Motivation:
Gasoline Direct Injection (GDI) engines have penetrated the automotive market due to their increased fuel efficiency and high power output. However, due to incomplete fuel vaporization and partially fuel-rich zones, GDI engines tend to produce more particulate matter than compared to conventional spark ignition engines. To aid in reducing PM, GDI engines could benefit from a particulate filter. However, adding a filter in the exhaust system is known to increase backpressure, which is especially problematic for GDI operation and can lead to a fuel penalty. To efficiently regenerate a Diesel Particulate Filter (DPF), the reactivity of GDI particulate matter must be understood. Previous work has shown that diesel particulate matter formation, nanostructure and reactivity is a function of fuel type. With ethanol being the leading and currently deployed biofuel for gasoline engines, there is interest in studying the effect it has on GDI PM reactivity.

Goal:
Investigation of the kinetics and mechanism for the oxidative reactivity of GDI particulate and the effect of ethanol blending on the reactivity and structure.

Approach:
Using the CRCL Microreactor (left) and Hiden QGA Mass Spectrometer:
- Quantify the relative fractions of volatile and fixed carbon by Temperature Programmed Desorption (TPD)
- Examine the effective oxidation rates by Temperature Programmed Oxidation (TPO) in 20% O2, 15% H2O with balance Ar.
- Measure the Arrhenius kinetics by Isothermal Pulsed Oxidation (IPO) and study how they change with extent of reaction.
- Investigate total specific surface area by flowing BET in order to understand the nature of the physical structure of the samples and how they change with extent oxidation.

Results:
Likely due to the higher volatility of ethanol and gasoline hydrocarbons, both the E0 and E30 PM samples were found to have lower volatile fractions as compared to MD-Diesel PM. These were measured by TPD to 600°C in Ar.

The TPO comparison shows that the E30 PM is more reactive and the E0 PM is less reactive than the MD-Diesel PM.

Future Work:
- Finish analysis of additional temperatures for Isothermal experiments for both PM samples.
- Investigate whether reactivity is changing over the course of the burnout – and if there should be k values defined by burnout segment.
- Transmission electron microscopy (TEM) could verify the physical difference in the nanostructure.
- Publish paper

Summary:
The effect of fuel type was investigated by studying the bulk oxidative reactivity of the nascent and devolatilized PM by TPO, quantifying the volatile content by TPD, measuring the surface area with extent of reaction by BET, and determining the kinetic parameters with IPO. Further work is ongoing to include more temperatures for the IPOS and to

Conclusions to Date:
GDI E30 PM is more reactive than Diesel PM, which is in turn more reactive than GDI E0 PM. The differences in effective reaction rates come from physical differences in the carbon nanostructure. It is likely that ethanol has an effect on how GDI PM is being formed in cylinder similar to what has been seen for other biofuels. We suspect that GDI E30 PM is composed of shorter carbon lamellae than Ethanol.

We believe that this indicates that the nanostructure is uniform and has been strongly influenced by the ethanol. It is likely comprised of short, curved lamellae. HR-TEM would confirm this hypothesis.

References: