Thermographic analysis of gasoline and diesel exhaust particles

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Objective

This study was carried out to evaluate the relative amounts of organic carbon (OC) and elemental carbon (EC) contributed by particles emitted from diesel and gasoline engines in Mexico City.

Motivation

Particles from combustion in gasoline and diesel motors are often the major source of pollution in urban areas. Usually they are dense spheres in the size range of 20 – 30nm (primary particles) which rapidly coagulate to form aggregates(3). Although diesel cars obtain 25 to 35 percent better mileage and emit less carbon dioxide than similar gasoline vehicles, they can emit 25 to 400 times more mass of particulate black carbon and associated organic matter ("soot") per mile. The Polycyclic Aromatic Hydrocarbons (PAH) associated to vehicular combustion particles constitute an important public health problem.

Methodology

In this study, particles were collected directly at the vehicle tailpipes onto aluminium substrates in the eight stages of a Micro Orifice Uniform Deposit Impactor (MOUDI) over the size range from 0.18 – 10µm in aerodynamic diameter. All samples were analysed with Evolved Gas Analysis (EGA) and some of the samples were also analysed with a scanning electron microscope (SEM) to characterise particle shape, structure and elemental composition.

Thermograms obtained from the EGA technique were evaluated to determine the carbon content in the samples. The carbon compounds were classified in three temperature ranges: 1) OC whose thermal degradation occurs below 250°C, 2) OC > 250°C and < 500°C, and 3) the elemental carbon that evolves at T > 500°C).

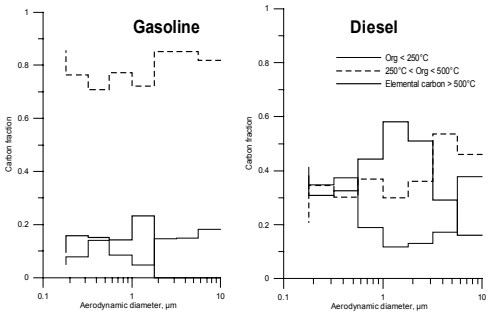

Figure 1. Fraction of organic and elemental carbon to total carbon in gasoline and diesel particles. The fraction of OC range 2 is present in almost 70% of gasoline particles with no contribution from elemental carbon. Diesel particles have on average 40% of elemental carbon and much lower concentration of OC than particles emitted from gasoline combustion.

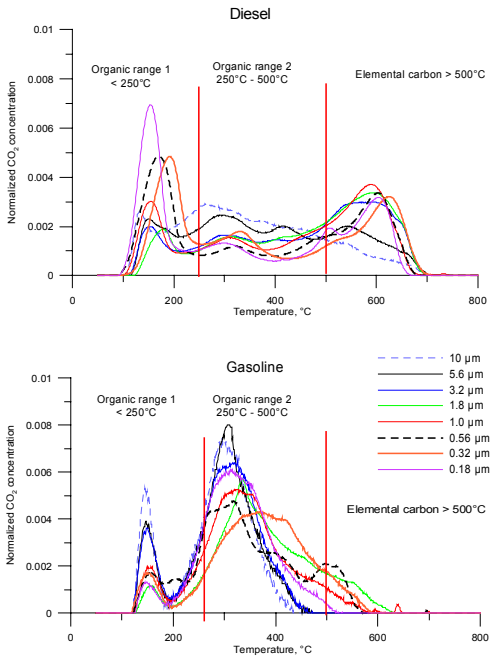

Figure 2. Thermographic analysis of 10 – 0.18µm aerodynamic diameter particles. (**Above**) Diesel particles show high concentrations of OC range 1 and elemental carbon. (**Below**) Gasoline particles present higher concentration of OC range 2 (perhaps PAH) than diesel particles in all size cuts.

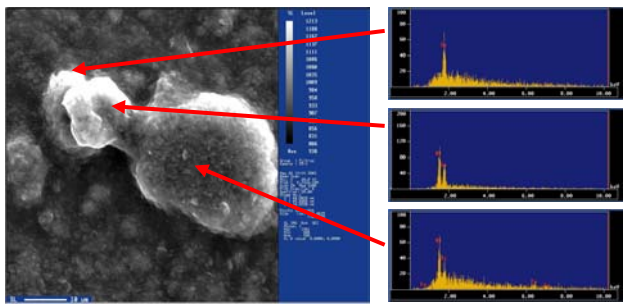

Figure 3. (**Left**) Image of organic particle emitted from a diesel engine, from a sample on the 1.0µm aerodynamic diameter stage. (**Right top**) Spectrum of structure in the extreme left. (**Right middle**) Spectrum of round particle at centre. (**Right below**) Spectrum of big particle at the right. A layer of silicon spray was applied to avoid bouncing of particles on the aluminium substrates(2). Fe is a very common additive present in diesel emissions(1).

Results

- Gasoline particles collected at all size cuts contained very low EC concentrations, whereas on average, in diesel particles EC accounted for 40% of the total carbon.
- Virtually no EC was observed in gasoline particles in size cuts larger than 1.8µm. In smaller size cuts, EC was at most 20% of the total carbon.
- Most of the EC in diesel particles was found in size cuts smaller than 3.2µm and had the mode in the 1.8µm size cut.
- Gasoline particles contained primarily OC in range 2, accounting for about 80% of the total carbon. It is likely that these compounds are associated to PAHs present in the particles.
- Diesel particles contained about the same fraction of OC in ranges 1 and 2.
- SEM analysis identifies metals such as Fe, Zn, Ce, Pt, Cu in the particles sampled. In combination with the thermographic analysis it is possible to better identify the source of particles.

References
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