Improved data for the modelling of the exposure to MNMs
Deliverable 3.4

Introduction

Production and handling of nanomaterials by industry poses a risk for workman's exposure to airborne nanoparticles. To predict these risks and to take adequate measures to minimize them, it is important to have information of the actual or expected level of exposure in industrial settings and the effectiveness of measures to avoid those risks.

Measuring of exposure levels of airborne nanomaterials in industrial settings is complicated and costly. Thus, there is a great need for models that can adequately predict aerosol exposure levels in relevant situations and for different emission levels; both for people directly working with processes that emit airborne nanomaterials as well as for people in the vicinity of the source of exposure. Calibration and validation of such models requires data on the exposure in real-world situations.

One goal of NANoREG is to test and improve existing exposure models. To help fulfil this goal a series of comprehensively-monitored nanoparticle exposure experiment were undertaken inside a large climate-controlled chamber at Danish Technical University (DTU). The work was interlinked to other NANoREG task groups and included their expertise, reference materials and experimental equipment. This deliverable factsheet briefly describes the experiments and intended uses of the generated data.

Description of Work

Aerosol emission experiments have been carried out in a large climate-controlled chamber at DTU, see Fig. 1. In order to disturb the airflow inside as little as possible, nanoparticle monitors were placed outside on the roof of the chamber. The chamber air was sampled using sampling gas lances, for which particle losses were corrected. In order to study the temporal development of the aerosol concentration and particle size distribution with as much detail as possible, more than 20 aerosol monitors were used in a joint effort of NANoREG partners and external collaborators. To allow for improved mapping of the airflow, tracer gases were added to the emission source and monitored by laser absorption spectroscopy.

Fig.1: Photograph of the DTU climate chamber inside the hall with ventilation and aerosol monitoring installations on the roof.

A series of experiments was conducted using strength-calibrated nanoparticle emission sources. These experiments were set up to mimic typical workplace exposure scenarios while handling MNMs. The experiments achieved a detailed mapping of the chamber airflow dynamics at eight different sampling locations. Inter-comparison experiments of the monitoring instruments were also performed.

After completion of the experiments the data were collected, collated and checked for consistency. Analyses of the experimental data provide valuable insight into the chamber airflow dynamics at the different sampling locations and allow the derivation of space and time averaged exposure concentrations.

Main Results and Perspectives

Deliverable D3.04 gives an overview of the preparatory experiments as well as the detailed exposure experiments.

In the first category, “age of air experiments” were carried out to determine the air exchange effectiveness and the air mixing time constants of the ventilation installation. The aerosol concentration when flushing the room always followed an exponential decay, which is typical of perfect mixing through ventilation, and the vertical age of air profile was found homogeneous and close (by less than 15%) to the perfect mixing time constant of the room for the two tested air exchange rates. The “instrument intercomparison experiments” showed a high degree of correlation for the installed aerosol monitors.

In the second category, “source variation experiments” were carried out to measure the influence of source position on particle concentrations throughout the room. Diffusive transport explains the broadening of the temporal response profile of aerosol monitors according to their distance to the source location and the relative ventilation direction.

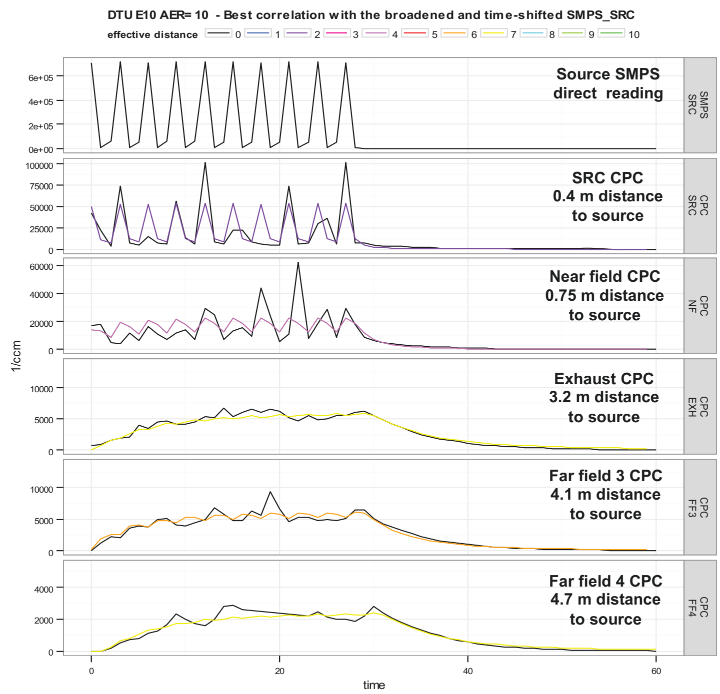

Fig. 2: Spiking experimental data on particle number concentration from aerosol monitors (1) directly connected to the source (SRC) and (2) sampling at different locations with increasing distance to the source. The overlaid curves result from fitting an effective distance parameter of a broadening function used for convoluting the source signal.

“Spike experiments” were carried out to mimic emission scenarios where the nanoparticles are released intermittently (e.g. pouring nanomaterial from bags) and to study the emission spike broadening according to ventilation rate and aerosol monitor location, see Fig. 2.

“Coagulation experiments” studied effects of injecting SiO_2 nanoparticles into an existing background aerosol, focusing on interactions between engineered and natural particle emissions. Also nanoparticle wall losses were studied using SiO_2 and fluorescein particles and compared to theoretical predictions.

Both, field measurement and emission test data will be used to test quantitative exposure models and enable an assessment of the accuracy and uncertainty of model-predicted concentrations. Using the data provided here, model accuracies can be evaluated for different scenarios (varying emission pattern, ventilation rate and material) allowing for feedback on which situations the model works best and potentially identifying why a model may be underperforming in other scenarios.

The results will be combined with other work being carried out to develop guidance for users of exposure models and tools. The guidance document will look to identify the applicability domain of each tool/model, what information is essential to obtain a sensible estimate of exposure, and how reliable these estimates are likely to be. In addition, recommendations will be made to model developers to highlight the potential issues with their model identified through the testing process as well as general aspects to be taken into account.

The consortium will publish the experimental exposure data. This way, a validated dataset will be made available with many potential uses for those dealing with measuring and modelling of occupational exposures to ENM.

For more details about NANoREG please visit the official website **www.nanoreg.eu**.

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