# Hypergolic Propellants Lab

https://engineering.purdue.edu/Hypergol/

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HYPERGOLIC PROPELLANTS CHARACTERIZATION

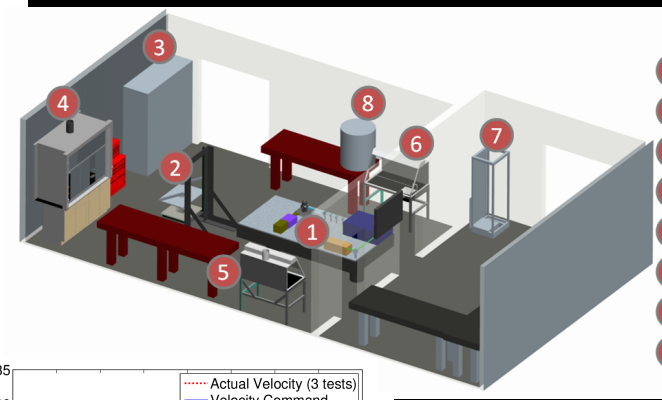
## Dedicated to mixing, vaporization, and combustion of hypergols

Developed for MMH/NTO compatibility

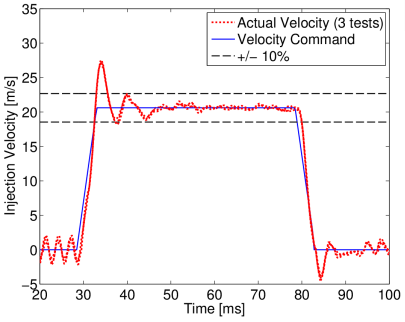
Designed with support from DoD, industry, Purdue fire protection engineers and industrial hygienists

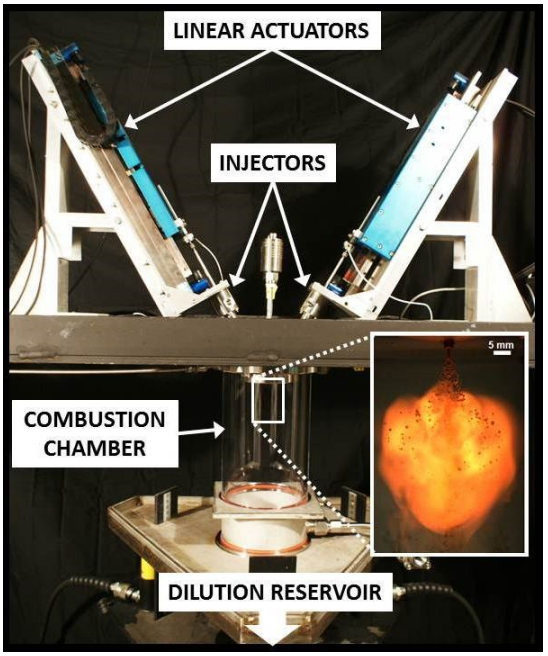
Recent experiments:

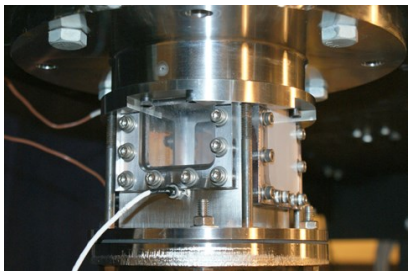
- Ignition and combustion experiments with unlike doublet electromechanically driven injection system in 360° optically accessible combustion chamber
- Viscosity measurements at rocket injection conditions (for gels & suspensions in liquids)
- Drop size and OH distribution measurement with MMH/air diffusion flame
- Drop size and temperature measurements under NTO environments
- Time resolved IR and UV spectrometry of MMH/nitric acid
- Development of reaction kinetic sets and liquid to ignition CFD models
- Dynamic meshing, run time balancing, and phase tracking in OpenFoam based models of hypergolic ignition

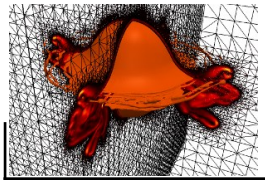



1. OH PLIF and Chamber
2. Impinging Jet Rig
3. Capillary Rheometer
4. Main Fume Hood
5. Fuel Workstation
6. Oxidizer Workstation
7. Data Acquisition System
8. Resodyne Mixer

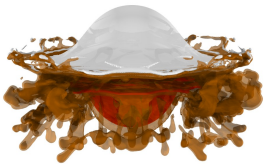


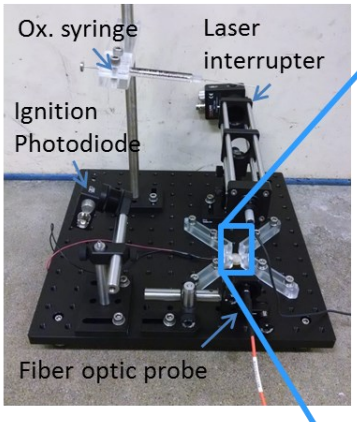



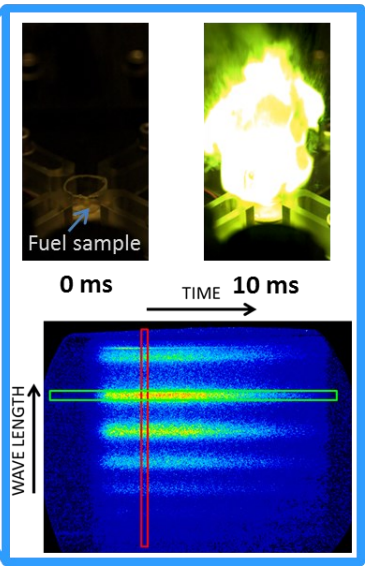





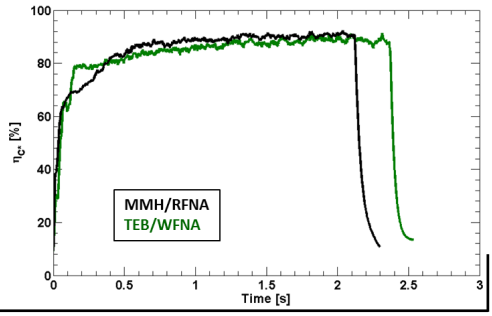
MMH/NTO liquid to ignition modeling with dedicated chemistry sets






Time resolved streak camera spectroscopy with boron based hypergols




Performance characterization with unlike doublet injector at ~200 psia

## MAJOR EQUIPMENT

- 1300 CFM ventilation system with 3 fume hoods and a portable canopy hood
- Ignition/combustion setup with μm and μs injection resolution at up to 120 ft/s injection velocity
- Agilent Cary 680 FTIR with ATR spectroscopy
- Streak camera coupled UV spectrometer for 200 nm to 900 nm sweeps over 100 ns to 30 ms at up to 40 ps resolution
- Resodyn LABRAM mixer, 500 g mixing capacity
- 5kHz OH PLIF laser diagnostic capability
- Dedicated LABView based data acquisition and control
- MMH and $NO_2$ gas analyzers (Dräger Pac III and Interscan 4000)
- Capillary rheometer capable of shear rate up to $10^6$ $s^{-1}$

R&D in hydrogen storage systems and materials

HYDROGEN SYSTEMS LAB

# Hydrogen Systems Lab

https://engineering.purdue.edu/H2Lab/

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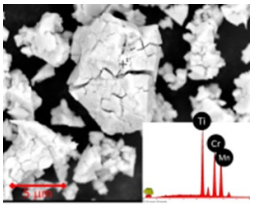
## HYDROGEN STORAGE RESEARCH

**Dedicated to design, development, and characterization of hydrogen storage systems and materials**

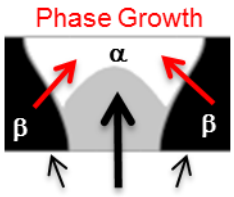
Research supporting industry, DoD partners, and national and international laboratories

Recent experiments:

- Storage of hydrogen gas in high pressure metal hydrides and chemical hydrides (automotive and aerospace applications)
- Development of metal hydride heat pumps for stationary heat recovery
- Magnesium hydride characterization
- $H_2$ storage in cryogenic sorbent materials
- In situ thermal property measurement
- Hydride phase field modeling




SEM image of TiCrMn (5 μm scale) and elemental detection



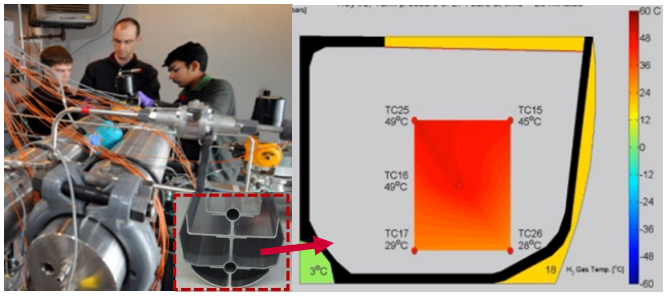

Modeling of geometry-dependent transition of rate-limiting processes

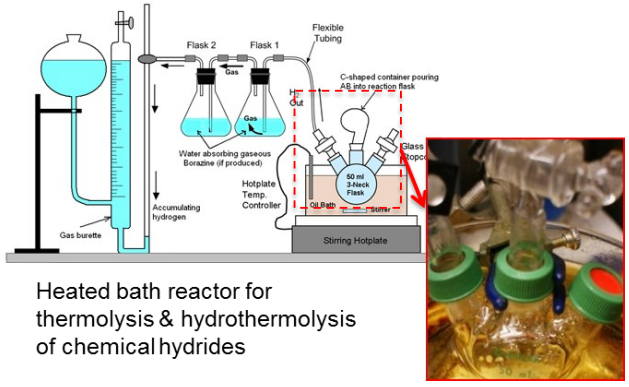
## Volumetric Gas Absorption (Sievert) System

- Hydrogen absorption up to 700 bar
- Pressure-composition isotherms (PCI) and kinetics of $H_2$ storage materials
- Rated from -30°C and 80°C using thermoelectrics

## Metal & Chemical Hydride Reactions

- Multiple kilogram scale hydrogen storage systems at pressures up to 410 bar; remotely controlled
- Analytical and CFD models of the filling process match experimental results

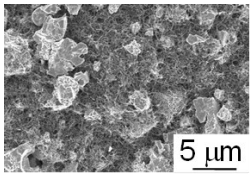


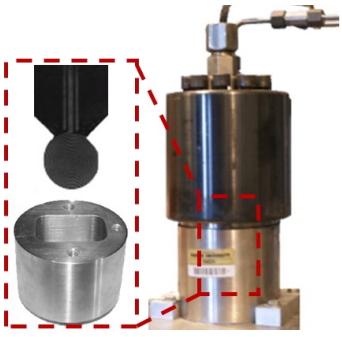



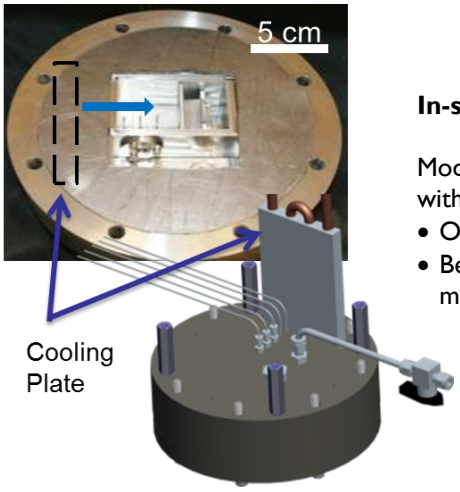

Heated bath reactor for thermolysis & hydrothermolysis of chemical hydrides

## In Situ Thermal Property Measurement

- Designed for operation at up to 630 bar $H_2$ gas
- Wide sample size range
- Study enhancement of metal hydride conductivity with polymers, metals, and carbon nanotubes






**In-situ $MgH_2$ Characterization:**

Modular hydride reactor system with:

- Optical access (visible and IR)
- Bed force and expansion measurements

## MAJOR EQUIPMENT

- 6 port glovebox: 1.5 $m^3$ of working space, Argon atmosphere (< 0.1 ppm $H_2O$ and $O_2$)
- Scanning electron microscope with 100,000x magnification energy dispersive X-ray spectroscopy (EDS) for element identification
- Large scale hydrogen storage: 22 $ft^3$ at 6000 psi, sized for propulsion and automotive applications, remotely controlled
- Volumetric gas absorption (Sievert) system
- Remotely controlled hydrogen storage experiments with LABView based data acquisition and control
- Agilent Micro GC 3000 gas chromatograph

**Major sponsors: General Motors, DoE, DoD, Industrial Technology Research Institute (ITRI) of Taiwan**