

Effect of Oxygenate Additives on Soot Production During Diesel Combustion

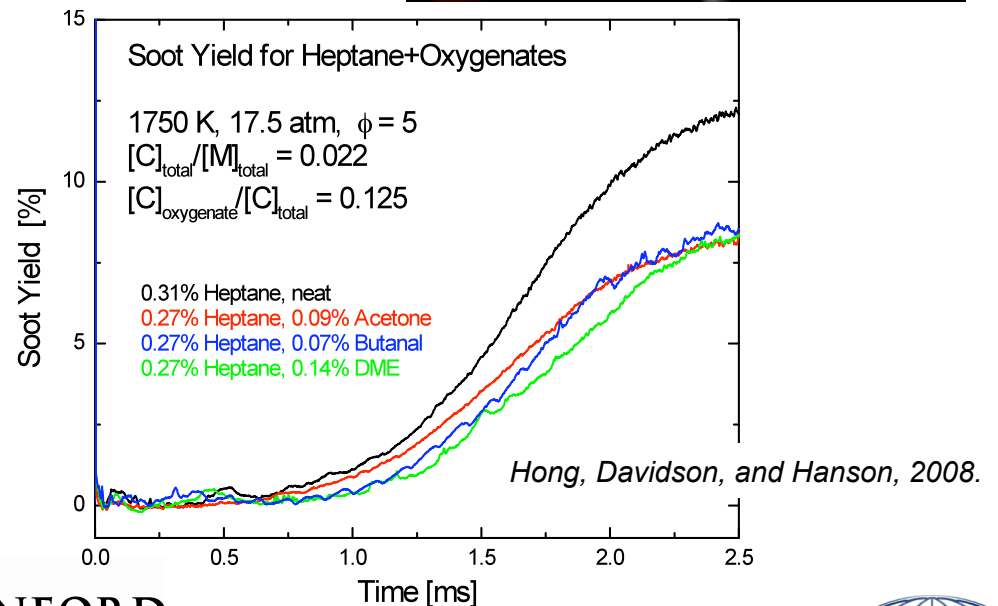
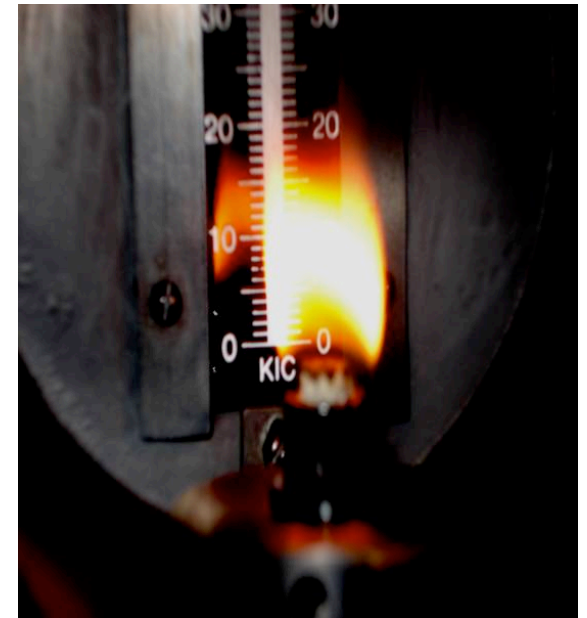
Stephen Kirby and André L. Boehman, The Pennsylvania State University

Ripudaman Malhotra, SRI International

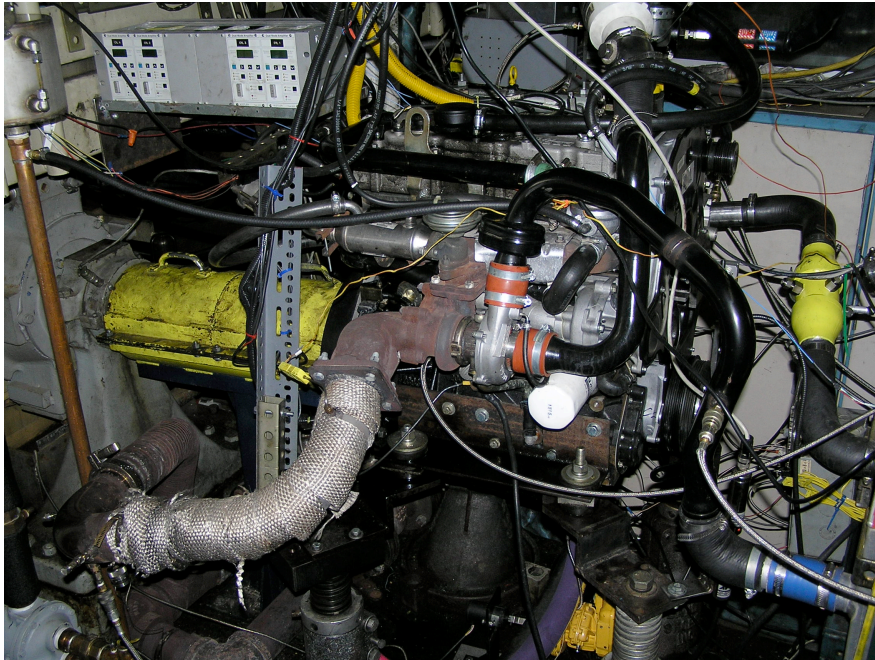
Tom Bowman and Heinz Pitsch, Stanford University

Motivation

- Validate findings from smoke point measurements and high-pressure combustion tests that ketone and aldehyde functions are effective soot suppressants in diesel combustion



Experimental: Engine Conditions



- 2.5 L common rail diesel engine run at 3600 rpm and loads of 51 and 153 ft.lb; no EGR
- Base fuel: BP15, an ultra low sulfur diesel
- Oxygenates: Acetone, pentanone, butanal, DME, and DMM
Treat rate: 5wt% Oxygen
- Pilot and main injection timings locked

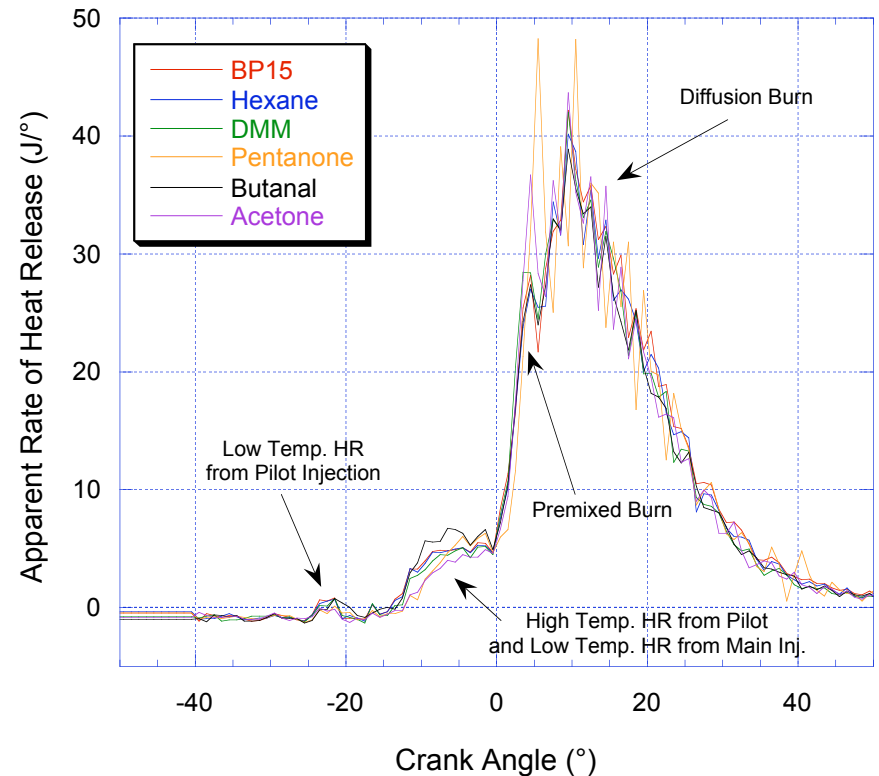
Experimental: PM Measurement

- PM mass measured by collection on filters using Sierra BG-2
- Filters extracted with dichloromethane to remove soluble organic fraction (SOF)
- Particle size distribution measured using Scanning Mobility Particle Sizer (SMPS) with a thermodenuder (TD)



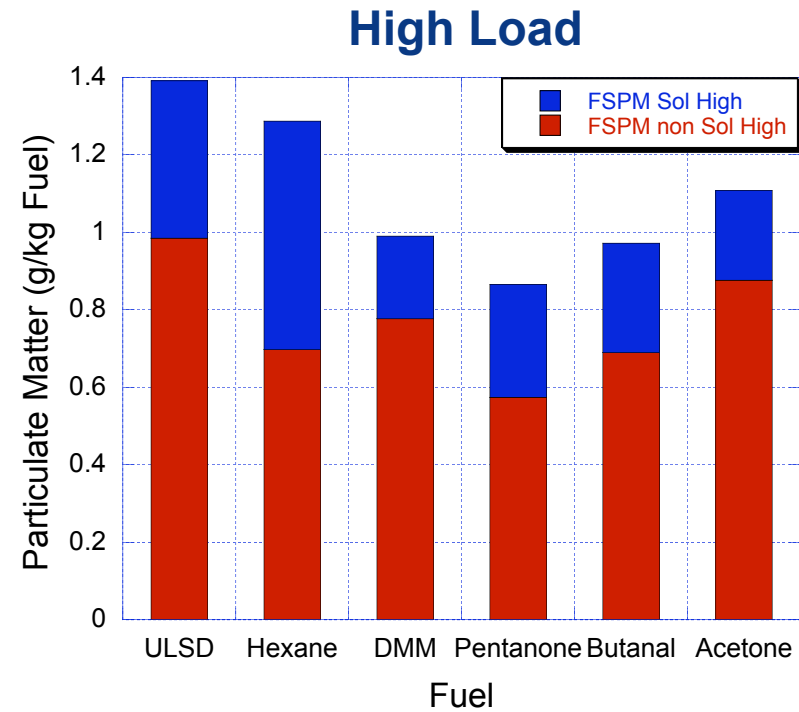
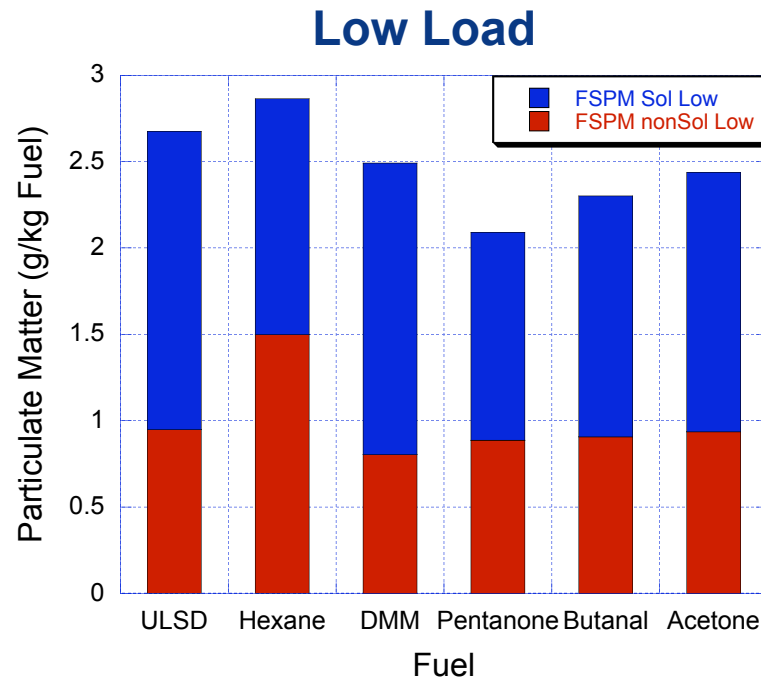
Results: Engine Performance

- Pentanone and acetone show delayed premixed burn at low load
- At high load the trend in magnitude of the premixed burn was: pentanone > acetone > DMM > butanal = ULSD = hexane



Heat release data for oxygenated fuels in a 2.5L DDC common rail engine at high speed and low load

Results: PM Emissions

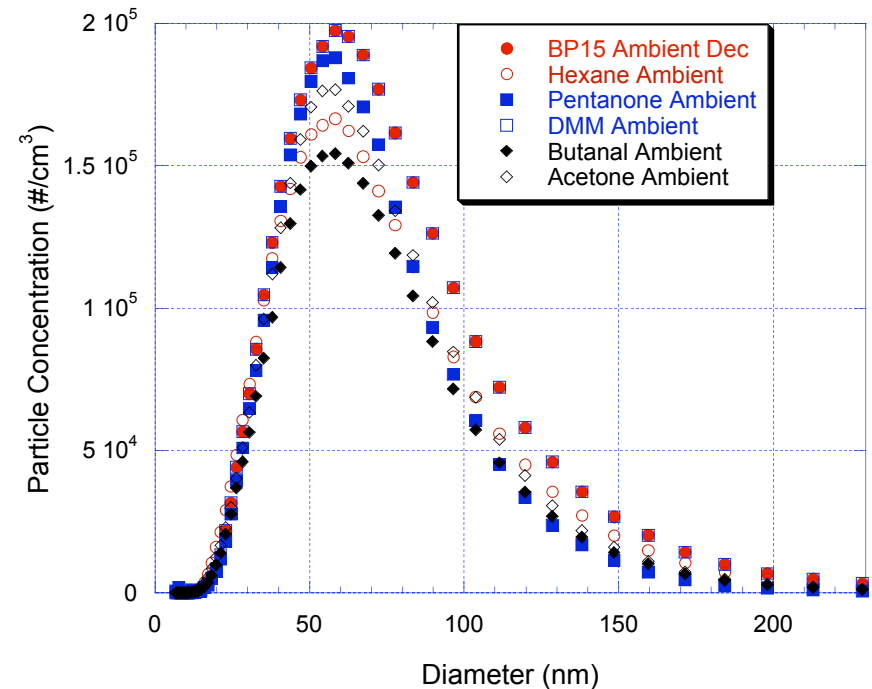


- Lower total PM mass and non-SOF mass with oxygenates at low load
- All oxygenates similar non-sol PM mass

- Lower total PM mass and SOF mass with oxygenates at high load
- Non-sol PM trend: pentanone < butanal < DMM < acetone

Results: PM Emissions Particle Size

- Particle size distribution shifted to fewer, smaller particles with addition of an oxygenate under both engine conditions
- Trend continued when volatile fraction (VOF) was removed



Total particle concentration at low load with varying particle size. TD set at 40°C.

Conclusions

- Addition of an oxygenate to diesel fuel reduced the total mass of PM produced during engine tests at low and high loads.
- Trend of soot suppression for 5 wt% atomic oxygen in the fuel:
smoke point lamp studies: pentanone > butanal > acetone > DMM.
high load non-soluble PM data: pentanone > butanal > DMM > acetone.
- Both techniques indicated pentanone as the greatest soot suppressor studied

