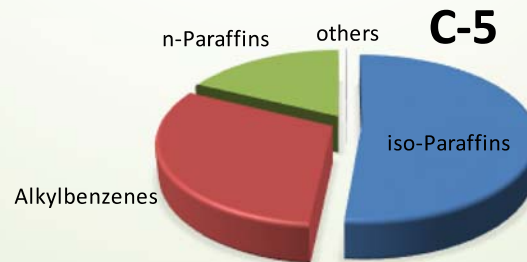
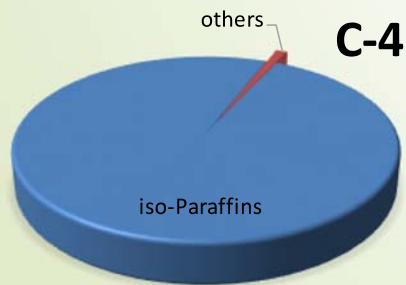
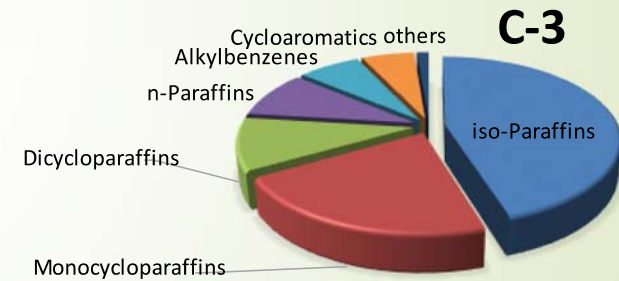
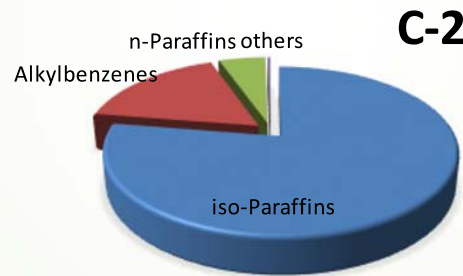
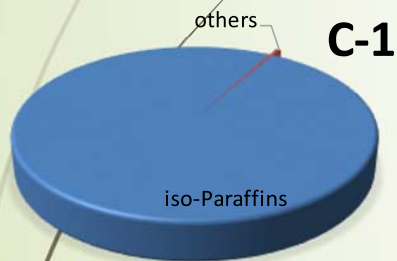
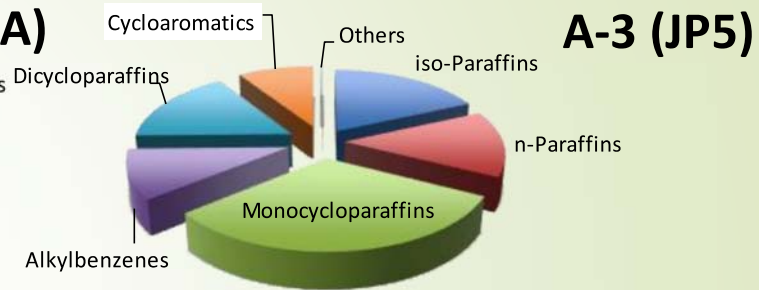
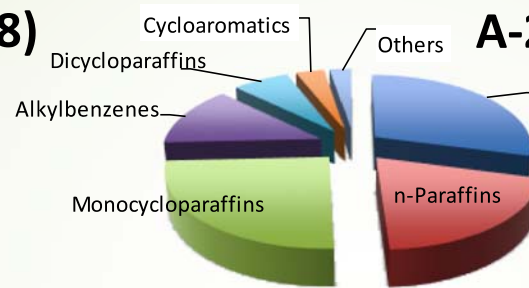
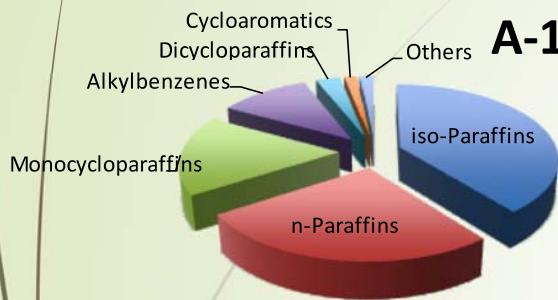
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Overview

- Description of Fuels
- Facility
- Experimental Procedure
- Flame and Flow Field Features
- Results
- Conclusion

Description of fuels

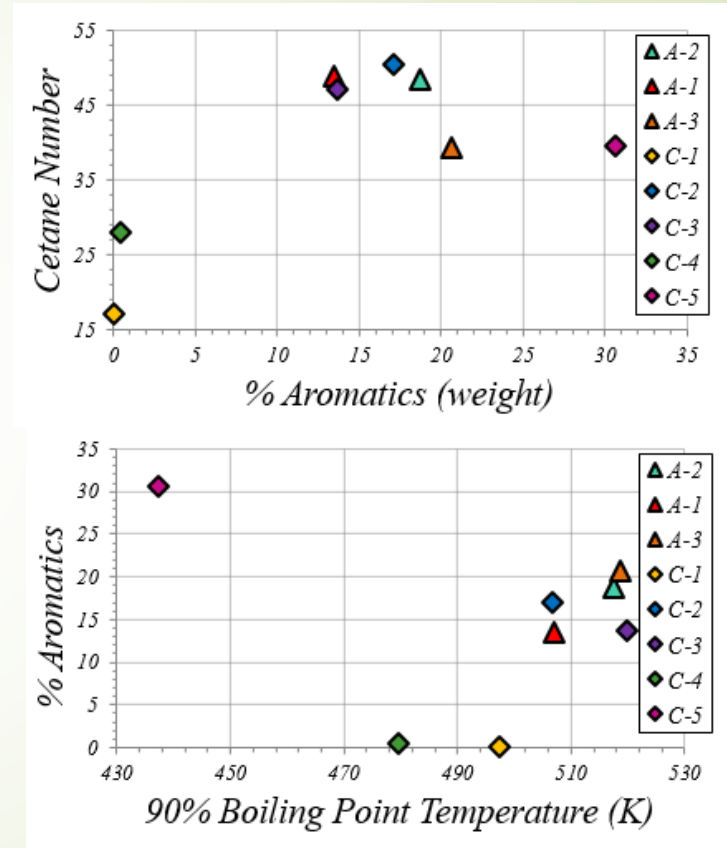
Fuel Composition



Interrelated Fuel Properties

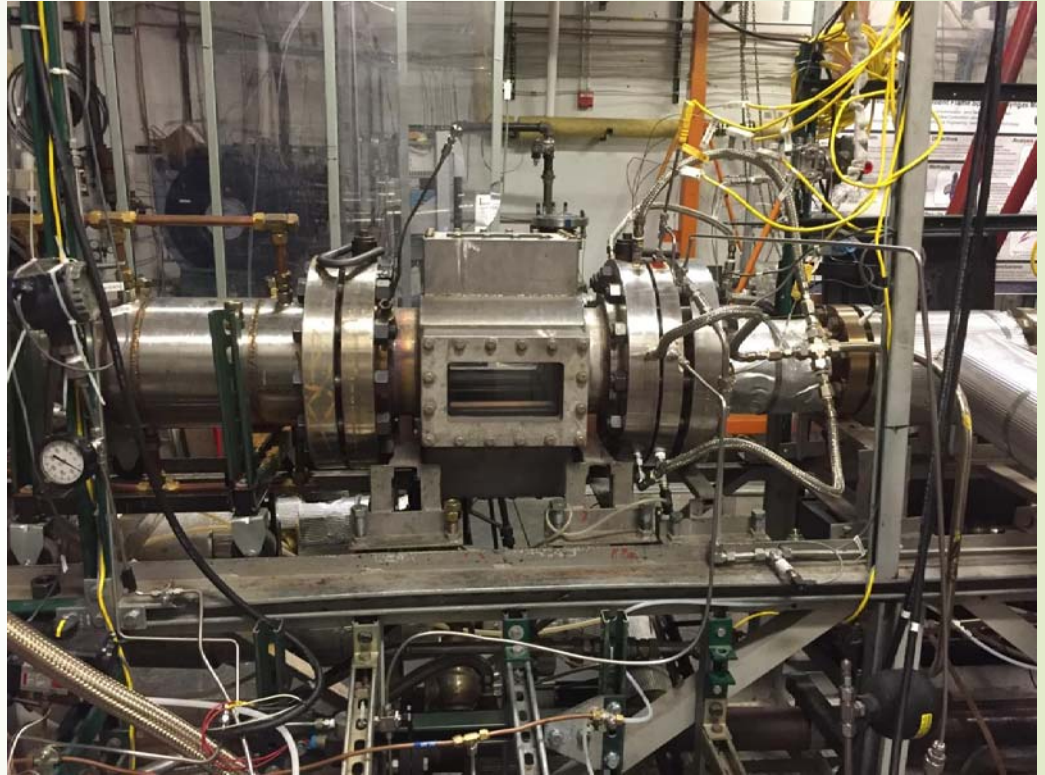
- “The various properties and characteristics of petroleum fuels are so closely interrelated that it is virtually impossible to change any one property without affecting many others. Thus the classical approach to experimental research, which is based on examination of the effects of varying one independent parameter, while maintaining the others constant, is precluded from the outset.”- Arthur Lefebvre

Lefebvre, A.H., 1983, “Fuel Effects on Gas Turbine Combustion.” AFWAL-TR-83-2004, Purdue University.

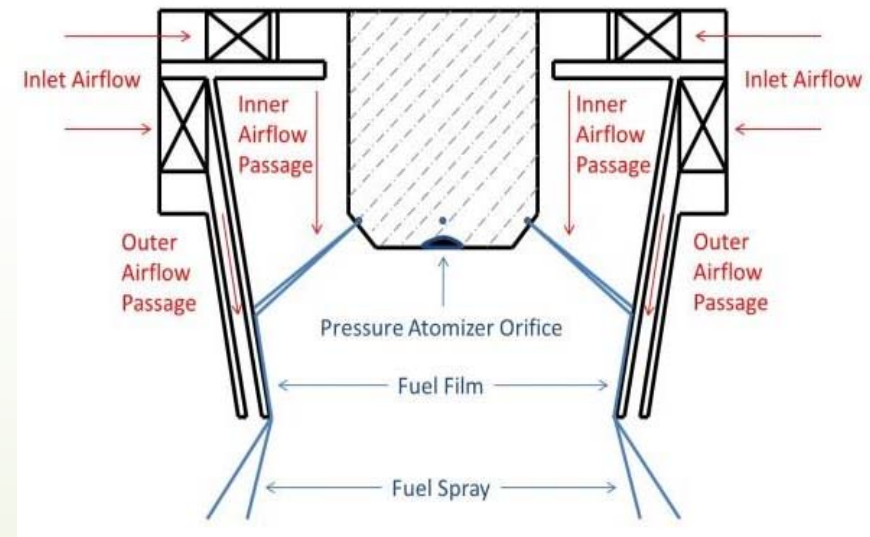
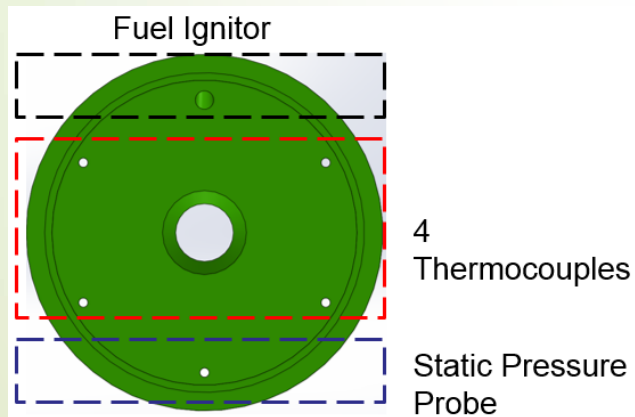
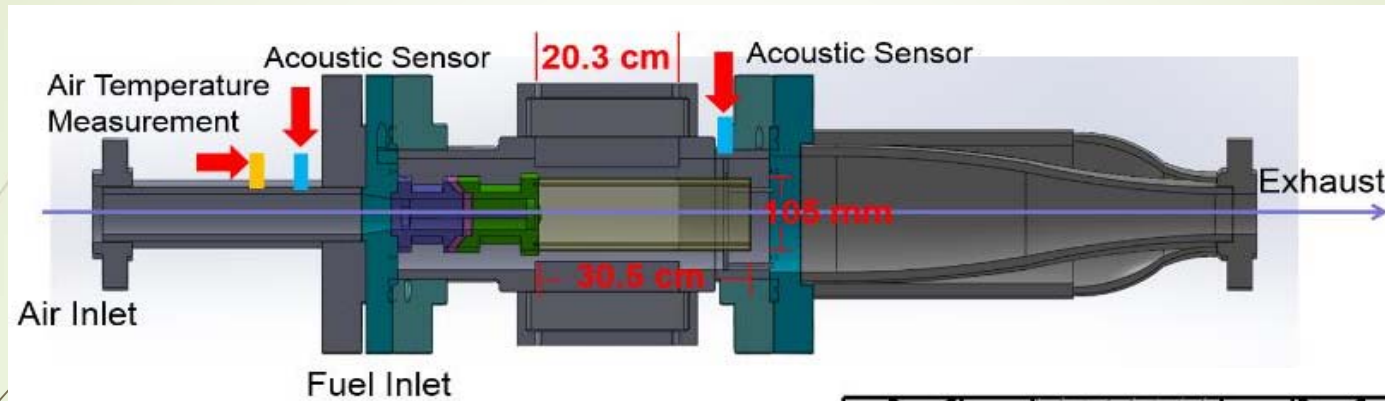


9

Facility



Facility



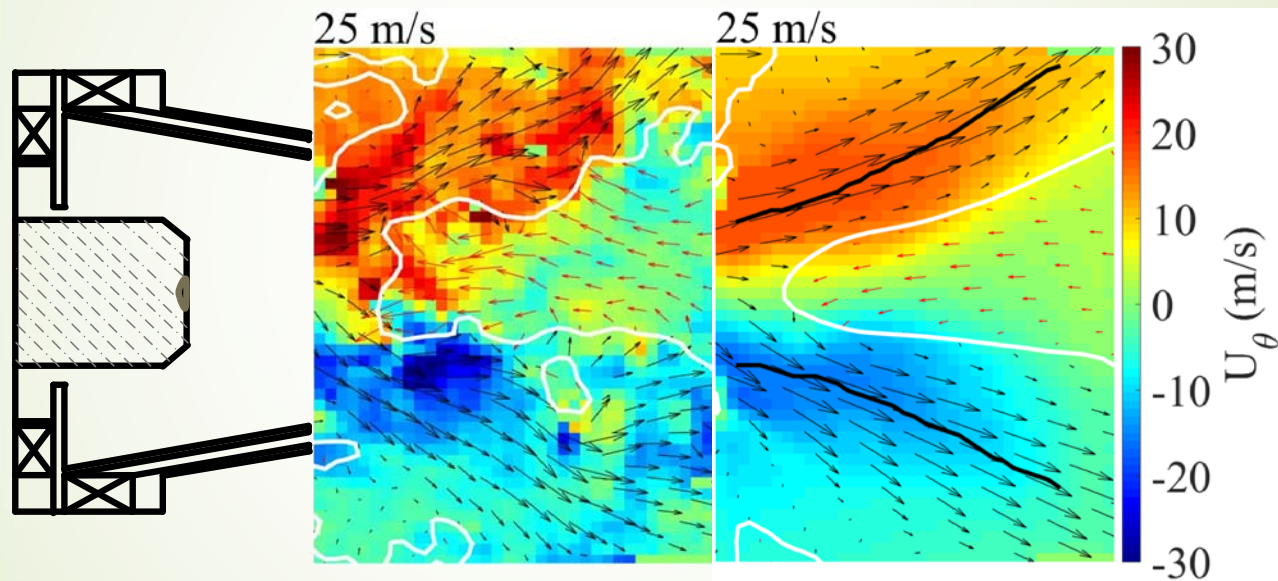
Fuel Screening Infrastructure

- ▶ Repeatability is difficult to achieve in blowoff experiments
 - Key consideration in design of procedure
 - Extreme caution was used to avoid mixing of fuels.
 - Fuel cart allowed all fuels to be tested on a single day.

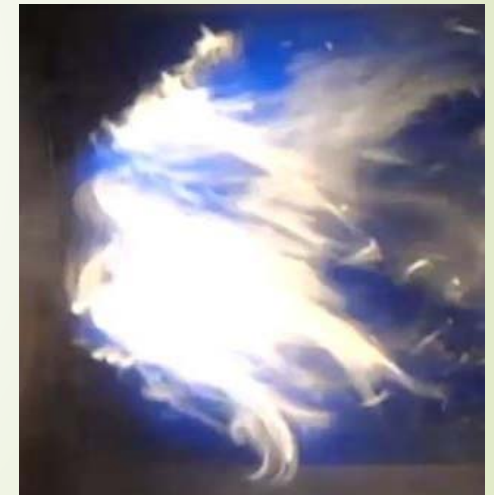
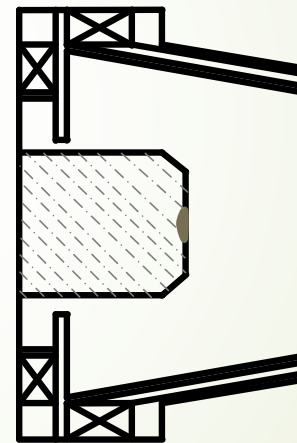
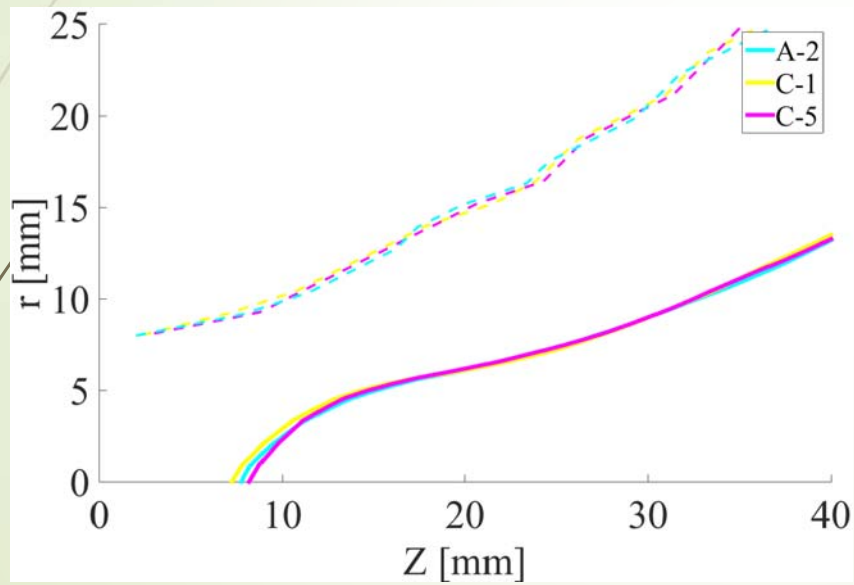


Flame and Flow Field Features

Flow Field Characteristics



Flame and Flow Characteristics



Progression of Results

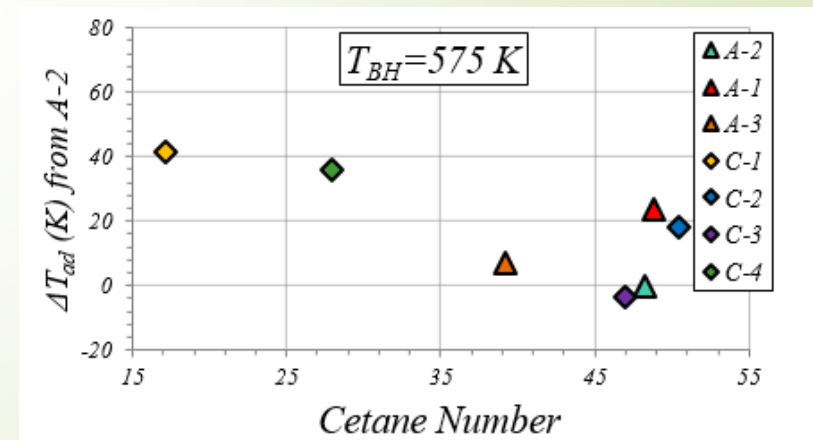
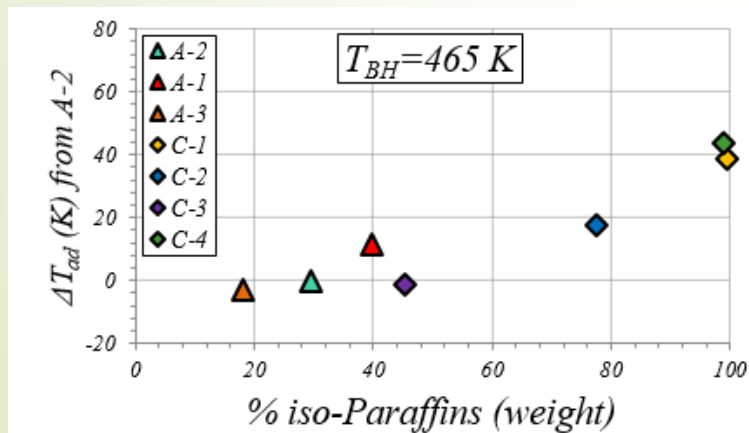
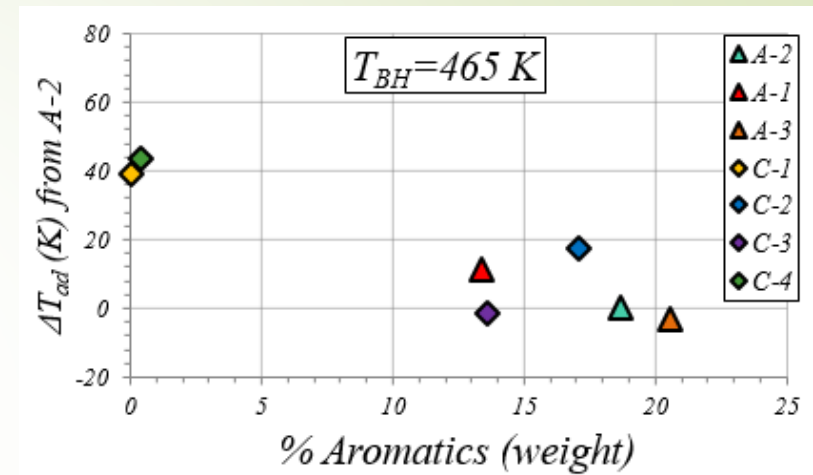
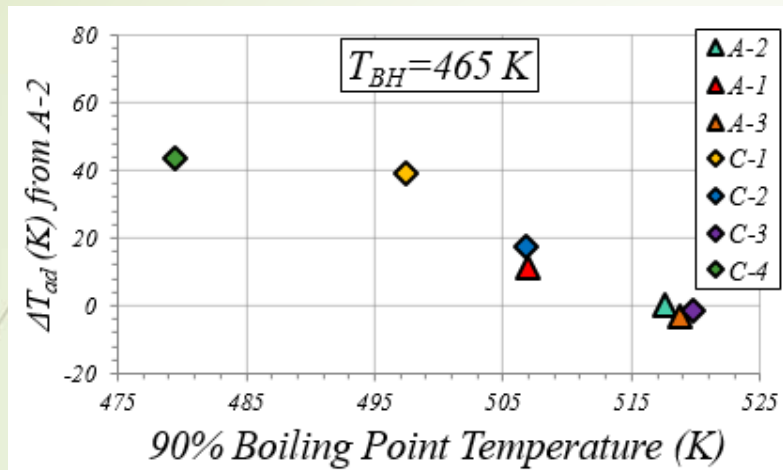
Correlations

- ▶ Blowoff results for all fuels were correlated with a range of physical and chemical properties.
- ▶ Physical Properties: Boiling point temperature, Viscosity, Density, Surface tension
- ▶ Chemical Properties: % Iso-Paraffins, % Aromatics, Cetane number, Radical index

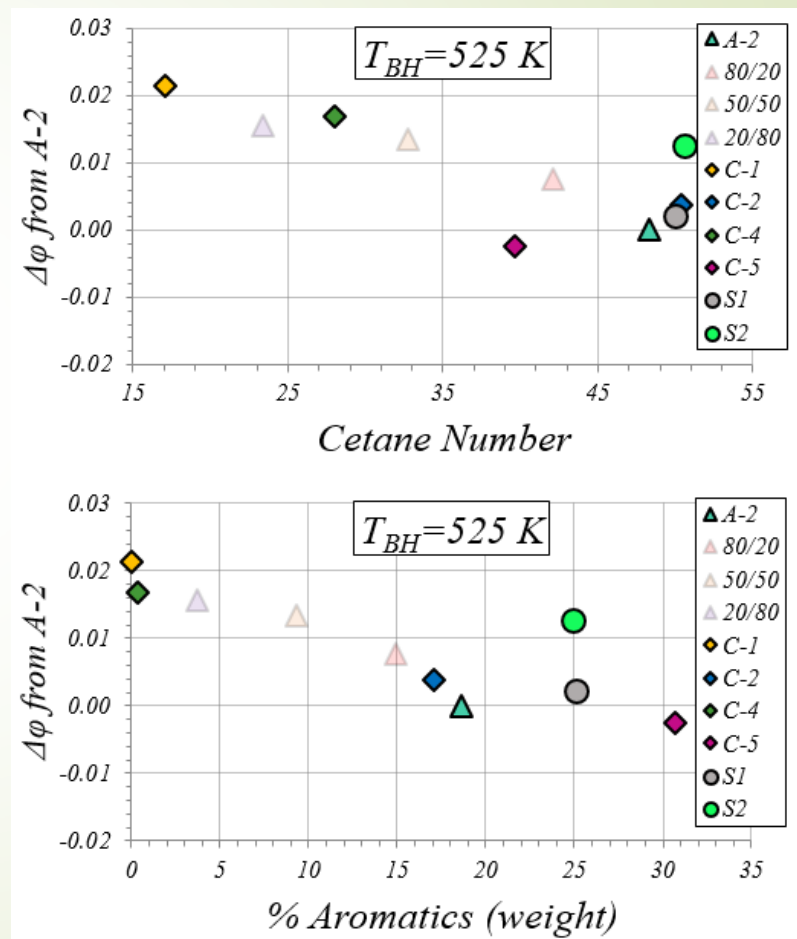
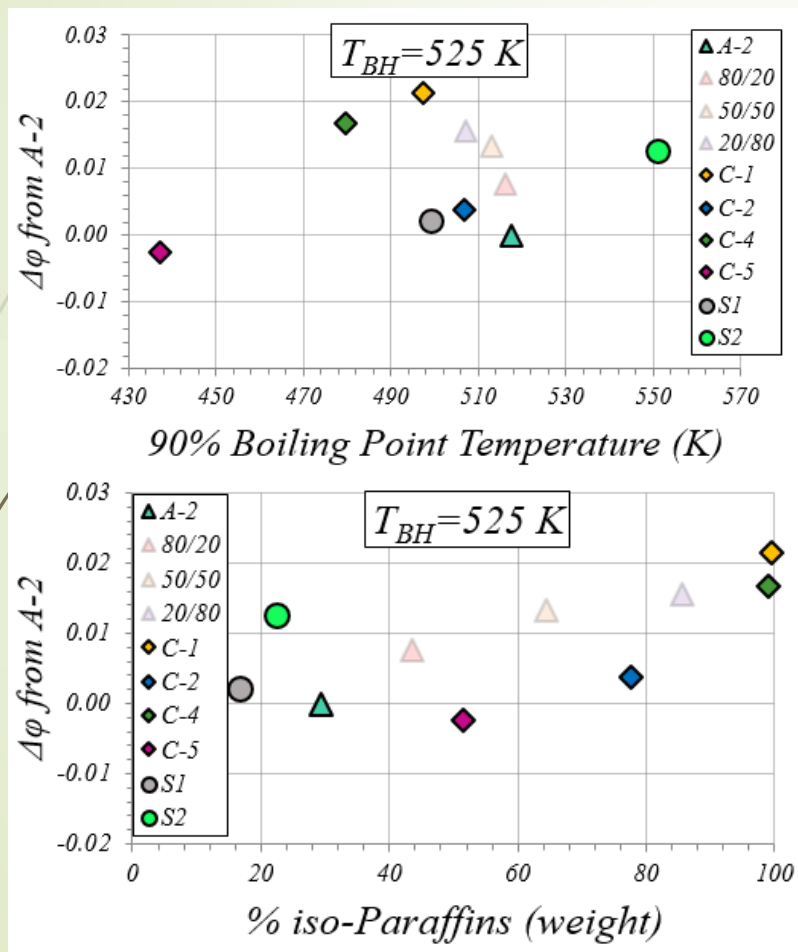
“Cetane number is a relative measure of the time delay between injection of fuel into the chamber and the start of combustion.”

- Compendium of Experimental Cetane Numbers

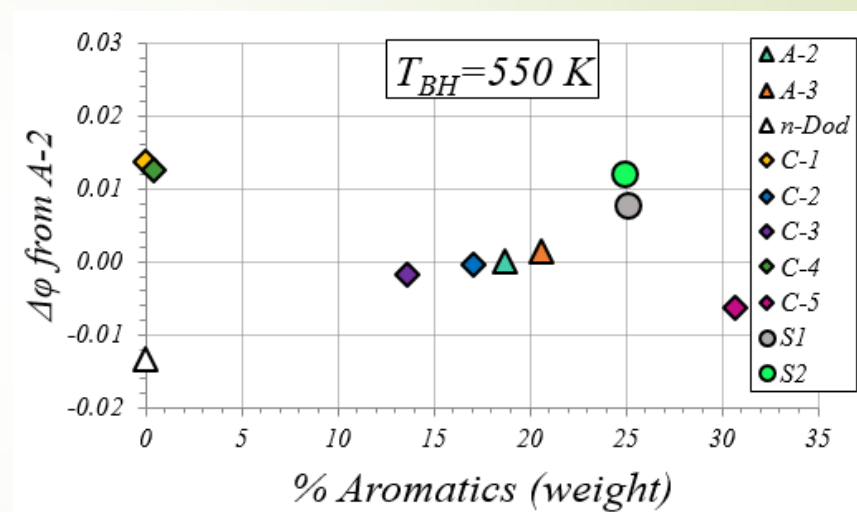
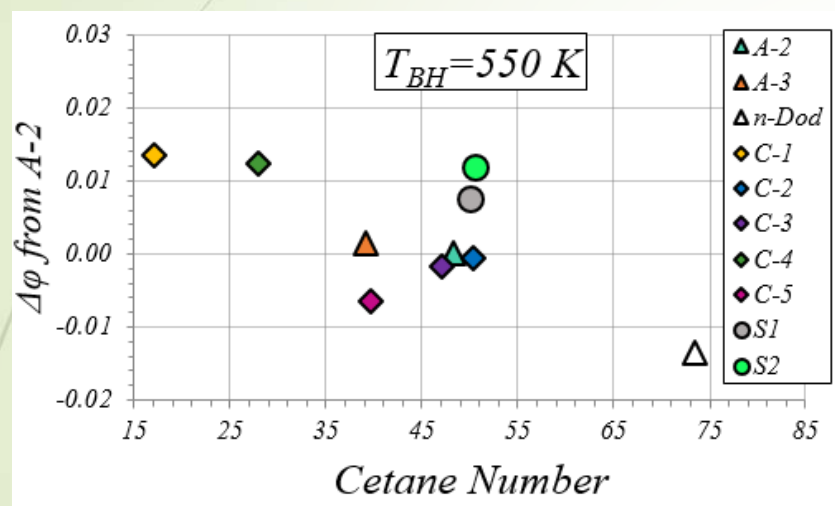
2015 Results



2016 Results

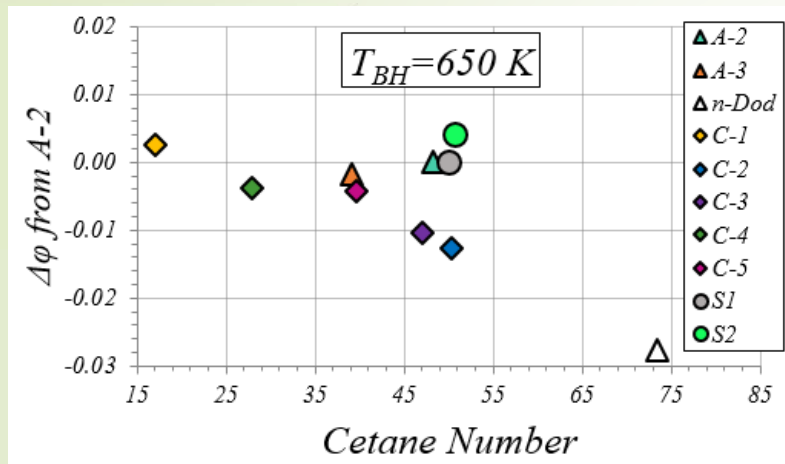


2017 Results

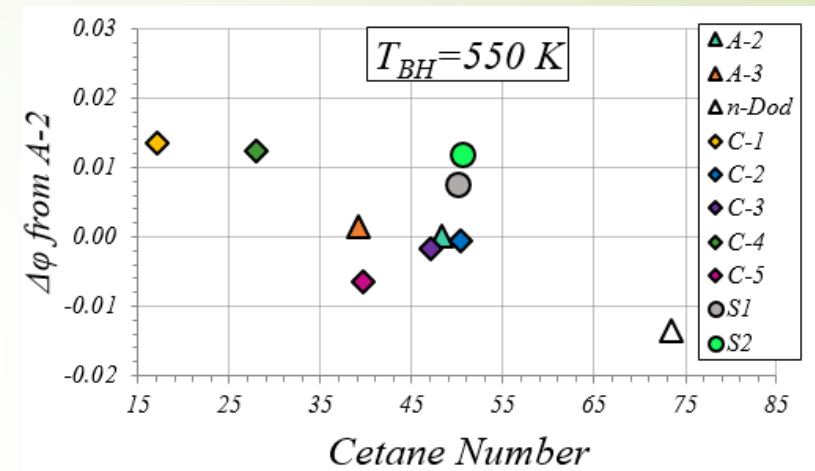


Air Temperature Effects

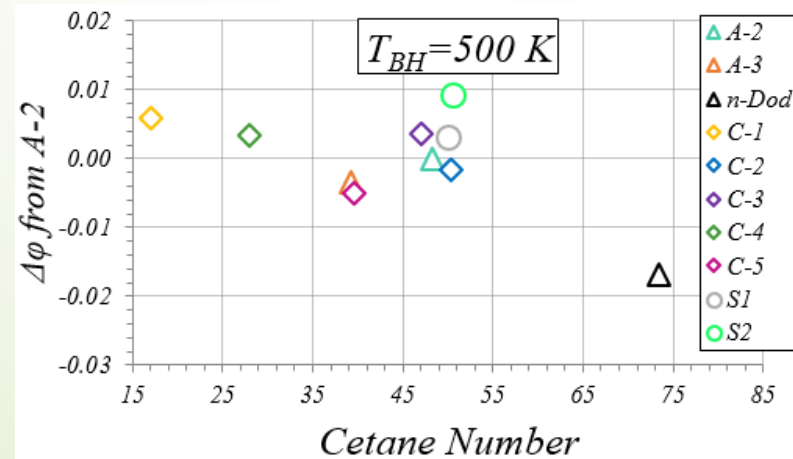
550 K



450 K

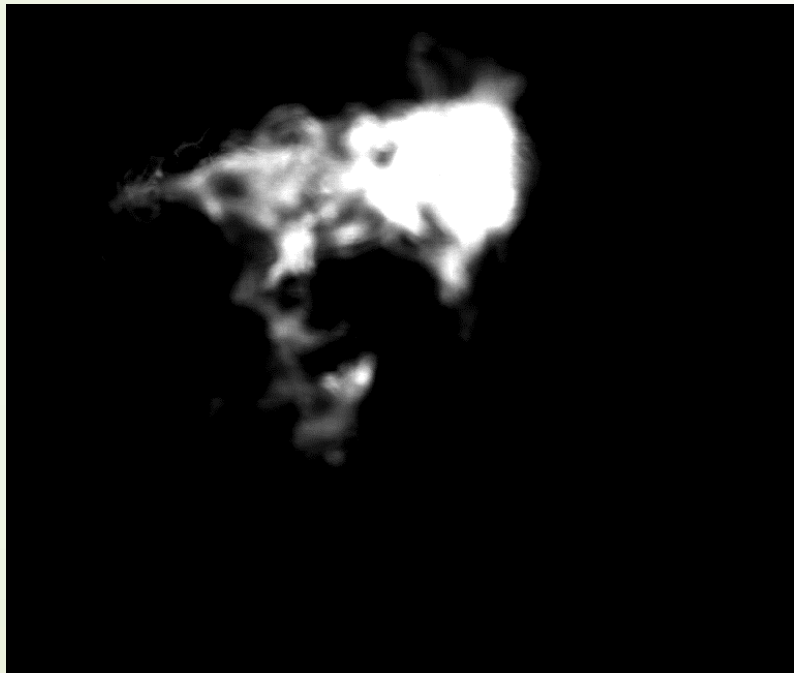


300 K

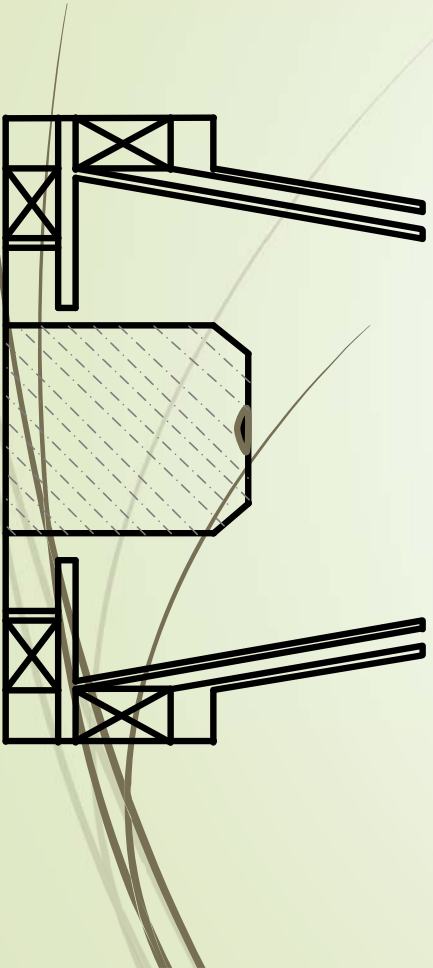
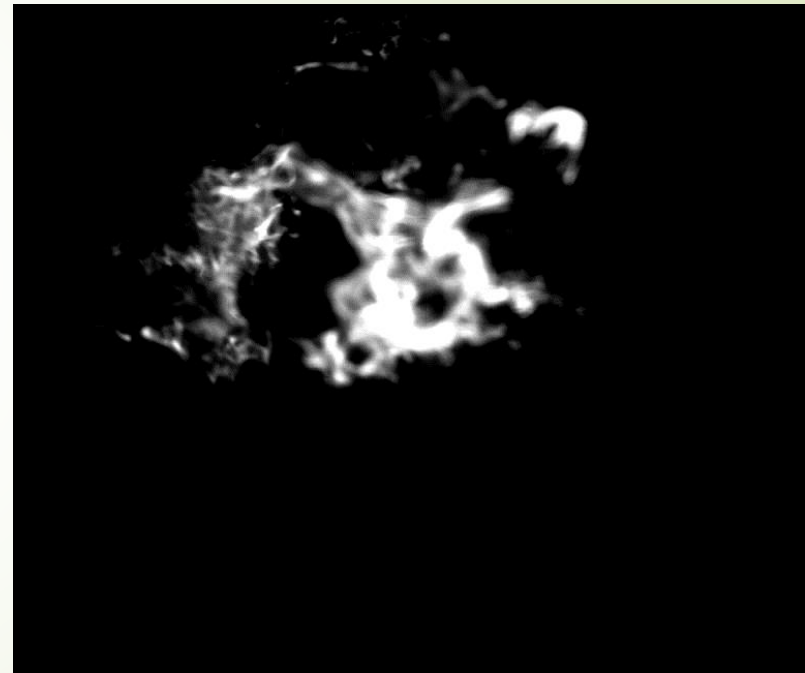


Blowoff Videos

Burning Stable



Blowoff Event



Conclusion

- ▶ Alternative fuel design space includes different sensitivities to blowoff.
- ▶ Cetane number appears to be the blowoff controlling parameter, although other factors are likely influential.
- ▶ Results are consistent across 14 different fuels.

Thank You

23

