Carbonaceous Aerosols Emitted from Light-Duty Vehicles Operating on Ethanol Fuel Blends

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In the United States and elsewhere ethanol is being used as a renewable fuel in motor vehicles in an effort to reduce greenhouse gases and dependence on imported oil. Air pollution is among the many environmental and public health concerns associated with increased ethanol use in vehicles. *Jacobson* [2007] showed for the U.S. market that full conversion to e85 ([85% ethanol, 15% gasoline]—the maximum standard blend used in modern dual fuel vehicles—from 100% gasoline may cause excess morbidity and mortality risk. Higher ozone, peroxy acetal nitrate (PAN), and volatile carbonyl concentrations in urban air are associated with ethanol fuel combustion in vehicles. Of the studies examining combustion emissions from light-duty vehicles (LDVs) operating on ethanol-gasoline blends, the vast majority characterize air toxics (e.g., benzene, 1,3-butadiene, acetaldehyde, and formaldehyde), criteria pollutants (e.g., CO, NOx, particulate matter [PM], and O_3), or greenhouse gases[*Graham et al.*, 2008; *Yoon and Lee*, 2011]. Fewer examine the PM composition despite its climate relevancy, toxicological importance, and use in regulatory-based air quality and predictive dispersion models.

This study aims to examine carbonaceous aerosol emissions from three Tier 2-certified 2008 model year LDVs burning e0, e10, and e85 fuel blends at -7°C and 24°C. The LDVs were tested on an electric chasis dynamometer using the LA-92 Urban Driving Cycle (UDC). Exhaust was collected from a dilution tunnel and constant volume sampling system. Chemical analysis of fine particle matter ($PM_{2.5}$) was the main focus of the study and was conducted using thermal-optical transmission (TOT) and thermal extraction (TE)-gas chromatography-mass spectrometry (GC-MS) techniques. Statistical regression models were applied to log-scaled measurements to assess relationships with the covariates of temperature, fuel type, and UDC phase.

UDC phase-integrated organic carbon (OC) and elemental carbon (EC) emissions factors varied from 30 to 618 µg/km and from 1 to 2748 µg/km, respectively. Figure 1 shows the log-transformed OC and EC data. UDC phase 1 and the -7°C cell temperature produce significantly higher carbonaceous aerosol emissions, and the relatively low OC/EC ratios are an interesting feature of these data.

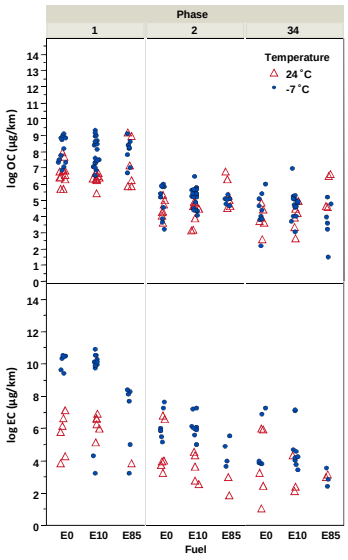

Figure 1. Fine aerosol OC and EC emissions (µg/km) from LDVs burning e0, e10, and e85 at -7°C and 24°C.

Historically, the OC and EC proportions in PM emissions from LDVs have varied rather substantially. In the U.S. emissions database (SPECIATE), OC (50.3% ± 40.3%) is significantly (p > 0.0001) higher than EC (30.7% ± 23.3%). The present LDV emissions study has produced higher mean pooled EC (60% ± 30%) likely due to the aggressive nature of the LA-92 UDC. Further analysis regarding the implications of these results will be provided. In addition, more on the exhaustive semivolatile organic compound (SVOC) analysis, including the polycyclic aromatic hydrocarbon (PAH), hopane and sterane marker, and saturated hydrocarbon emissions factors will be discussed.

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