Generation and Monitoring of Laser Printer Aerosols for an in-vivo Exposure Study with Human Probands

S. Seeger[1], M. Ehret[2], B. Herbig[2], R. Jörres[2], S. Karrasch[2], J. Langner[1], D. Nowak[2] and R. Schierl[2]
[1]Department 4.2 Materials and Air Pollutants, BAM, 12489 Berlin, Germany
[2]Institute and Outpatient Clinic for Occupational, Social and Environmental Medicine, Member of German Centre for Lung Research, DZL, 80336 Munich, Germany
Keywords: laser printer, particle emission, in-vivo exposure, health effects.
Presenting author email: stefan.seeger@bam.de

Laser printers (LP) emit - besides volatile organic compounds - ultrafine particles (UFP) at rather high rates but only negligible amounts of fine particles (FP), Barthel *et al* (2013). Since many years health problems in conjunction with the use of these ubiquitous office machines have been repeatedly reported, e.g. Pirela *et al* (2014). Cause-and-effect relation between LP particle emissions and reported specific medical conditions could neither be established nor completely ruled out by field studies, e.g. in copy shops or by in-vitro investigations. This motivated to perform the first human in-vivo-study worldwide on possible acute health effects of the exposure of probands to UFP emissions from LP, Seeger *et al* (2014).

For the study 23 healthy control individuals, 14 individuals with mild asthma and 15 individuals who reported discomfort when working with LP were carefully selected from a group of candidates. All volunteers were exposed in a 32 m³ test chamber on two different days in random order to an exaggerated particle number concentration of UFP, generated by preselected laser printers (HLE, high level exposures) and to a typical low indoor background concentration of UFP and FP without any measurable contribution from laser printers (LLE, low level exposures), adding to a total of 104 exposure sessions. During the sessions the subjects intentionally had the visual and acoustical impression of LP activity but they did neither know the particle exposure level in advance nor were able to realize it during the sessions. An exposure period of at least 75 minutes was necessary to let the probands work through several tests. Medical effects from HLE and LLE on the volunteers were recorded and compared using functional, biochemical and psychological methods. They covered as many of the complaints as possible which are typically reported by affected persons and can be tested by quantities that can be tested objectively. The medical tests comprised pre- and post-exposure examinations of the study subjects.

For HLE two laser printers with very high UFP emission and known size distributions and chemical compositions were used. A printing procedure was devolved in order to achieve a repeatable and easily describable particle exposure in the test chamber. It turned out that alternating printing of several pages with a monocolor test pattern was appropriate to quickly achieve and maintain a high and uniform concentration over 60 minutes without opening the chamber and paper reloading. A plateau of 10^5 particles per cm³ in total number concentration could be maintained after a steep initial rise. The plateau was nicely reproducible with a COV of less than 10%. This was verified by monitoring the aerosol in each session with a FMPS (Fast Mobility Particle Sizer, TSI 3091) and an OPC (Optical Particle Counter, Grimm 1.108) covering a particle size range between 5.6 nm and 20 µm. Two extremely low-emitting laser printers were used in the same way for LLE. The probands had the same acoustic and visual impression of printer activity but the low background FP concentration (~ 7,000 per cm³) was practically unchanged. The high reproducibility of HLE and LLE sessions was a prerequisite to obtain meaningful results in the medical tests.

Summarizing the findings, the medical tests do not suggest from a clinical perspective that high particle loads from LP emissions cause a disease process in the way that corresponds to the spectrum of reported diseases attributed to LP. Since the study reflects a short-term scenario, only limited conclusions are possible with long-term exposures.

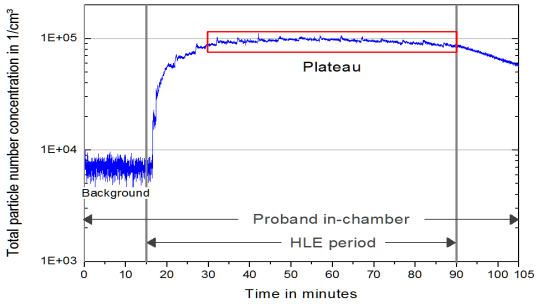

Figure 1. Typical particle concentration process during a HLE in the exposure chamber

This work was supported by the DGUV (German Social Accident Insurance) under grant FF-FP0294A.

Barthel, M., Seeger, S., Rothhardt, M., Wilke, O., Horn, W., Juritsch, E., Hahn, O., Jann, O. (2013) *UBA Texte, **74***, UBA German Environment Agency, https://www.umweltbundesamt.de/en/publikationen/measurement-of-fine-ultrafine-particles-from-office

Seeger, S., Langner, J., M. Ehret, M., Herbig, B., Jörres, R., Karrasch, S., Nowak, D. and Schierl, R. (2014) *Final Report **FF-FP0294A***, DGUV, German statutory accident insurance, http://www.dguv.de/Projektdatenbank/0294A/3228509v1.pdf

Pirela, S., Sotiriou, G., Bello, D., Shafer, M., Bunker, K., Castranova, V., Thomas, T., Demokritou, P., Marr, J. and Morrissey, S. (2014) *Nanotoxicology*. **11:1-9**.