

Critical issues for measuring workers' exposure to nanomaterials by multiparametric approach

The increasing deployment of engineered nanomaterials in industrial settings has highlighted the limitations of traditional approaches based solely on mass concentration for the assessment of occupational exposure. The distinctive properties of nanoparticles—such as their high surface-to-volume ratio, enhanced reactivity, and ability to penetrate deep into the respiratory tract—require the adoption of a multiparametric approach capable of integrating different aerosol metrics.

Among the most used parameters are particle number concentration, size distribution, specific surface area, and chemical composition. However, the selection of the most representative metric remains complex and context-dependent: number concentration is highly sensitive to the ultrafine fraction, whereas mass is largely dominated by larger particles; active surface area, although potentially more closely related to biological effects, still suffers from instrumental limitations and lacks standardisation.

A further critical aspect concerns the integration of heterogeneous measurement techniques, including real-time instruments (e.g. CPC, SMPS, APS) and offline analyses performed on filter-collected samples (such as ICP-MS or electron microscopy). This integration requires addressing issues related to temporal synchronisation, data comparability, and the conversion between different particle diameters (mobility, aerodynamic, and volume-equivalent), often based on uncertain parameters such as particle density and shape factor.

Distinguishing engineered nanoparticles from background aerosol represents an additional challenge, particularly in complex environments. Moreover, the variability of operational conditions makes it difficult to ensure the representativeness of sampling strategies. The lack of specific occupational exposure limits for many nanomaterials further complicates data interpretation.

Finally, the management of multivariate datasets requires advanced analytical approaches and an appropriate assessment of measurement uncertainty. In this context, the development of harmonised protocols and standardised methodologies is essential to improve the reliability of exposure assessment and to effectively support the protection of workers' health.