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Ultrafine particle exposure in Danish residencies

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SUMMARY
We measured ultrafine particle concentrations in 56 Danish residences, estimated the daily integrated exposure of the occupants and apportioned this exposure to source events. The residential daily integrated particle number (PN) exposure in the homes was substantial and source events, especially candle burning, cooking, toasting and unknown activities, were responsible on average for ~65% of the residential integrated exposure. Residents of another 60 homes were then asked to carry a backpack equipped with a GPS recorder and a portable monitor to measure real-time individual exposure over ~48 h. UFP exposure occurring in various microenvironments was estimated. The fractional contribution of each microenvironment to the daily integrated personal exposure corresponded to the fractions of the day the subjects spent in each microenvironment. The home environment accounted for 50% of the daily personal exposure, indoor environments other than home or vehicles contributed with ~40%, and being in transit or outdoors contributed 5% or less.

PRACTICAL IMPLICATIONS
Indoor sources should be considered in future assessments of ultrafine particle exposure and associated risks. Personal monitoring coupled with GPS provides the opportunity to assess the personal daily UFP exposure in various microenvironments and help to identify the microenvironments that may pose increased health risks.

KEYWORDS
Residential exposure, Source apportionment, Personal exposure, Ultrafine Particles

1 INTRODUCTION
Recent studies advocate that ultrafine particles (UFP) may be of concern regarding adverse health effects. Indoor sources, such as e.g. cooking, smoking or candle burning can significantly contribute to the total UFP exposure in homes (Wallace, 2006). When such indoor sources are not present, particles of outdoor origin are the major contributors to the overall indoor particle number (PN) levels. However, personal monitoring of UFP has been done in a limited extent in the past. The contribution of indoor and outdoor sources to the total personal exposure to UFP is therefore not well understood.

2 MATERIALS/METHODS
Particle number concentrations (PN; 10 - 300 nm in size) were continuously measured using a NanoTracer PNT1000 (Philips Aerasense, Netherlands) over a period of ~45 hours in 56 residences of non-smokers. The residents kept diaries on occupancy and particle related activities. The average residential daily integrated exposure (Bhangar et al., 2011) was calculated and apportioned among sources. In a companion study PN concentrations were

continuously measured over a period of ~45 hours in the living rooms of another 60 residences of non-smokers. One occupant in each home carried around a backpack with another monitor during the entire time of the monitoring (including outdoors and during work and pleasure activities). The backpack also contained a GPS tracking device. The integrated daily exposure to UFP was calculated for periods spent in the home, active transport, passive transport, other indoor locations – buildings and other outdoor locations.

3 RESULTS AND DISCUSSION

The highest particle number concentrations were measured when occupants were present and awake (GM: 22.3 x 10^3 cm^{-3}), the lowest when the homes were vacant (GM: 6.1 x 10^3 cm^{-3}) or the occupants were asleep (GM: 5.1 x 10^3 cm^{-3}). Source events resulted in increased PN concentrations. Exposure to elevated PN concentrations persisted for several hours after the source ceased to emit fresh particles. Source events were responsible for ~70% of the residential daily integrated PN exposure. Events contributing the most were candle burning and cooking (Table 1). Candle burning and cooking were responsible for nearly 60% and 30%, respectively, of the integrated exposure in the homes where these activities occurred.

For the personal monitoring, higher concentrations were measured during the periods when the index person was away from home compared to when the index person was within the home. The highest median UFP concentration was obtained during passive transport (vehicles). The home environment accounted for 50% of the daily personal exposure. Indoor environments other than home or vehicles contributed with ~40%. Being in transit or outdoors, each contributed 5% or less to the daily exposure (Figure 1). The fractional contribution of each microenvironment to the daily integrated personal exposure roughly corresponded to the fractions of the day the subjects spent in each microenvironment.

Table 1. Contribution of events to the total *residential* integrated exposure during occupancy.

Activity type (No.of homes with the event)	Average contrib. to the total residential integr. exposure (%)
Cooking (37)	29
Toasting (12)	11
Candle burning (28)	58
Special events (3)	22
Unknown (52)	14
Window opening (11)	3

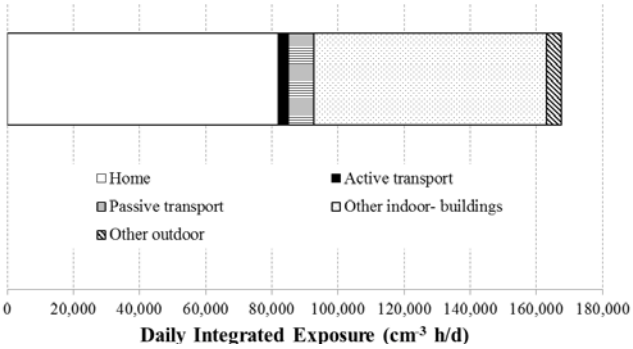

Figure 1. Apportionment of the daily integrated exposure to UFP between various microenvironments (geom.mean)

4 CONCLUSIONS

A significant fraction of the total personal daily integrated exposure to UFP occurs within the home and shouldn't be overlooked when evaluating the potential health effects of ultrafine particles. Indoor sources significantly contribute to this exposure. Outdoor sources are presumably responsible for most of the exposure that occurs away from home.

5 REFERENCES

Bhangar S, Mullen NA, Hering SV, et al. 2011. Ultrafine particle concentrations and exposures in seven residences in northern California. Indoor Air 21, 132-144.

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