On-road emission factors of PM pollutants for light-duty vehicles (LDVs) based on urban street driving conditions

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Related Publications


State of the Art

Light-duty vehicle (LDV) studies

Caldecott Tunnel bore (no heavy-duty vehicles (HDVs))
- Kirchstetter et al. 1999; Geller et al. 2005; Ban-Weiss et al. 2008

I-110 Freeway portion (no HDVs)
- Ning et al. 2008; Kuhn et al. 2005; Phuleria et al. 2007

Chassis dynamometer studies for various LDVs
- Schauer et al. 1999; Yanowitz et al. 1999; Fujita et al. 2007

On-road studies

Mobile laboratory equipped with continuous instruments
Vehicle used:

- Honda Insight Hybrid 2011

Instruments used:

- **7 Personal Cascade Impactor Samplers (PCIS)**
  - collect PM_{10-2.5}, PM_{2.5-0.25}, and PM_{0.25}
  - Teflon and Quartz substrates
  - Total flow 70 LPM

- **Battery-powered pumps**

- **TSI Q-trak**
  - CO₂ measurements

- **Garmin GPS for tracking**
Sampling Campaign Details

PCIS Impactor Set Up

On-road campaign

Honda Insight Hybrid 2011
**Sampling Logistics and Chemical Analysis**

**Logistics:**

- **Wilshire and Sunset Boulevards**
- M-F from 6AM – 5PM on March 9-16 and April 26-May 5, 2011
- N=2, each representing ~60h of sampling per run

**Chemical analysis:**

- Total metals (SF-ICPMS)
- Organic species (GC/MS)
- EC/OC (Thermal Evolution/Optical Transmittance)
Fuel-based Emission Factors (EFs)

$E_p = \text{emission factor of pollutant } P \text{ in mg/(kg of fuel burned)}$

$[P] = \text{pollutant concentration in } \mu g/m^3$

$[CO_2] = \text{CO}_2 \text{ concentration in } C/m^3$

$st \text{ and } bg \text{ refer to streets and background site (USC campus), respectively}$

$w_c = \text{carbon weight fraction of gasoline, 0.85}$

(Kirchstetter et al. 1999; Phuleria et al. 2006; Ning et al. 2008)
## Earlier LDV studies

<table>
<thead>
<tr>
<th>Sampling location/test cycle</th>
<th>Sample/test period</th>
<th>Relevant results for comparison</th>
<th>Reference</th>
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<tbody>
<tr>
<td>Wilshire/Sunset Blvds</td>
<td>March-May 2011</td>
<td>-</td>
<td>current study</td>
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<tr>
<td>LDV freeway (northern portion of I-110)</td>
<td>May-Jun 2004, Jan 2005</td>
<td>mass, EC, OC, metals, PAHs, hopanes and steranes</td>
<td>Ning et al. (2008)</td>
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<tr>
<td>LDV tunnel (Bore 2 of Caldecott Tunnel)</td>
<td>Aug-Sept 2004</td>
<td>PM mass, EC, OC, metals</td>
<td>Geller et al. (2005)</td>
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<tr>
<td>LDV tunnel (Bore 2 of Caldecott Tunnel)</td>
<td>Aug-Sept 2004</td>
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<tr>
<td>LDV dynamometer study (warm-start UDC)</td>
<td>Summer 2001</td>
<td>mass, EC, OC, metals, PAHs, hopanes and steranes</td>
<td>Fujita et al. (2007)</td>
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<tr>
<td>LDV dynamometer study (cold-start FTP)</td>
<td>-</td>
<td>PM mass, PAHs, hopanes</td>
<td>Schauer et al. (2002)</td>
</tr>
</tbody>
</table>
EFs – PM components and elements

Emission factors (mg/kg of fuel)

PM$_{10-2.5}$
PM$_{2.5-0.25}$
PM$_{0.25}$
Ratios of PM$_{2.5}$ in Various LA Freeways and busy streets vs USC (urban background site)—from *Kam et al Atmos Environ 2012*

2-5 fold higher levels of PM-bound metals from road dust in busy streets compared to urban background
Total PM2.5 PAH concentrations in Wilshire/Sunset Blvds 8 times higher than urban background site of USC (Kam et al, Atmos Environ, 2012)
Significant non tailpipe emissions of metals

- Wilshire/Sunset
- LDV freeway (Ning et al. 2008)
- LDV tunnel (Geller et al. 2005)
- LDV dyno (Fujita et al. 2007)
EFs – PAHs and Hopanes and Steranes

- Pyrene
- Benz(ghi)fluoranthene
- Benz(a)anthracene
- Chrysene
- Benzol(e)pyrene
- Indeno(1,2,3-cd)pyrene
- Benzol(ghi)perylene
- Coronene
- Benzo(b+k)fluoranthene
- Benzo(e)pyrene

Emission factors (µg/kg of fuel)

PM$_{10-2.5}$
PM$_{2.5-0.25}$
PM$_{0.25}$
PM$_{2.5}$ EF comparison to earlier studies

* Ning et al. 2008 reported positive OC adsorption artifact; Geller et al. 2005 omitted ultrafine fraction
PM$_{2.5}$ EF comparison to earlier studies

- Wilshire/Sunset
- LDV freeway (Ning et al. 2008)
- LDV tunnel bore (Phuleria et al. 2006)
- LDV dyno (Fujita et al. 2007)
- LDV dyno (Schauer et al. 2002)
Concluding Remarks

- On-road sampling of two major surface streets (Wilshire/Sunset Blvd) in Los Angeles, CA

- Emission factors are representative of a LDV fleet characterized by frequent acceleration and deceleration

- Previous LDV studies were conducted near freeway and tunnel, and chassis dynamometers

- EFs from current study showed higher levels of metals and trace elements associated with vehicular abrasion (Fe, Ca, Cu, and Ba) and crustal origins (Mg and Al)

- PAH EFs from current study are lower than LDV from tunnel studies and higher than LDV freeway studies

- Hopane and sterane EFs are comparable between studies
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