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Topic C3: Nanoparticles in indoor environment

HUMAN EXPOSURE STUDIES OF AIRBORNE PARTICLES FROM COMMON SOURCES

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Keywords: Aerosols, nanoparticles, chamber studies, biomarkers

INTRODUCTION

Several epidemiological studies show correlation between exposure to airborne particles and adverse health effects. Exposure measures used are often based only on mass concentration of particles with sizes below certain limits (PM₁₀, PM_{2.5}, PM₁, i.e. particulate matter with diameters less than 10, 2.5 and 1 μm , respectively) regardless the shape, morphology and chemical composition of the particles. There is a need for information based on precise experimental methods in order to increase our understanding on the mechanisms behind the adverse effects and to determine the exact nature of exposures which can cause the adverse effects.

The aims of the study are i) to develop settings for experimental human exposure studies for commonly abundant indoor air particle types and ii) to experimentally determine physiological effects on human test subjects.

METHODOLOGIES

A stainless steel walk-in chamber of the volume 22 m³ is used (Figure 1). Air can only enter and leave the chamber through a well-controlled ventilation system. Systems for exposure of various commonly abundant indoor particles are being developed. Test subjects have been and are being exposed to particles from candle lights, terpene-ozone reactions, metal inert gas welding, zeolite particles from detergent residues, cooking and diesel engine in a controlled way with respect to concentration, size distribution and particle characteristics. Concentrations and size distributions are in accordance with what can be found in indoor environments where air is contaminated by particles from these sources. Test persons (three or four at the time are sitting in the chamber) are being exposed to one particle type at one occasion and clean (virtually particle-free) air at another occasion, according to a double blind protocol. A number of biomarkers from the test subjects are determined (e.g. markers of inflammation in body fluids, ECG-registration with heart rate variability (HRV) analysis and

respiratory physiological parameters). Biochemical biomarkers are measured immediately after and 24 hours after exposure.

RESULTS AND DISCUSSION

Exposure studies show that effects of airborne particles from different sources on biomarkers can be studied in a well-controlled experimental model systems. Various test aerosols could be artificially created and added to the chamber air with realistic properties compared to what can be found in real environments.

Aerosols with particles from candle lights, terpene-ozone reactions, welding, diesel engine were achieved with realistic particle concentrations and characterized with respect to mass and number concentrations and chemical composition (Isaxon et al. 2013 I ; Isaxon et al. 2013 II., Pagels et al. 2009; Wierzbicka et al. 2014). Mass concentrations achieved were typically 200 $\mu\text{g}/\text{m}^3$ for candle smoke, 80 $\mu\text{g}/\text{m}^3$ for terpene-ozone generated particles, 1 mg/m^3 for welding fume and 300 $\mu\text{g}/\text{m}^3$ for diesel exhaust particles. In addition to these particle types, zeolite particles from detergent residues in textiles (Gudmundsson et al. 2007) are being generated in mass concentrations of 300 $\mu\text{g}/\text{m}^3$ and particles from frying hamburgers in concentrations of 300-400 $\mu\text{g}/\text{m}^3$.

Results on effects on biomarkers have, until today, been observed for candle light smoke: significant increase of high frequency HRV compared to clean air and compared to terpene-ozone-generated particles (Hagerman et al. 2014). Exposure to diesel exhaust caused a significant decrease in the high frequency of heart rate variability spectrum. Heart rate variability is since long a well-recognized, noninvasive, independent method, for cardiovascular risk prediction in high prevalent groups (Malik, 1996). The studies, so far show significant negative impact on HRV of diesel exhaust compared to clean air and significant positive impact of candle light smoke on HRV compared to clean air and compared to terpene-ozone generated particles.

CONCLUSION

Experimental chamber human exposure methodology have been developed in order to examine effects of exposures to common indoor airborne particles. The studies have so far shown significant negative effects on heart rate variability of diesel exhaust compared to particle-free air and significant positive effects on heart rate variability of candle light smoke compared to particle-free air and exposure to terpene-ozone generated particles, for healthy individuals.

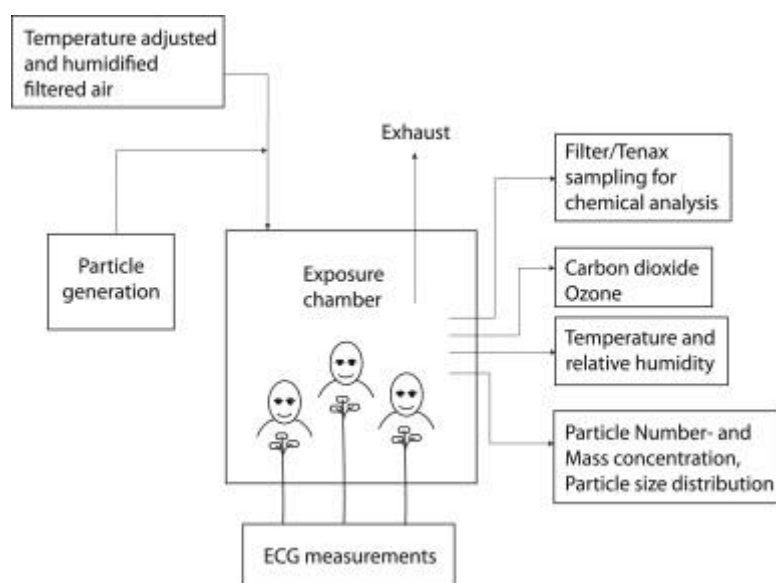


Figure 1. Simplified sketch of the experimental set-up for the chamber exposure studies.

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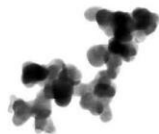


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1 million nanoparticles/min.



1 billion nanoparticles /min.

Many studies show adverse effects of airborne particles.

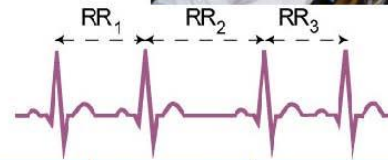
Measures used are often based on mass concentrations (PM₁₀, PM_{2.5}, PM₁, i.e. mass of particles with diameters less than 10, 2.5 and 1 μm)

The aim is to experimentally determine physiological effects on human test subjects of particles from common sources.





ECG-recordings
Beat-to-beat-variability



Results

SOURCE	CONCENTRATION		MEDIAN DIAMETER	NUMBER OF TEST PERSONS	CHANGE IN HF OF HRV (%)	INCREASE/DECREASE	p
	Mass ($\mu\text{g}/\text{m}^3$)	Number ($\#\text{cm}^{-3}$)	(nm)				
Candle	200 ± 30	$8 \cdot 10^5$	Bimodal 23; 270	18	$+22 \pm 5$	↑	0.01
Terpene. Ozone	80 ± 10	$3 \cdot 10^4$	100	17	-7 ± 5	↘	0.4
Diesel	280 ± 30	$4 \cdot 10^5$	90	18	-15 ± 5	↓	0.04