Nanoparticle exposure levels at a research facility during handling of TiO_2, ZnO and carbon nanotubes

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The use of nanotechnology is increasing explosively along with the number of workers handling engineered nanomaterials (ENMs). The objective of this study was to find out if the workers are exposed to ENMs, when nanomaterials are handled in exhausted enclosures. During the measurements, 1) equipment (tubes, ducts and different parts of the aerosol generator) contaminated with TiO_2, ZnO and carbon nanotube (CNT) ENMs were cleaned inside a glove box using running water and compressed air, and 2) TiO_2 and CNT ENMs were handled (spooned into a beaker, poured from one beaker to another, beakers were shaken) inside a fume hood. Particle number concentration was monitored with CPCs and transmission electron microscopy (TEM) samples were collected inside and outside the fume hoods. The average particle number concentrations inside the enclosures were 3600 and 1100 particles/cm^3 during cleaning operations and ENM handling, respectively. The use of compressed air for cleaning increased the concentrations shortly up to 100000 particles/cm^3 inside the enclosures. There were mainly TiO_2 particles in TEM samples collected inside the glove box, and hardly any TiO_2 or CNTs were detected during ENM handling. The average particle number concentration outside the enclosures were 2500 and 1000 particles/cm^3 during cleaning operations and ENM handling, respectively. These particles were mainly background particles not originating from ENM operations, since only a few single ENMs were detected in TEM samples outside the enclosures. In conclusion, exhausted enclosure and wet methods used for cleaning diminish workers' exposure to ENMs during cleaning and handling operations effectively.