PARTICLE EMISSION SIZING DURING HOUSEHOLD VACUUM CLEANING

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Introduction

During the last few years measurements of size distributions of ambient and indoor aerosols have received increasing attention, e.g. for the investigation of possible exposure to nanoparticles and fine particulate matter posing health risks. Numerous sources of particles have been documented, including a large variety of anthropogenic aerosols. The World Health Organization reported around 3.7 million deaths every year as a result of exposure to fine particulate matter, covering both household and ambient air pollution (WHO, 2014).

The size distribution, number concentration, and surface area of nanoparticles represent key parameters in the determination of their risk, as has been identified by many health studies. One study reported a high rate of pulmonary deposition of nanoparticles, and their ability to travel from lung to systemic sites as well as their high inflammation potential (Oberdörster et al., 2005). In addition particles in the nanometer range are found to be more biologically active due to their greater surface area per mass (Gurr et al., 2005).

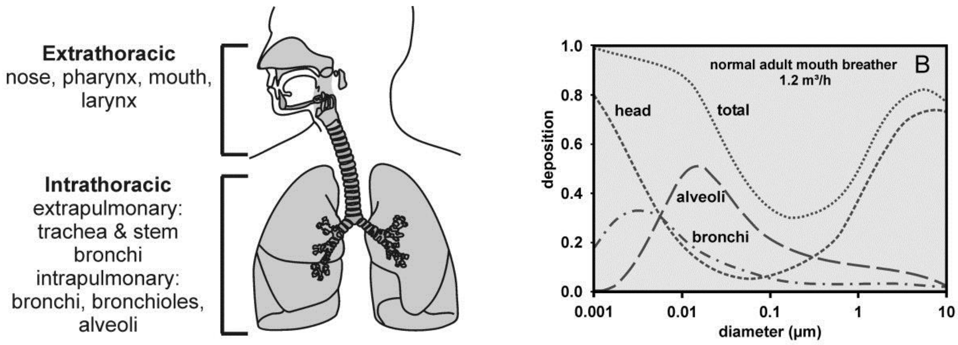

Figure 1: Deposition of nanometer-sized and ultrafine particles in the human respiratory system. Adapted from Geiser and Kreyling, 2010.

Method and Results

An experiment of indoor aerosol emissions during standard vacuum cleaning is presented here. Data were collected to represent particle number concentration exposure during this common household activity. The total number concentration was measured with two battery-operated, portable particle sizers described elsewhere (Tritscher et al., 2013), the NanoScan SMPS (TSI, model 3910) that measures number-size distributions from 10 to 420 nm, and an Optical Particle Sizer (OPS, TSI model 3330) that measures the size of particles from 300 nm to 10 µm. The data from both instruments were merged and post-processed with version MIM 2.0 of the Multi-Instrument Manager software (Han et al., 2011). This software facilitates merging of data based on electrical mobility diameter with those based on optical equivalent diameter to compile a single, wide-range data set. The software is particularly useful when the agreement of size distributions from different equivalent diameters is challenging.

During the experiment we measured the performance of two types of vacuum cleaners: the first device with a standard paper filter and a paper bag to collect the dust. The second vacuum cleaner used a water tank to collect the dust and remove it from the air. We found that the total number concentration and size distribution varied based on the type of vacuum cleaner used. In Figures 1 and 2 we show an example for particle size measurements of vacuum cleaners with NanoScan SMPS and OPS with the resulting composite fit. The curve fitting algorithm (red line) uses up to three modes of lognormal distribution function to curve fit the data. The blue and green lines represent average data from the instruments taken during vacuum cleaning. The red line in Figure 1 represents the software fitting function in an experiment with the vacuum cleaner using a paper bag, and shows one dominant peak at 13 nm. The red line in Figure 2 is the result of an experiment with the vacuum cleaner using a water tank. It shows a bimodal shape and main peaks at 19 and 87 nm, respectively.

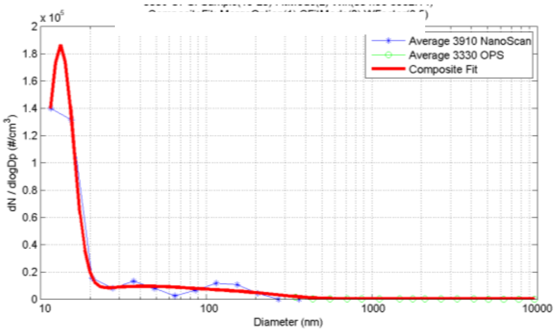

Figure 1: Example of a number-size distribution of a vacuum cleaner using a paper bag.

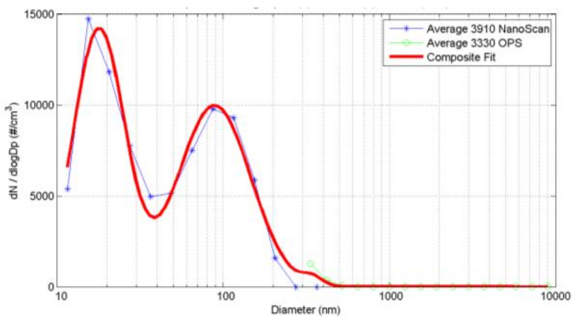

Figure 2: Example of a number-size distribution of a vacuum cleaner using a water tank.

Conclusions

We used two portable particle size instruments, a NanoScan SMPS and an OPS, to determine the size and concentration of the particle emission resulting from household vacuum cleaning. The Multi-Instrument Manager used to merge and post-process data from both instruments was found to be an easy to use tool. With this combination of battery-powered instruments and merging software, online data acquisition over a wide particle size range and data processing from two instruments is possible. During our measurements we observed that the total number concentration during experiments with a vacuum cleaner using a paper bag was four times higher than the number concentration of a vacuum cleaner using a water tank. We conclude that certain types of vacuum cleaners are elevating the number concentration of nanometer and ultrafine particles in indoor environments. However, we would need to conduct more experiments to analyze this effect and its cause in more detail.

Literature

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