Gasoline Aromatic and Oxygen Content Impact Formation of Secondary Aerosols from a Gasoline Direct Injection Vehicle

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Background & Motivation:

Secondary Aerosol (SA) has been measured to contribute up to ~75% of total PM2.5 in anthropogenic regions (Huang, 2014). Total SA consists of inorganic salts and secondary organic aerosol (SOA). Inorganic salt formation is well understood, and can be accurately modeled if emission inventories are accurate and up to date. Organic aerosol formation is much more complex and less understood. SOA is formed through the photo-oxidation of volatile organic compounds and in urban areas, gasoline powered vehicles are major contributors.

Driven by stringent legislative measures on vehicle GHG emissions, the transportation sector has changed significantly in the past decade with the introduction of gasoline direct injection (GDI) engines. In GDI engines, liquid fuel is spray directly into the combustion chamber allowing a higher compression ratio than greater efficiency. Improving mixing due to incomplete fuel evaporation, results in increased PMI content for GDI engines (Karavalakis, 2015; Liang, 2013). The effect of the market shift to GDI engines on total SOA formation has not been fully explored.

Another variable that may affect the SA formation potential of emissions is the composition of the fuel used. Currently conventional gasoline has 10% ethanol content but it has been found that higher ethanol blends could possibly lead to greater fuel efficiencies and lower greenhouse gas emissions (EESL, 2015). A fundamental issue linked with high ethanol content in fuel, is the increased production of ozone, acetone, and polyaromatic hydrocarbons. (PAN) (Correa, S.M), however, the effect on SA formation is not currently understood.

Chamber, Vehicles, Fuels, & Testing Procedure:

UCR’s MACH1 was used for irradiation experiments
- 30 m² 2mil FEP Teflon film reactor (largest mobile chamber in the known universe)

Vehicle was tested over duplicate cold-start LA-92 driving cycles on 8 fuels

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<th>Make &amp; Model</th>
<th>Emission Std.</th>
<th>Engine &amp; Mileage</th>
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Exhaust was introduced to the chamber throughout the entire LA92 driving cycle (excluding hot soak)

1.0 ppm of H2O2 was injected as the initial OH radical source

Test Facilities: Vehicle Emissions Research Laboratory (VERL) & Atmospheric Processes Laboratory (APL):

- 30 m² FEP Teflon film reactor
- AADCO Purified Air
- Characterization of irradiated emissions
- Six Phase instrumentation
- Aerosol instrumentation

PMI and SOA formation and fuel composition effects:

- **SOA Formation & Fuel Composition Effects:**
  - High aromatics have larger SOA formation & largest total carboxenous mass
  - Increasing aromatics led to higher SOA production
  - Higher SOA formation for the high PMI fuels with increasing ethanol content – A possible charge evaporative effect will influence both the primary PMI and SOA
  - A trend towards lower SA formation for the low PMI fuels
  - The splash blends (F5 & F8) showed lower SA formation – combination of oxygen content and aromatics dilution
  - Overall, lower SA formation with higher ethanol fuels

- **Conclusions & Future Work:**
  - Less volatile fuel properties (TT0, T90, and C10) Aromatics also correlated with SOA formation
  - Non-oxygenated fuels will produce more SOA than oxygenated fuels
  - Possible ethanol evaporative cooling for the high PMI fuels affected the production of SOA
  - Positive correlation with PMI
  - In future an SOA-focused PMI may improve PMI correlation to SA formation

References


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