J15.8 Fast response measurements for the dispersion of nanoparticles in vehicle wake and street canyon

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Abstract

Current regulations to control atmospheric particulate matter (PM) use PM_{10} ($D_p \leq 10$ μm) and $PM_{2.5}$ ($D_p \leq 2.5$ μm) mass concentrations, but not particle number concentrations (PNCs). Recent epidemiological and toxicological studies suggest correlations between adverse health effects and exposure to ultrafine particles ($D_p \leq 100$ nm) at high number concentrations (Pope III and Dockery, 2006). Our experimental results show that hourly averaged PNCs for roadside measurements, where people may actually inhale particles, can increase above ambient levels by an order of magnitude in certain size ranges (Kumar et al., 2008a). Moreover, instantaneous or short time averaged (i.e., over seconds) PNCs can be up to three orders of magnitude larger than hourly averaged PNCs (Kumar et al., 2008b); exposure of ultrafine particles at high concentrations during short bursts may aggravate existing pulmonary and cardiovascular diseases (Brugge et al., 2007), and hence require regulation.

For the first time, a fast response differential mobility spectrometer (DMS500), originally designed to measure the particle number distributions (PNDs) and concentrations from engine exhaust emissions, was deployed to measure the particles in the 5–1000 nm size range at a sampling frequency of 10 Hz. Measurements were taken at a fixed position (20 cm above road level) in the middle of the wake of a moving diesel–engined car together with separately taken measurements along the roadside in a street canyon in Cambridge, UK. The aims of the measurements were to investigate the evolution of particle number emissions in the wake of a moving car by determining the competing influences of dilution and transformation processes (nucleation, condensation and coagulation etc.) on the PNDs.

Results from vehicle wake measurements suggested that effect of transformation processes was nearly complete within ≈1 s after the emissions due to rapid dilution of PNDs in the vehicle wake. Furthermore, roadside measurements in a street canyon showed that the time for the traffic emissions to reach the roadside was ≈ 45 ± 6 s. These observations suggested a hypothesis that the transformation processes are generally complete by the time the particles are measured at roadside and total particle numbers can then be assumed as conserved. This hypothesis was supported by our other studies when roadside and rooftop measurements were compared for the production of new particles at both levels (Kumar et al., 2008a–b), suggesting that complexity of transformation processes can be ignored for the modelling of nanoparticles in street canyons after the very near exhaust processes.

Keywords: Fast response measurements, Particle number distribution, Vehicle wake, Street canyon

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