Occupational exposure parameters for characterization of nanoparticulate matter

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People face various degrees of exposure to nanoparticles—both natural and caused by human activity (engineered and non-engineered nanoparticles)—on a daily basis. However, there is still a lack of both theoretical and practical understanding of the impact of nanoparticles on human health and possible mechanisms of their interaction with biological objects. Recent developments in the use of nanotechnology and discussions about it in the scientific community have resulted in the new science of nanotoxicology, specializing in research on nanodevices and nanostructures in living organisms (Sellers et al., 2009). In order to determine the potential risks and safe levels of human exposure to nanoparticles, it is necessary to develop reliable methodologies for the identification of potential hazards.

Three different environments (three case studies) were chosen in order to perform pilot measurements for this study: an office environment (without printing and copying processes) to assess the background level (level without nanoparticles generated by human activity during work processes) and distribution of nanoparticles; the metalworking industry to assess the processes involving welding (shielded metal arc welding) and grinding, which emit a significant amount of particles at the nanoscale range (<100 nm), and the woodworking industry to assess particles of mainly biological origin.

The particles were collected by electrical low-pressure impactor (ELPI+, Dekati Ltd, Finland) on aluminium (Al) substrate foils for SEM (scanning electron microscopy with a Nova NanoSEM 650) analyses and a 14-stage cascade impactor was used for air quality measurements to measure the particle size distribution, number, surface area, and mass.

The measurements of the total particle number concentration (particles/cm^3) showed a very high concentration level of particles [272,370 particles/cm^3 with a counted median diameter (CMD) of particles of 54 nm] in workplaces in the metal industry (welding and grinding) and almost four times lower concentration (80,510 particles/cm^3, CMD = 12 nm) in workplaces in the woodworking industry (grinding and polishing). The particle number concentration level in the office environment (11,707 particles/cm^3, CMD = 39 nm) showed very low concentrations.

There is also a similar tendency for the analysis of total mass (mg/m^3) data, where the results show the lowest total mass of particles in the office environment (0.17 mg/m^3, CMD = 4.4 µm) even though it exceeds the recommended limit value of 0.015 mg/m^3 of the Government of Alberta (2009), while the highest total masses were detected in workplaces in the metal industry (4.17 mg/m^3, CMD = 3.5 µm), and the results for these particular workplaces also exceeded the occupational exposure limit value for Latvia (Rule no. 325, 2007), which is set at 4.00 mg/m^3 . The total mass concentrations were unexpectedly low in workplaces of the woodworking industry (0.52 mg/m^3, CMD = 6.6 µm), where they did not exceed the occupational exposure limit value for Latvia, which is set at 6.00 mg/m^3. This could be explained by the wood dust characteristics, with most of the particles exceeding 10 µm in size, so additional further analyses by field measurements by ELPI+ and total dust mass detection by gravimetric methods are required to describe the wood particle mass concentration distribution by particle size as related to total mass concentrations.

The measurements for workplace particles across the three different environments described above were also analysed by SEM. It was detected that particles consisted of several inorganic elements, and there were some differences in their chemical compositions. Particles from the metal-working industry comprised Fe > C > Si > Ca > Zn > Cr > Mn (in decreasing order), while particles from workplaces in the wood-processing industry comprised C > Si > Ca > Fe > Mo > Na (in decreasing order).

The results obtained by an electrical low-pressure impactor (ELPI+) in this study show that the particle number concentration and surface area are significantly higher in workplaces of the metal- and wood-working industries but concentrations of mass are lower. Therefore, the characteristics of mass should not be used on their own as a representative parameter for the description of occupational exposure and cannot be used for occupational risk assessment as a single parameter. The nanoparticles ratio together with occupational exposure limits could possibly be used as the background for occupational risk assessment. At the same time, it is essential to mention that the nanoparticle ratio alone is insufficient and parameters like concentration levels, chemical composition, and shape characterization must also be taken into account, especially in occupational toxicology studies done in the future.

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