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2014

Link to publication

Citation for published version (APA):

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Comparison of direct reading instruments for Particle Measurements

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Keywords: Aerosol measurement techniques, instrument intercomparison, engineered nanomaterials

For exposure measurement of engineered nanomaterials (ENM), traditional gravimetrical analysis alone is known to be insufficient due to the low total mass of the aerosol. Direct reading instruments for measurement of particle number, size and surface area are often used as replacement or complement to the gravimetrical measurement. Proper aerosol measurements within industrial processes demand a high time resolution in order to properly capture fast transients in the particle concentrations and sizes. An analysis of workplace measurements suggest that short singular release events may generally be detected in number concentration measurements at a time-resolution lower than ca. 1 minute (Asbach et al., 2014). However, the high temporal resolution and the needed measurement procedure should not come at the cost of reliability of the measurement. Therefore thorough evaluation of the performances and data achieved by different candidates for aerosol monitoring should be completed.

This study focuses on the measurement of particle size distributions using some of the most commonly used aerosol measurement instruments. We investigate whether particle size distributions of spherical particles and industrial-like aggregated and agglomerated aerosols can be properly measured at high time resolutions and what limitations there are for such measurements. Using these aerosols, we also investigate the reliability in conversions from number size-distributions into surface area concentration and the direct measurement of surface area monitors. This is relevant as the surface area concentration exposure is considered as a potential new metric in health-related exposure assessment.

DEHS and Au aerosols were introduced into a large ventilated volume to ensure stable aerosol conditions. A flow-through sampling line was used to lead the aerosols to the respective instruments. Instrumentation included CPC, SMPS, FMPS, ELPI, NSAM and Partector.

Size distribution measurements of quasi-monodisperse DEHS oil particles gave results that matched well between SMPS, FMPS and ELPI up until \textasciitilde200 nm. Above 200 nm the correlation between SMPS and ELPI remains good while the FMPS underestimates the particle sizes as compared to the other instruments (Figure 1). Due to these instrument-related differences, conversion of size-distribution measurements to surface area concentrations will vary considerable depending on the aerosol size-distribution and the level of agglomeration.

Work-place like aerosols generated by rotating drum dustiness testing show a similar discrepancy between FMPS and ELPI as the size distribution of the particle agglomerates usually peaks above 100 nm particles and reach into the µm size-range (Schneider and Jensen, 2009). Results from dustiness tests and workplace measurements using these instruments and different metrics need to be carefully evaluated and understood in reporting. A significant amount of work and documentation is still required before any of these online measurement devices can be used for quantitative exposure assessment and regulatory purposes.

Figure 1. Fitted GMD of FMPS/ELPI against SMPS.