Source characterisation and estimation of daily residential exposure to ultrafine particles

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Humans, at least in the industrialized part of the world, spend a large part of their lives in their homes, and are hereby subjected to various indoor generated airborne particles, which often dominate the particle concentrations (Wierzbicka, 2008). Most of our knowledge concerning particles of indoor origin and their potential health effects is derived from epidemiological studies based on measurements of outdoor particles. These particles are considered to be the background exposure indoors. There is a need to further investigate the contribution from human activities to concentrations in indoor environments.

The aim of this study has been to characterize the air quality in residential dwellings, identify sources of indoor particles (<300 nm) on the basis of residential activities, quantify their source strength and from measurements and detailed log books estimate daily residential exposure levels (concentration*hours per day).

For seven consecutive days, time resolved stationary measurements were conducted in randomly selected homes (N=42) in the urban area of Lund in southern Sweden. Number concentrations, and mean diameter of particles <300 nm were monitored with Discmini (University of Applied Sciences, Windisch, CH) and Nanotracer (Philips Aerasense). Since a majority of particles generated by indoor activities are smaller than 100 nm, results from the Nanotracer and Discmini could be considered as good approximations of ultrafine particles. The accuracy of both the Nanotracer and Discmini are ±30% (Asbach et. al., 2012). All measurements were made during off-pollen season (October-April). The instruments were placed centrally in the dwelling, but not in, or close to, the kitchen. CO_2 data was collected, by a custom-made instrument from Technical University of Denmark, DTU, and used to calculate air exchange rates based on the ASTM standard (2002). The habitants filled in detailed activity log books, and reported when they were present or absent in the dwelling.

A data classification was carried out by sorting the data into two categories: occupancy time (at least one person present in the home) and non-occupancy time. Occupancy time occurred during an average of 77 % of the measurement period. Activities occurred on average 33 % of the occupancy time. Average concentration of particles (<300 nm) during occupancy time was 49000±64000 cm^{-3}, and during non-occupancy time 6000±4000 cm^{-3}. The origins of elevated concentrations were identified using the activity logs. Several of the concentration peaks were results of a combination of two or more particle generating activities. 13 different single activities could however be identified as contributing significantly to the indoor air particle concentration (Figure 1). Cooking activities (boiling, frying, oven, microwave oven, toaster, and their combinations) and candle burning were shown to be the major particle sources, contributing to 31 and 26 % of the daily residential exposure, respectively.

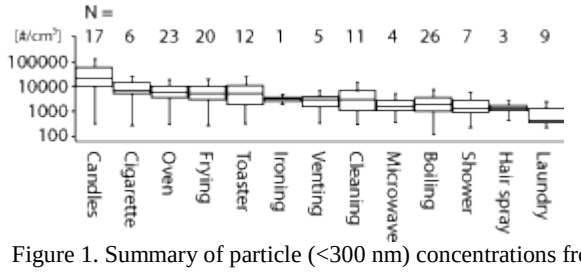

Figure 1. Summary of particle (<300 nm) concentrations from various indoor sources. Box plots denote minimum values, 1st quartile, median, 3rd quartile and maximum values. N is the number of events the calculations are based on.

Source strengths could be estimated for 8 of the 13 activities, using the method described by Wierzbicka (2008). The particle source strengths ranged from $1 \cdot 10^{12}$ to $8 \cdot 10^{13}$ min^{-1}.

The average daily residential exposure was estimated to 399000 cm^{-3}h/d, the same range as in Californian homes as reported by Bhangar et al (2011). Indoor activities contributed to 86 % of the daily residential exposure, while the background (outdoor generated) particles contributed to 14%.

Most particles generated by indoor activities are small (<300), and have the potential to be deposited deep in the respiratory system. A major part of the daily residential exposure has its origin in human activities, thus these should be considered in personal exposure assessment and their potential health effects should be evaluated. Time resolved data and activity logs are important tools to assess the contribution of various activities to the overall residential exposure.

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