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Workplace atmospheres — Ultrafine, nanoparticle and nano-structured aerosols — Inhalation exposure characterization and assessment

Air des lieux de travail — Particules ultrafines, nanoparticules et aérosols nanostructurés — Caractérisation et évaluation de l'exposition par inhalation

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Foreword

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Introduction

Aerosol exposure has historically been characterized by the mass concentration of airborne material, usually associated with specific size ranges corresponding to different deposition regions within the respiratory system. However, there are indications that mass concentration alone may not provide a suitable indication of the health risks associated with some aerosols. A number of toxicology studies have indicated that, on a mass for mass basis, some very small respirable insoluble particles may be more toxic than larger respirable particles with a similar composition [4 to 11]. Ambient aerosol epidemiology studies since the early 1990s have demonstrated an increase in health impact from particles smaller than 2,5 µm compared to those smaller than 10 µm on a mass for mass basis [12 to 22]. While there is very limited health impact data specific to inhaling very fine respirable particles from the occupational environment, there is evidence to suggest that health effects associated with inhaling such particles generated in hot processes, such as metal processing and welding, are greater than mass-based exposures would indicate [23][24]. Taken together, the evidence points towards a particle size-related health risk following inhalation exposure to some occupational aerosols that is not appropriately reflected by mass concentration alone. In recognition of the potential importance of particle size, the term "ultrafine aerosol" has gradually been adopted and loosely refers to particles "smaller than 100 nm in diameter". The term is now widely used to refer to incidental aerosols where there are potential particle size-dependent health effects. As research and development into nanotechnology has increased over recent years, concern has also been expressed over the potential health impact of purposely generated particles with nanometre diameters or nanoscale structures [25 to 28]. In this context, the terms "engineered nanoparticle" and "engineered nanoaerosol" have also been used loosely to describe particles and aerosols associated with engineered nanometre-structured materials. However, a generally accepted set of definitions for these terms is still under discussion. For clarity, in this report, the term "nanoparticle" is used to describe all aerosol particles with diameters smaller than approximately 100 nm that present a potential inhalation health hazard. Larger particles with a nanometre-scale structure that may also present a potential health hazard (such as agglomerates of nanoparticles and nanometre-diameter fibres) are referred to as "nanostructured" particles, and aerosols of nanoparticles and nanostructured particles are referred to as "nanoaerosols".

With only limited toxicity data and negligible exposure data, it is currently unclear how exposure to nanoaerosols should be most appropriately monitored and regulated. There is strong toxicity-based evidence that aerosol surface area is an appropriate exposure metric for low solubility particles that removes the dependency on particle size [5][8][9][29]. However, there are also indications that in some instances particle number within specific particle size ranges may be important [23]. Recent studies on particle translocation within the body have further indicated a size-dependency on the likelihood of deposited particles moving from the respiratory system to other organs [30][31]. At the present time, there is insufficient information to determine which physical exposure metrics – size-selective number, surface area and mass concentration – are most relevant, or which are the most appropriate exposure characterization techniques to use. A first step to providing the necessary information is to establish the means by which exposure can be measured against different metrics. In the short term, this will provide a means to evaluate exposures where there is concern over the inadequacy of mass-based methods, particularly in emerging nanotechnologies where engineered nanoparticle exposure may be significant. It will also provide a basis for developing a deeper understanding of associations between aerosol exposure and health effects using a range of exposure metrics and will lay the foundation for future characterization standards.

In this context, the overall aim of this Technical Report is to provide generally accepted definitions and terms, as well as guidelines on measuring occupational nanoaerosol exposure against a range of metrics. By providing the means to undertake potentially more relevant exposure measurements where current methods and standards appear inadequate, it addresses an immediate need and will form a basis for extending knowledge on how occupational exposure to nanoaerosols should most appropriately be measured. The development and adoption of appropriate measurement approaches is an essential step toward developing and implementing future exposure measurement standards for nanoaerosols.

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