Mass-mobiltiy Relationship of Soot Generator and Diesel Soot

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Mass-mobility relationship of soot generator and diesel soot

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When measuring aerosol particle size distributions many different techniques can be used. For the different techniques particle diameter can be defined differently depending on the principle of the technique. For example, the Differential Mobility Analyzer (DMA) classifies particles according to their mobility diameter (d_{me}), impactors according to the particle aerodynamic diameter, etc. To be able to compare the results, or convert between number and mass size distributions, information about the particle morphology and density is needed.

In this study the DMA–Aerosol Particle Mass Analyzer (DMA-APM) technique was used to study the effective density (ρ_{eff}) and mass fractal dimension of particles resulting from two combustion sources; a combustion soot generator (Abdulhamid et al., 2009) operated at 3 different air-to-fuel ratios, and an idling diesel engine (VF Passat -98, passenger car). Additionally, during all measurements a Scanning Mobility Particle Sizer (SMPS) measured the mobility number size distribution.

The DMA-APM system (Park et al., 2003) consists of a DMA coupled in series with an APM. The DMA selects particles one mobility diameter (50 to 400 nm were characterized). The APM consists of two rotating cylinders rotating at a rotational speed, ω. The mass size distribution of the selected particle size is measured by scanning the APM voltage (V_{APM}) and from the peak voltage, the particle mass (m) is calculated according to (Park et al., 2003):

$$m = \frac{\pi}{6} d_{ve}^{3} \rho_{true} = \frac{\pi}{6} d_{me}^{3} \rho_{eff} = \frac{qV_{APM}}{r^{2}\omega^{2} \ln\left(\frac{r_2}{r_1}\right)}$$

where r is the difference in radius of the APM inner and outer cylinder (r_2 - r_1) and q the particle charge.

Making the assumption that the radius of gyration is linearly proportional to the mobility diameter, which should hold for the conditions in this study (Park et al., 2003), the mass fractal dimension (Df_m) is given by $m = Cd_{me}^{Df_m}$.

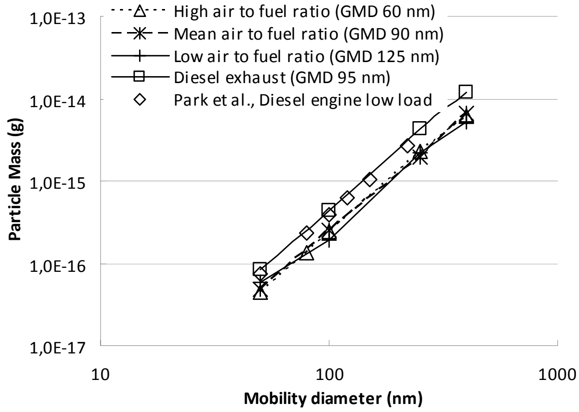

Figure 1. Particle mass as a function of mobility diameter.

The results of the study are presented in Figure 1 and 2. For the soot generator the aerosol effective densities were found to vary between 0.85 and 0.16 g/cm^3 over the size range studied, indicating that the particles become progressively more irregular as the mobility size increased. The fractal dimension of the burner particles was determined to 2.22, 2.35 and 2.38, increasing with increasing air to fuel ratio.

The particles from the diesel engine had a higher effective density than those resulting from the soot generator, and a fractal dimension of 2.41. This is very similar to the results found in Park et al., 2003 where the fractal dimension of a high-duty diesel engine working at low load was determined to 2.41 and at high load 2.33, see Figure 1 and 2. Assuming an inherent material density of 2 g/cm^3, extrapolation of the densities gave a primary particle size was of 25 nm for the diesel particles and 10-19 nm for the soot generator.

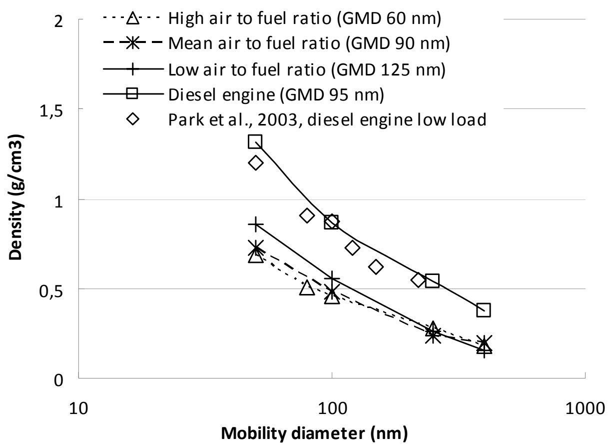

Figure 2. Effective densities for the aerosols studied.

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Park K.., Cao F., Kittelson D.B., and McMurry P.H. (2003). Relationship between Particle Mass and Mobility for Diesel Exhaust Particles, Environ. Sci. Technol., 37,577-583.

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