Lung deposited surface area size distributions in different urban areas

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Numerous of studies are reporting particle mass and number concentrations in urban areas (e.g. Putaud et al., 2004). However, it has been argued that none of these metrics properly describes the negative effect of particulate matter on human health. In this respect, particle surface area concentration is more relevant (Oberdörster, 2001). Some surface related quantities, as the lung deposited surface area or the active surface area, have been proposed to be the metric for the negative health effects. Common for these surface related quantities is that they are rather close to the response of a diffusion charger. For example, the nanoparticle surface area monitor (NSAM) is based on diffusion charging and it measures the lung deposited surface area concentration. In this study, an electrical low pressure impactor (ELPI) is calibrated and used to measure the lung deposited surface area concentrations in different urban environments. The advantage of the ELPI is that, in addition to the total concentration, also the surface area size distributions can be analyzed.

Three different measurement campaigns were carried out in the metropolitan area of Helsinki. The first campaign was held in December 2010, the second in February 2012, the third campaign in October 2012. All the campaigns included stationary measurements at different measurement sites and on-road measurements with a mobile laboratory ‘Sniffer’. The stationary measurements were carried out at two traffic sites (TS), at two residential area sites (RA) and in the city center. The on-road measurements represent the variety of different routes in the metropolitan area including the city center, major roads and residential areas. In order to use the ELPI for surface area measurements, the instrument was calibrated by comparing the output of the instrument to the signal of an NSAM and to the size distributions given by a differential mobility particle sizer (DMPS). In all the experiments, the ELPI was used to measure particle surface area size distributions. The results were also compared to simultaneous PM2.5, PM10 and particle number measurements.

The average surface area size distributions for different urban environments are shown in Figure 1. It is seen that the shape of the distributions varies and the surface area is emphasized in different size ranges at different environments. The total surface area concentration is clearly higher at the traffic sites and in the city center compared to the results from the residential areas, as expected. Especially, the soot mode and non-volatile particles from traffic seem to dominate in the surface area distribution. In the residential areas, the surface area size distribution can also be affected by the amount of long range transported background aerosol. By analyzing the size distributions, the role of different particle modes on the total exposure of the lung deposited surface area can be estimated.

Figure 1. The averaged surface area size distributions from the stationary measurements and from the on-road measurements. TS refers to traffic site and RA to residential area.

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